



Exploring the Students' Mathematical Communication Ability Related to Learning Style Appertaining to Junior High School

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Article Info	Abstract
Received February 7, 2024	The scarcity of mathematical communication abilities needed attention along with students' learning styles as a personal characteristic causing these abilities to differ. This descriptive study aimed to determine the mathematical communication abilities of students with specific learning styles. Eighth-grade public junior high school students (N=23) in Lembah Gumanti participated in this study to complete a learning style questionnaire and a mathematical communication abilities test. The study found that the visual learning style was most dominant, with the highest percentages in the high and low ability categories, and equal to auditory in the medium category but lower than kinesthetic. Students with a kinesthetic learning style in the low and high ability categories both had the same percentage as students with an auditory. There were strong mathematical communication abilities in the dual learning style of auditory-kinesthetic. Auditory students, regardless of their ability levels, made errors in mathematical symbols, so their communication abilities varied based on understanding and symbol usage. Visual and kinesthetic learners generally excelled in articulating and solving problems. Based on these results, it is recommended that teachers consider students' learning styles to be able to use appropriate models to improve students' mathematical communication abilities.
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INTRODUCTION

Mathematics serves as a symbolic language that allows for fair and accurate communication. According to Astuti (2017), the purpose of learning mathematics is for students to be able to communicate ideas, make conclusions, and synthesize evidence in the form of sentences, complete tables, icons, diagrams, and so on to solve existing problems. Thus, communication abilities are required in mathematics learning to support learning achievement and to convey ideas or concepts related to subjects between teachers and students or between students and other students.

Communication is an important part of teaching mathematics (National Council of Teachers of Mathematics [NCTM], 2000; Widyanti et al., 2021). One of the five process standards highlighted in NCTM is communication. The others are problem solving, arguing and providing, communicating, connecting, and representing. As a result, when learning mathematics, students must have mathematical communication abilities in order to solve problems.

Mathematical communication is the ability to connect and explain one or more ideas using mathematical patterns such as sentences and mathematical equations, graphs and diagrams, and tables (Widyanti et al., 2021). Mathematical communication abilities are important in academic programs that aim to prepare students for the ability to construct and communicate mathematical thinking in English, the language of mathematics, to peers and teachers in a clear and accurate manner. To accomplish all of this, several factors must be carefully considered, one of which is the student's learning style, which will later facilitate and help these students.

According to Hariyanto (2017), students' mathematical communication abilities are still considered weak, particularly in conveying their mathematical ideas, being unable to reason well, understanding a situation, or expressing problems in the form of symbols, diagrams, or mathematical models. Meanwhile, Munawaroh et al. (2018) observes that the mathematical communication abilities of students' oral and written results are still relatively weak. The subject's facts also show that students' mathematical ideas are not properly conveyed when confronted with math problems.

Students' mathematical communication abilities are closely related to students' ability to solve story problems. Solving math problems in the form of word problems is one way to assess mathematical understanding and communication. Pritananda et al. (2016) and Wahyuddin (2017) emphasized that the task of presenting words is one of the tasks for problem solving. Word problems are math problems in which sentences in the form of stories must be converted into mathematical sentences or mathematical equations (Widyaningrum, 2016). Word problems frequently employ commonplace words or phrases in the form of a series of simple and meaningful sentences. Students understand how to solve math problems, including the steps to solving polya problems. The benefit of using polya steps is that students can be cautious when analyzing tasks based on the problem-solving process (Anwar & Amin, 2013). Therefore, at the final stage of Polya, a review of the calculations was carried out, the purpose of which was to find a solution to the problem and validate all data.

Every student has a unique way of comprehending and communicating the same information. According to Wulandari et al. (2014), students' ability to communicate their mathematical ideas is related to how they receive, organize, and process information. A person's learning style refers to how they receive, organize, and process information when learning (Wijayanti et al., 2019). Even if students are in the same school or class, they all have a different learning style, and their ability to communicate mathematical ideas varies. This also refers to how students absorb, process, and manage the information they are given during the learning process. Students' mathematical communication abilities influence students' ability to solve mathematics problems (Kusuma et al., 2020).

Students' learning style influence students' performance (Ramadoni, 2023). According to Syarifah et al. (2017), a person's learning style refers to their ability to absorb, assimilate, and process information. Learning styles are divided into three types: visual, auditory, and kinesthetic. Because visual learners are more likely to use sight to aid learning, they prefer to learn by seeing, observing, and describing things. Students with an auditory learning style use their listening abilities to help them learn. Students who learn actively use more physical parts as learning tools. Research by Sari (2017) supports this, demonstrating that learning styles can have a significant impact on mathematical communication abilities, as students who learn in this style generally have better mathematical communication abilities. Visual, auditory and kinesthetic learning styles affect students' mathematical abilities (Handayani et al., 2023; Ikawati & Kowiyah, 2021).

The Pythagorean material is one of the mathematics subjects taught to junior high school students. The Pythagorean theorem is important to learn because it is a fundamental concept for calculating mathematical concepts and is useful for solving everyday problems (Alghadari & Noor, 2020; Manalu et al., 2020). According to Fajriah and Nor (2017) research on Pythagorean Theorem material, students' mathematical communication is severely lacking in terms of expressing mathematical ideas through writing and visual descriptions. According to Priyanto et al. (2015), students made 43% reading errors, 46% understanding errors, 49% problem transformation errors, 55% procedural skill errors, and 61% final answer writing errors when solving Pythagorean theorem questions. Another mistake made by students was discovered in Hasan et al. (2019) research, which revealed that at the concept stage, the subject made a mistake in drawing a right triangle and finding the hypotenuse, a procedural error in taking roots. Students often make conceptual errors when working on mathematics problems (Ramadoni & Shakinah, 2023). Whereas, Students' conceptual abilities are essential for students' success in learning (Ramadoni & Mustofa, 2022; Ramadoni & Chien, 2023).

