Research Article https://doi.org/10.12973/eu-jer.13.3.1043

European Journal of Educational Research

Volume 13, Issue 3, 1043 - 1056.

ISSN: 2165-8714

https://www.eu-jer.com/

How the Learning Style and Working Memory Capacity of Prospective Mathematics Teachers Affects Their Ability to Solve Higher Order Thinking Problems

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Received: August 25, 2023 ▪ Revised: November 28, 2023 ▪ Accepted: January 4, 2024

Abstract: This study aims to analyze the effects of working memory capacity and learning styles of prospective mathematics teachers on their ability to solve higher-order thinking problems. In the present study, learning style was considered students' tendency to learn visually or verbally. In addition, the types of higher-order thinking skills (HOTS) problems are complex and non-complex. Multiple regression tests were used to analyze the effects of learning style and working memory capacity. An ANOVA test was also conducted to analyze the ability of each group to solve each HOTS problem. In addition, one hundred twenty-six prospective mathematics teachers voluntarily participated in this study. The study found that learning styles only affected visual problems while working memory capacity (WMC) only affected the ability to solve complex problem-solving skills. Furthermore, WMC affected the ability to solve complex HOTS problems, not non-complex ones. The ability of visual students to solve HOTS problems will greatly increase when the problems are presented in visual form. On the other hand, the obstacle for visual students in solving verbal problems was to present the problem appropriately in visual form. The obstacle for students with low WMC in solving complex HOTS problems was to find a solution that met all the requirements set in the problem.

Keywords: *Higher-order thinking skill problems, learning style, prospective mathematics teacher, working memory capacity.*

To cite this article: Juniati, D., & Budayasa, I. K. (2024). How the learning style and working memory capacity of prospective mathematics teachers affects their ability to solve higher order thinking problems. *European Journal of Educational Research*, *13*(3), 1043-1056. https://doi.org/10.12973/eu-jer.13.3.1043

Introduction

The most important thing in learning mathematics is solving problems. Problem-solving allows students to apply the theories they have learned to solve various problems they encounter in their environment (Juniati & Budayasa, 2017). According to Jonassen (2000), problem-solving is a salient cognitive activity that plays a role in everyday and professional life. From the perspective of the cognitive activity required to solve a particular problem, there are two types of problems: Low-order and high-order thinking. Problems that require only memorization and recall of information are classified as lower-order thinking skills (LOTS) problems, while problems that require analysis, synthesis, evaluation, and critical and creative thinking are classified as higher-order thinking skills (HOTS) problems. A significant change in education that has been widely recognized as inevitable is the shift from the traditional method of teaching LOTS to HOTS (Avargil et al., 2012; Rotgans & Schmidt, 2011). Given the challenges of the 21st century, students must have literacy and numeracy skills and be eager learners. In addition, students need to learn more to solve HOTS problems that require critical and creative thinking (Craft & Wegerif, 2006). According to the results of the PISA study (Organisation for Economic Co-operation and Development [OECD], 2019), the HOTS of Indonesian students are still far from satisfactory. Therefore, there is an urgent need to find appropriate strategies for teaching HOTS to students. The results of Tanudjaya and Doorman (2020) and Marsitin et al. (2022) show that students had difficulty solving HOTS problems. One of the reasons for this result was that teachers rarely gave HOTS problems in class because they thought HOTS problems were only for gifted students. Because of this belief, teachers did not teach the HOTS problem in class. In addition, there were still many teachers who had difficulty understanding HOTS problems and who did not know how to create HOTS problems. Due to this fact, training for prospective teachers on HOTS problems is urgently needed. For this reason, it is necessary to examine prospective teachers' HOTS in problem-solving and the factors that influence them.

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Prospective mathematics teachers later become teachers who guide students in their learning, help them when they have difficulties, and teach them mathematics and how to solve problems effectively and efficiently. The experiences prospective teachers have in studying mathematics and their success in overcoming problems would be very helpful when they teach their students (Juniati & Budayasa, 2022a; Lestari et al., 2018; Pambudi, 2022). Therefore, research on prospective mathematics teachers concerning their HOTS is crucial.

Students receive and process information differently. This also applies to mathematics learning, as students have unique learning styles. Learning styles are how students learn, perceive, and process information in different and unique ways. For example, students with a visual learning style find it easier to understand information when presented in tables, pictures, or other visual forms, while students with a verbal learning style find it easier to understand information in text form (Juniati & Budayasa, 2022a). Therefore, it is interesting to examine how learning styles influence students' ability to solve HOTS problems presented in different forms (visual and verbal).

Working memory capacity (WMC) refers to how much information a person can receive and process at a given time. Wiley and Jarosz (2012a) showed that WMC supports cognitive problem-solving abilities. Although WMC influences problem-solving ability, according to Wiley and Jarosz (2012b) this relationship is not always positive as it also depends on the nature of the problem, whether it is an analytical or creative problem. Therefore, it is important to examine the influence of WMC on HOTS problem-solving ability in prospective mathematics teachers, as this has implications for determining strategies to improve HOTS abilities.

Previous research on HOTS (Maf'ulah et al., 2017; Marsitin et al., 2022; Tanudjaya & Doorman, 2020; Wiley & Jarosz, 2012b) is limited to elementary and high school students. The researchers focus on the HOTS of the students and not on the HOTS of the prospective teachers who will later teach and guide the students in performing HOTS. Therefore, this study aims to determine the effects of prospective mathematics teachers' learning styles and WMC on their ability to solve HOTS problems (visual HOTS problems, verbal HOTS problems, and complex HOTS problems). It is expected that the results of this study will be useful in determining strategies to improve prospective mathematics teachers' ability to solve HOTS problems based on differences in their learning styles and WMC.

Literature Review

Higher-Order Thinking Skills

HOTS are critical, complex thinking skills used to find general or multiple solutions to a particular problem. Krathwohl and Anderson (2010) and Kruger (2013) defined HOTS as thinking that analyzes, evaluates, and creates. Problems that encourage students to demonstrate their HOTS are open-ended problems that allow students to be creative in identifying different paths and solutions or in the form of non-routine problems where the solution method requires analytical, critical, and creative thinking (Avargil et al., 2012; Brookhart, 2010; Tanudjaya & Doorman, 2020).

Several research studies have studied the phenomenon of HOTS at different levels. The results of the research conducted by Tanudjaya and Doorman (2020) and Marsitin et al. (2022) showed that students had difficulty solving HOTS problems. One of the reasons for this finding was that teachers rarely introduced HOTS problems into lessons because they believed HOTS problems were only for gifted students. Thompson's (2008) study of thirty-two middle school teachers revealed that teachers had difficulty interpreting and creating HOTS tasks for students. Moreover, appropriate technology can help and train students to solve HOTS problems (Juniati & Budayasa, 2021). It can be inferred that teaching HOTS is not easy because it requires continuous efforts to establish appropriate strategies accompanied by teachers' reflections while teaching HOTS.

Learning Style

When it comes to learning, students have unique ways of feeling comfortable; in other words, they have learning preferences. Kolb and Kolb (2005) defined learning style as a personal way of processing information, feelings, and behaviors in learning situations. Many researchers have classified learning styles according to different criteria and points of view. Kolb's model of learning style is based on how a person captures and transforms experiences. Kolb proposed the model of accommodation, convergence, divergence, and assimilation (Kolb & Kolb, 2005). Walter Burke Barba proposed the learning styles of visual, auditory, and kinesthetic (VAK). Fleming extended the VAK model by adding reading/writing to the model so that it is now visual, auditory, reading/writing, and kinesthetic (VARK) (Hawk & Shah, 2007; Leite et al., 2010; Prithishkumar & Michael, 2014). Finally, Felder and Silverman have developed the Index of Learning (IoL), which consists of four extreme pairs: Active/Reflective, Sensing/Intuitive, Verbal/Visual, and Sequential/Global (Felder & Spurlin, 2005).

Research on learning styles has had a major impact on the field of education and has been conducted for all levels, from elementary school to higher education (Ariem & Cabal, 2021; Bhattacharyya & Shariff, 2014; Bosman & Schulze, 2018; Budayasa & Juniati, 2019; Cabi & Yalcinalp, 2012; Syamsuddin et al., 2020). The industry has widely used the findings of learning style research to fill appropriate professional positions (Cabi & Yalcinalp, 2012; McCarthy, 2016; Yasmeen et al., 2020). Students would achieve the best learning outcomes if given appropriate learning methods and instructions that suit their learning style (Prithishkumar & Michael, 2014). Some researchers (Ariem & Cabal, 2021; Bosman & Schulze, 2018) stated that the mismatch between teachers' teaching styles and students' learning styles can lead to poor mathematics achievement and negative attitudes towards mathematics. They recommended that teachers use teaching methods catering to their students' learning styles.

Mayer and Massa's (2003) study of ninety-five college students showed that differences in learning preferences and cognitive abilities depended on the visualizer-verbalizer dimension. Next, Massa and Mayer (2006) examined the effect of Verbalizer and Visualizer learning styles on learning tests by using multimedia according to preference in learning. In addition, Mayer and Massa suggested that verbal and visual learning styles need to be strongly supported by multimedia instruction. Tsai and Shirley (2013) used Felder and Silverman's IoL to classify subjects' learning styles. They found no correlation between learning styles and creative thinking in mathematics students. In addition, Juniati and Budayasa (2022a) showed that the learning styles of prospective mathematics teachers influence their problem-solving strategies; groups with different learning styles show different strategies for solving mathematical problems. Cabi and Yalcinalp (2012) showed that prospective teachers' learning styles did not significantly affect their ability to develop time management, effort management, and help-seeking strategies. Bhattacharyya and Shariff (2014) emphasized the need for teachers and curriculum designers to design learning tasks that match individual learning style preferences. They believed that students given various tasks tailored to their learning style are motivated, feel comfortable with the type of task, and feel more challenged to complete it. No research has revealed the influence of prospective mathematics teachers' learning styles on HOTS problem-solving.

Working Memory Capacity

According to Baddeley (2003), working memory is a person's temporary cognitive system ready to be processed. If someone is given a piece of information and asked to repeat it after a second, they will have difficulty if given too much information. Students' ability to memorize and process complex information reflects their working memory capacity. Therefore, working memory capacity (WMC) can limit how much information can be retained, stored, and processed within seconds (Cowan, 2013; Oberauer, 2019). Working memory capacity varies from person to person and is related to their capacity to understand language, reason, and be generally intelligent (Alloway & Passolunghi, 2011; Anjariyah et al., 2022; Conway et al., 2003). Roeser et al.'s (2013) research on teachers showed that WMC is not static but can be improved through practice.

Many studies (Alloway & Passolunghi, 2011; Anjariyah et al., 2022; Ashcraft & Krause, 2007; Juniati & Budayasa, 2020, 2022b; Mousavi et al., 2012; Passolunghi et al., 2016) have been conducted on WMC. Previous studies (Alloway & Passolunghi, 2011; Anjariyah et al., 2022; Juniati & Budayasa, 2020, 2022b; Mousavi et al., 2012) have also shown that there is a relationship between WMC and mathematics achievement in elementary to higher education students. Mathematical reasoning in problem-solving differs according to the WMC level, which is true for middle school students and prospective mathematics teachers (Palengka et al., 2019, 2021; Wiley & Jarosz, 2012b). In general, the higher the WMC, the better the performance in various cognitive domains, including problem-solving (Alloway & Passolunghi, 2011; Anjariyah et al., 2022; Juniati & Budayasa, 2020, 2022b; Mousavi et al., 2012; Passolunghi et al., 2016), but a high WMC is sometimes even detrimental to solving certain problems because a better capacity to control attention leads to being distracted. People with a high WMC tend to always use complex approaches, even for simple problems, so their attention is not optimal for solving a specific task (Chein et al., 2010; Crouzevialle et al., 2015; DeCaro et al., 2016; Gaissmaier et al., 2006; Oberauer, 2019). Therefore, it is very interesting to examine whether the level of WMC influences the ability to solve HOTS problems, namely HOTS non-complex problems and HOTS complex problems.

Methodology

Research Design

Quantitative methods were used to examine the influence of learning style and WMC on HOTS problems. In this study, HOTS problems consisted of 3 types, namely visual, verbal, and complex HOTS problems. The multiple regression test was conducted three times, and the independent variables were the visual, verbal, and complex HOTS scores. An ANOVA test was also conducted to examine each group's ability to solve visual, verbal, and complex HOTS problems. A questionnaire was also completed to explore the students' reasons for differences in their ability to solve each type of HOTS problem.

Sample and Data Collection

This study used cluster random sampling as a method for selecting samples. One class was randomly selected for each freshman, sophomore, and junior grade. The mathematical abilities of the students in each class were the same. A total of one hundred twenty-six prospective math teachers from Universitas Negeri Surabaya voluntarily participated in this research. The age range was between 18 and 21 years old. The group consisted of 99 female and 27 male participants.

Instruments and Analysis of Data

This study determined learning style based on students' tendency to learn visually or verbally. The instrument used to determine learning tendencies was Felder and Silverman's Index of Learning Style (Felder & Spurlin, 2005). In this instrument, 11 multiple-choice questions indicate the preferred way of learning or receiving information visually or verbally. An example item is: In a book with many pictures and charts, I am likely to…. The two response options are: a) look over the pictures and charts carefully, and b) focus on the written text. If a) is selected, the visual value is increased by 1, while for b), the verbal value is increased by 1. The learning style score is the difference between the visual and verbal scores. If the respondent selects 11 visual responses, the learning style score is visual11, while for 3 visual and 8 verbal responses, the learning style score is verbal5. For the grouping of learning styles, the subjects with the scores Visual11, Visual9, Visual7, and Visual5 were categorized in the Visual learning style group, while the students with the scores Visual3, Visual1, Verbal1, and Verbal3 were categorized in the Neutral learning style group. In addition, the results from Verbal5 to Verbal11 were categorized into the Verbal learning style group. The effect of learning style on HOTS problem-solving abilities was determined using a Visual Tendency Score. If the learning style was rated Visual5, then the Visual Index Score is 5; if the learning style was rated Verbal3, then the Visual Index Score is -3.

WMC is measured using a computerized task developed by Juniati and Budayasa (2020) to measure operation span with automatic timing. The numbers were displayed within 4 seconds between the appearance of the numbers. Subjects were asked to perform a mathematical operation. At the end of the session, they had ten seconds to write down the numbers to be memorized in the correct order. The WMC score was determined by adding up the numbers that could be memorized in the correct order, whereby the mathematical operations had to be at least 80% correct. WMC score is between 0 and 100; see Juniati and Budayasa (2020) for details. In the present study, subjects with a WMC score of less than 70 were placed in the low WMC group, while subjects with a WMC score of 70 or above were placed in the high WMC group.

In this study, we constructed the HOTS problems. The constructed problems consisted of non-complex HOTS problems and complex HOTS problems. Non-complex HOTS problems were created involving a mathematical concept (in this case, the concept of distance and area), and there is no routine way to solve them. They required participants to think creatively to find different solutions. Complex HOTS problems are open-ended problems that require subjects to use their creative thinking to find different solutions involving multiple mathematical concepts and meeting multiple requirements (in this case, the concepts of area and perimeter of different geometric objects). There were three types of problems, namely visual HOTS problems, verbal HOTS problems, and complex HOTS problems. The visual and verbal problems were similar, but the forms of presentation were different; the visual problems used pictures, while the verbal problems used only words. The distance problem involved finding the shortest path between two points with an obstacle. The area problem involved creating different geometric objects with the same area under certain conditions. The complex problems involved several mathematical concepts and some constraints or generalization problems to be satisfied. The complex problem of distance required the subject to make generalizations using the properties of triangles. The complex area problem required subjects to create four different geometric objects with the same area, where the sum of the perimeters of the four objects equals 100 units. The score for the HOTS problem ranged from 0-11.

The influence of learning style and WMC on problem-solving skills for each type of HOTS problem was analyzed three times using multiple regression tests, where the independent variables were the scores for visual, verbal, and complex problems.

The ANOVA test revealed the difference in the capacity to solve HOTS problems between the three types of problems for each group.

Findings/Results

The study involved 126 prospective mathematics teachers as participants. All participants completed a learning style questionnaire and a WMC test and performed the three types of HOTS problems. Table 1 displays the results.

Table 1. Learning Style (Index of Visual), WMC, and Scores of Students' HOTS Problems

	Visual Index	WMC	Visual Problem Score	Verbal Problem Score	Complex Problem Score
Mean	4.46	71.23	8.65	7.16	5.00
Std dev	4.17	15.26	1.94	2.54	2.13
Min	-7	26	2	2	1.38
Max	11	100	11	11	10.31

Table 1 shows that the average HOTS problem-solving ability from high to low is solving visual form problems, verbal form problems, and complex problems, respectively. The average WMC was 71.23, and fifty-one subjects with a WMC score of less than 70 were included in the low WMC group. The remaining seventy-five students were included in the high WMC group. Interesting results were gathered regarding learning styles. The average visual index was 4.46. This finding indicates that the students' tendency to learn visually was quite high. It can also be appeared that of the one hundred twenty-six subjects, sixty-seven subjects had a visual learning style, fifty-seven subjects had a neutral learning style, and only two subjects had a verbal learning style (Verbal5 and Verbal7).

To analyze the influence of learning style and WMC on HOTS problem-solving abilities, a multiple regression test was conducted three times, where the independent variables were visual problem scores, verbal problem scores, and complex problem scores. The statistical tests were conducted using SPSS software. Before performing the multiple regression test, the classical assumption test was first performed to check the data's normality, homoscedasticity, and lack of multicollinearity. The regression residuals must be normally distributed, which can be achieved using a normal distribution and predictive probability plots. Figure 1 shows a normal predictive probability (PP) plot of visual, verbal, and complex problem scores. It can be noted from Figure 1 that the dots in each plot move along a diagonal line. The results in Figure 1 show that the data on visual, verbal, and complex questions are normally distributed.

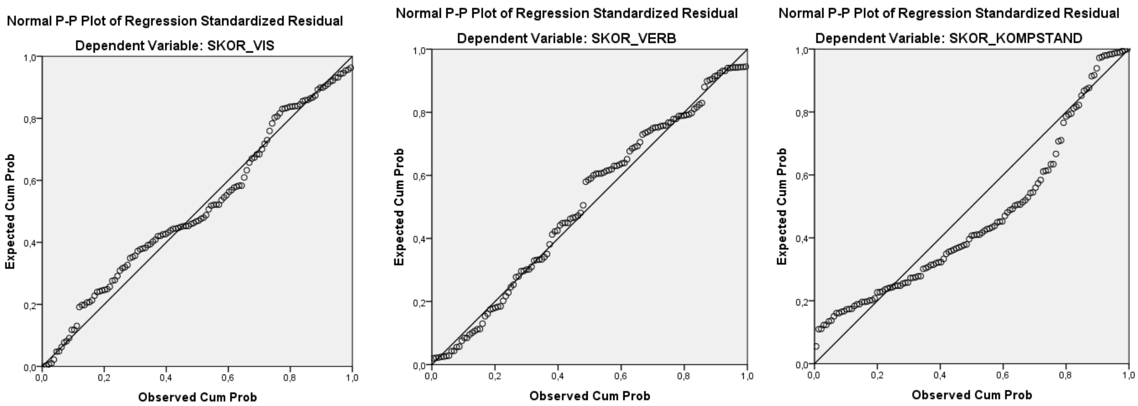

Figure 1. Normal Prediction Probability Data Plot

Homoscedasticity means the points are evenly distributed, and a scatterplot of the residuals verifies this condition. Figure 2 shows that the points are distributed above and below zero and to the left and right of zero for each scatter. The criterion of homoscedasticity is therefore fulfilled. Since the residuals are regularly homoscedastically distributed, the predictor variable in the regression has a linear relationship to the outcome variable.

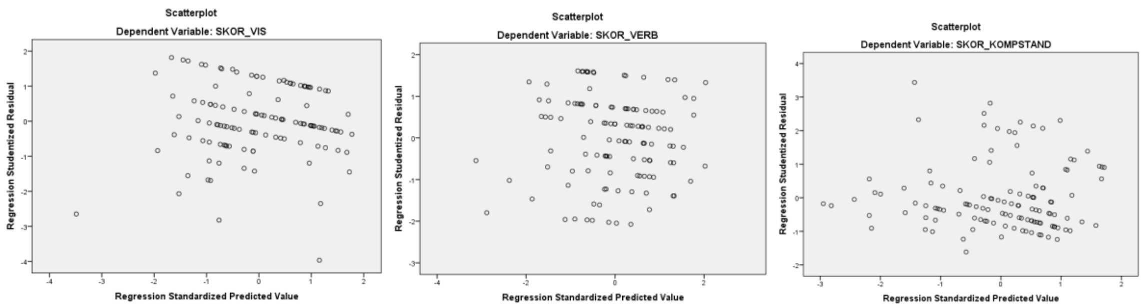

Figure 2. The Scatter Plots of Residual

Multicollinearity is a condition that arises when the independent variables in a multiple linear regression test are significantly correlated with each other. This condition is not desired in a multiple linear regression statistical test. To check for multicollinearity, we can use a tolerance value higher than 0.8 and a VIF (Variance Inflation Factor) value of less than 5. Tables 2a, 2b and 2c show the results regarding this condition.

Table 2a. Collinearity Statistics of Visual Problem Scores

Collinearity Statistics	Visual Index	WMC
Tolerance	0.998	0.998
VIF	1.002	1.002

a. Dependent Variable: Visual Problem Score

Table 2b. Collinearity Statistics of Verbal Problem Scores

Collinearity Statistics	Visual Index	WMC
Tolerance	0.998	0.998
VIF	1.002	1.002

b. Dependent Variable: Verbal Problem Score

Table 2c. Collinearity Statistics of Complex Problem Scores

Collinearity Statistics	Visual Index	WMC
Tolerance	0.998	0.998
VIF	1.002	1.002

c. Dependent Variable: Complex Problem Score

Tables 2a, 2b, and 2c above show that all VIF values were less than 5, and all tolerance values were greater than 0.8, meaning there was no multicollinearity. Thus, the classical assumption test was fulfilled so the multiple regression tests could continue. Table 3, Table 4, and Table 5 show the coefficients and the significant values of the analysis.

Table 3. Multiple Linear Regression for Visual Problem Score

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	7.064	0.836		8.454	.000
Visual Index	0.132	0.041	0.285	3.252	.001
WMC	0.014	0.011	0.110	1.262	.209

F= 5.925 with a significance *p* value =.004 and *R*= .301, *R* square= .091 with the dependent variable: Visual problem score

Table 3 demonstrates the multiple linear regression for visual problem score *F*=5.925 with significance *p*-value=.004<.05. This result indicated that the model matched the data well. The model regression was: $y=7.064+0.132x_1 +0.014x_2$, with y: visual problem score, x_1: visual index, x_2: WMC. The significance *p*-value for the visual index was .001<.05, while for WMC, it was .209>.05, so the visual index affected the visual problem score, while WMC did not.

Table 4. Multiple Linear Regression for Verbal Problem Score

Model	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
	B	Std. Error	Beta		
(Constant)	6.184	1.144		5.407	.000
Visual Index	-0.028	0.056	-0.045	-0.498	.619
WMC	.015	0.015	0.092	1.010	.314

F=0.656 with a significance *p* value = .521 and *R*= .104, *R* square= .011 with the dependent variable: Verbal problem score

Furthermore, Table 4 demonstrates the ANOVA for a complex problem score of *F*=0.656 with a *p*-value=.521>.05. This result indicated that the regression model was not a good match for the data. The *p*-value for the visual index was .619>.05, while for WMC, it was .314 > .05, so the visual index and WMC did not affect the verbal problem score.

Table 5. Multiple Linear Regression for Complex Problem Score

Model	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
	B	Std. Error	Beta		
(Constant)	0.716	0.873		0.820	.414
Visual Index	0.041	0.042	0.081	0.976	.331
WMC	0.058	0.012	0.413	4.971	.000

F= 12.629 with a significance *p* value =.000 and *R*= .417, *R* square=.174 with the dependent variable: Complex problem score

Finally, Table 5 indicates the ANOVA for the complex problem score of *F*=12.629 with *p*-value=.000 < .05. This result indicated that the regression model matched the data well. The model was: $y=0.716+0.041x_1 +0.058x_2$, with y: complex problem score, x_1: visual index, x_2: WMC. The *p*-value for the visual index was .331 > .05, while for WMC, it was .000 < .05. Therefore, WMC affected the complex problem score, while the visual index did not.

The visual HOTS problem-solving ability of the visual learning style group (average 9.270) was higher than that of the neutral learning style group (average 8.010). Meanwhile, the complex HOTS problem-solving ability of the high WMC group (average 5.726) was higher than that of the low WMC group (average 4.054).

An ANOVA test was then conducted to determine the differences in the subjects' ability to solve these three types of problems for each group. Subjects were divided into 4 groups, namely: Visual learning style subjects with low WMC (visual-low WMC group), visual learning style subjects with high WMC (visual-high WMC group), Neutral learning style subjects with low WMC (neutral-low WMC group), and neutral learning style subjects with high WMC (neutral-high WMC group). The verbal subjects were not divided into groups, as there were only 2 people. The group with the visual learning style consisted of 67 students, the neutral learning style consisted of 57 students, the group with the high WMC of 75 students, and the group with the low WMC of 51 students. Table 6 describes the average score of each group for the three types of HOTS problems.

Table 6. The Average Score of Each Group for Three Types of HOTS Problem

	Verbal Problem Score		**Visual Problem Score**		**Complex Problem Score**	
	Mean	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Neutral-Low WMC Group (N=20)	7.1500	2.54	7.7500	2.29	3.9188	2.10
Neutral-High WMC Group (N=37)	7.3514	1.99	8.2703	1.54	5.2770	1.67
Visual-Low WMC Group (N=29)	7.1034	3.30	9.3793	1.60	4.6659	2.26
Visual-High WMC Group (N=38)	6.8947	2.42	9.1579	1.73	6.0247	2.37

We conducted the ANOVA tests to determine the difference in the ability of each group to solve three HOTS problems. This process began with a test of variance similarity of scores on three different HOTS problems using Levene's statistical test. Then, the tests for similarity of means between the three problem types continued to see if there was a significant difference in the mean by examining which scores of the different problem types used the post hoc test. In this study, the Tuckey HSD test would be used if the group variances were the same, and the Games-Howell test would be used if they were different. Tables 7a, 7b, and 7c show the results of the ANOVA test for the neutral-low WMC group.

Table 7a. Test Homogeneity of Variances of Neutral-Low WMC Group

Levene Statistic	**df1**	**df2**	**Sig**
1.211	2	57 .305	

Table 7b. ANOVA Table of Neutral-Low WMC Group

	df	**Mean Square**	**F**	**Sig**
Between Groups	2	84.932	15.842	.000
Within Groups	57	5.361		

Table 7c. Tuckey HSD Test of Neutral-Low WMC Group

(I) HOTS Problem	**(J) HOTS Problem**	**I-J Mean Diff**	**Std. Error**	**Sig**	**Lower Bound**	**Upper Bound**
Verbal	Visual	-0.6000	0.7322	.693	-2.3620	1.1620
	Complex	3.2313*	0.7322	.000	1.4693	4.9932
Visual	Complex	3.8313*	0.7322	.000	2.0693	5.5932

*The mean difference is significant at the .05 level

Based on the results of the Levene test, the value is p = .305, which is greater than .05 (alpha value). This result indicates that the group variances were the same, so the test for similarity of differences in means uses the Tuckey HSD test. Furthermore, from Table 7b (the ANOVA table), the value of F = 15.842 with a value of .000 is less than .05. This result indicates that a difference was present in the means of all the groups. From Table 7c (Tuckey HSD test), it can be inferred that the p-value between the verbal problem score and the visual problem score is .693, greater than .05, so there is no significant difference. Meanwhile, from a p-value that was less than .05, it can be obtained that the complex problem score is different from the verbal problem score and the visual problem score. Therefore, the ability of the neutral-low WMC group to solve HOTS verbal and visual HOTS problems was the same but different when solving complex HOTS problems. Tables 8a, 8b and 8c demonstrate the results of the ANOVA test for the neutral-high WMC group.

Table 8a. Test Homogeneity of Variances of Neutral-High WMC Group

Levene Statistic	df1	df2	Sig
2.072	2	108 .131	

Table 8b. ANOVA Table of Neutral- High WMC Group

	df	Mean Square	F	Sig
Between Groups	2	86.992	28.645	.000
Within Groups	108	3.037		

Table 8c. Tuckey HSD Test of Neutral- High WMC Group

(I) HOTS Problem	(J) HOTS Problem	I-J Mean Diff	Std. Error	Sig	Lower Bound	Upper Bound
Verbal	Visual	-0.9189	0.4052	.065	-1.8818	0.0439
	Complex	2.0743*	0. 4052	.000	1.1115	3.0372
Visual	Complex	2.9932*	0. 4052	.000	2.0304	3.9561

Based on the results of the Levene test, the value of p = .131, which is greater than .05 (alpha value), shows that the group variances were equal. Hence, the test for similarity of differences in means used the Tuckey HSD test. Furthermore, from Table 8b (the ANOVA table), the value of F = 28.645 with a value of .000 is less than .05; this result shows a difference in the means of all the groups. From Table 8c (Tuckey HSD test), it can be inferred that the p-value between the verbal problem score and the visual problem score was .065, greater than .05. Therefore, no significant difference was found. Meanwhile, from a p-value of less than .05, it was gathered that the complex problem score differs from the verbal and visual problem scores. Therefore, the ability of the neutral-high WMC group to solve HOTS verbal and visual HOTS problems was the same but different when solving complex HOTS problems. Based on the average score on complex HOTS solving, the ability of the neutral-high WMC group is higher than that of the neutral-low WMC group. Tables 9a, 9b, and 9c show the results from the ANOVA test for the visual-low WMC group.

Table 9a. Test Homogeneity of Variances of Visual-Low WMC Group

Levene Statistic	df1	df2	Sig
12.061	2	84 .000	

Table 9b. ANOVA Table of Visual-Low WMC Group

	df	Mean Square	F	Sig
Between Groups	2	161.128	26.090	.000
Within Groups	84	6.176		

Table 9c. Games-Howell Test of Visual-Low WMC Group

(I) HOTS Problem	(J) HOTS Problem	I-J Mean Diff	Std. Error	Sig	Lower Bound	Upper Bound
Verbal	Visual	-2.2759*	0.6800	.005	-3.9305	-0.6212
	Complex	2.4375*	0. 7427	.005	0.6430	4.2320
Visual	Complex	4.7133*	0. 5135	.000	3.4733	5.9534

*The mean difference is significant at the .05 level

From the Levene test, we found the *p* = .000 less than .05 (Alpha valued), which indicated that the group variances were different, so the Games-Howell test had to be used. Furthermore, from Table 9b (the ANOVA table), the value of *F* = 26.090 with a value of .000 is less than .05. This result explains the difference in the means of all the groups. Table 9c (Games-Howell test) demonstrated that all significance values between the two groups were less than .05. This result shows that the visual-low WMC group's ability to solve HOTS problems differed for the three types of problems. Furthermore, the highest to lowest ability to solve HOTS problems, respectively, were when solving HOTS problems in visual form, solving HOTS problems in verbal form, and the lowest ability in solving complex HOTS problems. Tables 10a, 10b, and 10c demonstrate the ANOVA test for the visually-high WMC group.

Table 10a. Test Homogeneity of Variances of Visual- High WMC Group

Levene Statistic	df1	df2	Sig
6.170	2	111 .003	

Table 10b. ANOVA Table of Visual- High WMC Group

	df	Mean Square	F	Sig
Between Groups	2	99.408	20.584	.000
Within Groups	111	4.829		

Table 10c. Games-Howell Test of Visual- High WMC Group

(I) HOTS Problem	(J) HOTS Problem	I-J Mean Diff	Std. Error	Sig	Lower Bound	Upper Bound
Verbal	Visual	-2.2632*	0.4835	.000	-3.4220	-1.1043
	Complex	0.8701	0. 5498	.260	-0.4450	2.1851
Visual	Complex	3.1332*	0. 4759	.000	1.9928	4.2737

The Levene test results show that the p-value = .003, which is less than .05 (alpha value) and indicates that the group variances are different, so the Games-Howell test had to be used. Furthermore, from Table 10b (the ANOVA table), the value of F = 20.584 with a value of p = .000 is less than .05. This result shows a difference in the means of the three groups. From Table 10c (Games-Howell test), we found that the p-value for the verbal problems and the complex problems was .260 greater than .05. This finding indicates that the ability to solve HOTS problems in verbal form and complex HOTS problems was the same for the visual-high WMC group. Meanwhile, based on a p-value of less than .05, it was found that this group's ability to solve visual HOTS problems was higher than their ability to solve verbal HOTS problems and complex problems.

Based on the results of the differences in HOTS problem-solving abilities between the groups, it was found that there was no difference in verbal problem-solving abilities between all groups. The neutral group, both low WMC and high WMC, showed no differences in their ability to solve visual or verbal problems. However, this finding was not the case for the visual group. The low WMC group and the high WMC group with a visual learning style had a higher ability to solve visual problems than verbal ones. However, the high WMC group had a higher ability to solve complex problems than the low WMC group.

Description of Some Cases

Analysis of the results revealed that the ability of the visual learning style groups to solve verbal problems that occur were: students had modeled verbal problems incorrectly or represented them in the form of images, the model/representation of the problem was correct, but the purpose of the problem to be solved was not correctly represented, and students could not find an appropriate strategy for the requirements of the problem. From the questionnaire, some students with a visual learning style felt that they sometimes have obstacles in modeling HOTS problems or need more time to understand verbal problems and represent problems visually than when they need to solve visual problems. Figure 3 shows that the visual learning style group uses different models to solve verbal problems. They were given a problem where someone had to cross a rectangular field diagonally with a warehouse in the middle.

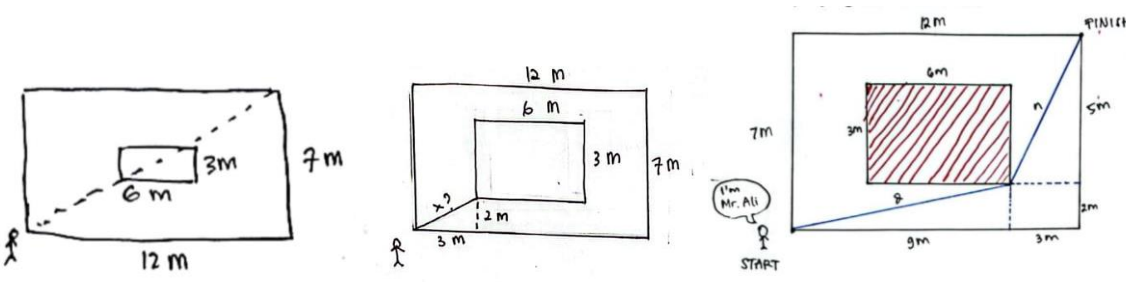

Figure 3. The Model Used by Visual Learning Style Students

Figure 4 shows the results of the visual learning style students when they created 4 triangles with the same area where one side length of each triangle is 2 units.

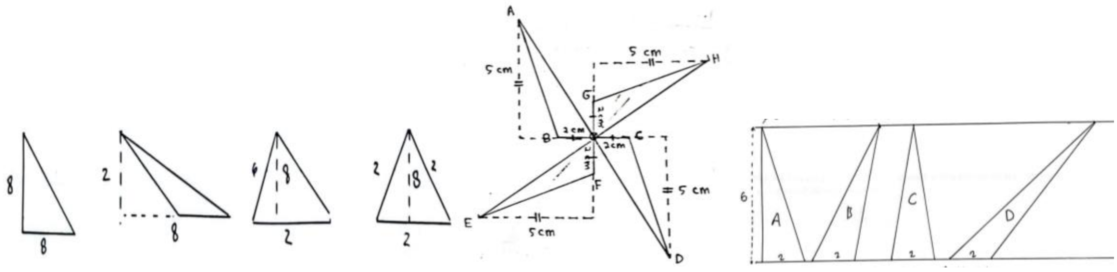

Figure 4. The Problem Solving by Visual Learning Style Students

When solving complex HOTS problems, not many students can solve all complex problems correctly, especially those with a low WMC. The questionnaire revealed that when solving generalization problems, subjects with low WMC could only give a few examples of possible cases but could not make generalizations. When solving complex problems that involve multiple concepts and need to meet certain requirements, students with low WMC had difficulty thinking of solutions to meet some of the requirements of the problem. Most of their results met only one of the requirements and failed to meet the others.

The following figure shows some of the results when solving generalization problems. When two distances between two positions are known from three different positions, students were asked to determine the possible distances from two positions whose distances are unknown.

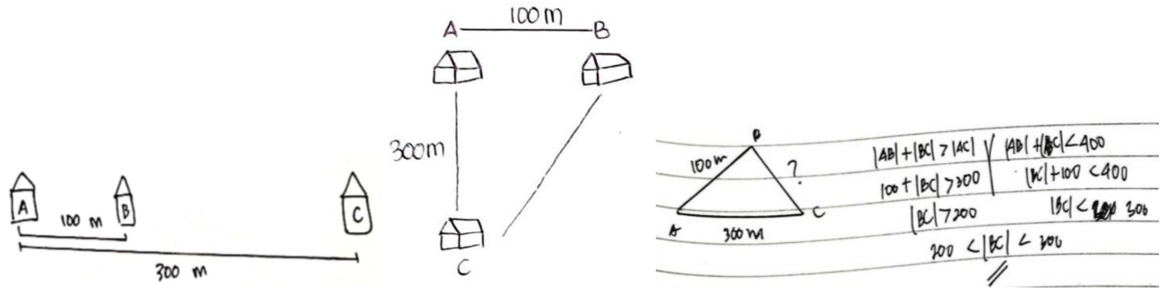

Figure 5. The Generalization Problem Result of Students

Discussion

From the results of the one hundred twenty-six subjects, sixty-seven students (53%) had a visual learning style, fifty-seven students (45%) had a neutral learning style, and only two students (less than 2%) had a verbal learning style. The students with visual learning styles were the majority group, so teachers need to pay attention to students' learning styles when conveying information and preparing math tests in class. Interestingly, this study's percentage of prospective mathematics teachers with a verbal learning style was very low, even though they often study abstract theory mathematics. It could be that this result is due to the rapid development of technology affecting the learning style of those who are more visually inclined. This is because, up until now, most teachers view students as the same and teach regardless of students' differences in learning mathematics.

The learning styles of prospective mathematics teachers affect their ability to solve visual HOTS problems but not their ability to solve verbal HOTS problems or complex HOTS problems. If many students had a verbal learning style, this could affect their ability to solve verbal HOTS problems. The visual learning style groups were more likely to be able to solve problems in visual form than in verbal form, even if it was the same problem. The obstacle for the visual group in solving verbal problems was that it takes time to understand verbal problems and that it is often difficult to model problems. This result aligns with the findings of Juniati and Budayasa (2022a) and Tanudjaya and Doorman (2020). Therefore, an appropriate strategy is needed to optimize the visual group's ability to solve HOTS problems. It is important to design a solution by giving mathematics tests in a form that suits the student's learning style. Also, students with a visual learning style could be trained to model verbal problems faster and more correctly.

WMC affects the ability to solve complex HOTS problems but not non-complex problems. In solving non-complex problems, the abilities of students with low WMC and high WMC were equally good. This result is consistent with Crouzevialle et al. (2015), Oberauer (2019), Palengka et al. (2021, 2022), and Wiley and Jarosz (2012a), who showed that high WMC does not always have a positive influence on problem-solving-because students with high WMC often think and apply complex methods to uncomplicated problems. However, WMC positively influences the ability to solve complex HOTS problems. Students with high WMC can manage more information and maintain attention to the context of problems compared to students with low WMC. Mousavi et al. (2012) and Wiley and Jarosz (2012b) demonstrated that higher WMC may be associated with better performance when dealing with complex cognitive activities. This result is consistent with research showing that high WMC can drive greater attention when implementing complex problem-solving strategies that require many more difficult steps than low WMC (Wiley & Jarosz, 2012a). According to Price et al. (2007), students with low WMC have greater difficulty differentiating information into relevant and irrelevant information when solving complex problems.

Conclusion

The findings showed that subjects' learning styles affected their ability to solve HOTS problems, not complex ones. Visual students' ability to solve HOTS problems would greatly improve if presented visually. On the other hand, the obstacle for visual students in solving verbal problems was adequately modeling the problem in visual form. Subjects' WMC level affected their ability to solve complex HOTS problems, but not non-complex HOTS problems. The obstacle for students with low WMC levels in solving complex HOTS problems was to find a solution that met all the requirements set in the problem. This obstacle was because they could not focus on much information to solve complex problems. Thus, learning style and WMC do not always affect the ability to solve HOTS problems, depending on whether they are complex.

Recommendations

The findings show that more than 50% of research subjects have a visual learning style. Therefore, educators need to pay more attention when determining learning models and strategies that could be used for the different learning styles of students. The ability of visual students to solve HOTS problems would be greatly improved if the problem was changed into a visual form. Therefore, mathematics learning has classically been conducted, assuming all students are the same. Mostly verbal and abstract methods have been used, which provide little visual material for the mathematical concepts and principles to be taught. Therefore, there is a need to examine whether providing different learning strategies for students with a visual learning style using different illustrations, visual forms, and verbal forms for students with a verbal learning style can improve the ability to solve HOTS problems. Meanwhile, we found that students with low WMC had difficulty solving complex HOTS problems because they had difficulty concentrating when there was a large amount of information. Therefore, it is interesting to study whether students with low WMC can solve complex HOTS problems when they are created in levels of complexity.

Limitations

In this study, we did not examine the HOTS problem-solving abilities of groups with verbal learning styles because the number of subjects was insufficient to examine them, namely less than 2% of all subjects. In addition, the investigation of HOTS problem-solving abilities in the visual and verbal learning style groups needs to be conducted on students to obtain complete results and help students with difficulties in learning mathematics.

Acknowledgements

The researchers would like to express their gratitude to Direktorat Jenderal Pendidikan Tinggi, Riset, dan Teknologi, Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia (Directorate General of Higher Education, Research and Technology, Ministry of Education, Culture, Research and Technology of the Republic of Indonesia) for funding the research. This article is one of the results of the 2023 Fundamental Research scheme. Thank you also goes to the reviewers who gave feedback and suggestions.

Funding

This research was funded by Direktorat Jenderal Pendidikan Tinggi, Riset, dan Teknologi, Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia with the grant number: 145/E5/PG.02.00.PL/2023

Authorship Contribution Statement

Juniati: Design, analysis, writing. Budayasa: Conceptualization, design, statistical analysis.

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