RESEARCH METHODS

This study employs a quantitative descriptive approach with the goal of describing students' mathematical communication in solving Pythagorean theorem problems based on student learning styles. A quantitative approach is thought to be capable of explaining events or phenomena in their entirety (Mamik, 2015). The description is carried out through direct observation, specifically analyzing the results of tests administered to research subjects and the results of a learning style questionnaire to classify student learning styles, namely visual, auditory, and kinesthetic, as well as interviews conducted to obtain strong data regarding the results of tests administered to students.

A quantitative research method, according to Sugiyono (2017), is a research method based on the philosophy of positivism that is used to examine the condition of natural objects. This study was carried out in class VIII SMP N 05 Lembah Gumanti from January 19 to January 26 2023, during the even semester of the 2022/2023 Academic Year. The sampling technique used in this study was purposive sampling. Purposive sampling is a technique for selecting respondents to be sampled based on specific criteria (Siregar, 2014). The subjects of the study were eighth-grade students. The subjects were selected based on the scores of many

students who were below the minimum ability criteria limit, namely 60%, as well as recommendations from the class VIII mathematics teacher at SMP N 05 Lembah Gumanti, so they became research subjects. There are 23 students in class VIII of SMP N 05 Lembah Gumanti.

In this study, questionnaires and written tests were used to collect data. The questionnaire used in this study is designed to categorize student learning styles. This questionnaire is written in the form of a statement, making it simple to identify students' learning styles, whether visual, auditory, or kinesthetic.

RESULTS AND DISCUSSION

Data on mathematical communication abilities and student learning styles were obtained as a result of the research. Data on students' mathematical communication abilities were obtained from processing test data, and data on learning styles were obtained from questionnaires and student interviews.

Students Learning Style

Table 1 shows data categories on learning style questionnaire results based on the total score of each visual, auditory, and kinesthetic learning style.

Table 1. Number of students in the learning style category

	Visual	Auditory	Kinesthetic	Auditory-Kinesthetic
Total	11	5	6	1
Percentage	47.83%	21.74%	26.08%	4.35%

According to Table 1, the majority students have visual learning style with 47.83% students, moreover 21.74% students have auditory learning style, furthermore 26.08% have kinesthetic learning style, and some had a dual learning style, specifically the auditory-kinesthetic learning style of 4.35%.

Student Distribution by Communication Abilities and Learning Styles

The mathematical communication ability test was administered. As respondents, 23 students took the test. Table 2 present the distribution of respondents in the categories of learning styles and mathematical communication.

Table 2. Respondents by communication abilities and learning styles

Learning Style	Communication Ability (%)			
	High	Medium	Low	Total
Visual	21.74	4.35	21.74	47.83
Auditory	4.35	4.35	13.04	21.74
Kinesthetic	4.35	8.70	13.04	26.08
Auditory-Kinesthetic	4.35	0	0	4.35
Total	34.78	17.39	47.83	100

Table 2 shows that mathematical communication abilities are based on varied learning styles; each student has a different learning style, and the most dominant was the visual learning style (47.83%), with a higher percentage than other types in the high ability category (21.74%) and low ability category (21.74%), while in the

medium ability category (4.35%), it was not higher than the kinesthetic learning style (8.70%) and was equal to the auditory learning style. Students with a kinesthetic learning style comprised 26.08%, where the low ability category (13.04%) and the high ability category (4.35%) both had the same percentage as students with an auditory learning style. The auditory-kinesthetic learning style had a percentage of 4.35%, and that was with strong mathematical communication abilities. Based on this analysis, it can be concluded that the majority of students had a visual learning style but poor mathematical communication abilities.

Student Ability and Characteristics Analysis

The researcher chose the following research subjects after learning about the students' learning styles and mathematical communication abilities.

Table 3. Research subjects

Students Code	Learning Style	Communication Ability
KZ	Visual	High
RR	Visual	Medium
YD	Auditory	High
FRH	Auditory	Low
MP	Kinesthetic	High
H	Kinesthetic	Medium

High Communication Ability with Visual Characteristics

KZ subjects correctly answered all of the mathematical communication ability test by meeting all of the indicators on the given problem. The questions posed. The results of the mathematical communication abilities test will be analyzed on the KZ subject with the question "If the lengths of the sides of a right triangle are x , 15, and $x+5$, respectively, what is the value of x ?"

Dit
 $a = x$
 $b = 15$
 $c = (x+5)$
 Dit
 Dikar: x
 Jawab
 $a^2 + b^2 = c^2$
 $x^2 + 15^2 = (x+5)^2$
 $x^2 + 225 = (x^2 + 10x + 25)$
 $x^2 + 225 = x^2 + 10x + 25$
 $x^2 - x^2 = 10x + 25 - 225$
 $0 = 10x - 200$
 $10x = 200$
 $x = \frac{200}{10}$
 $x = 20$

Figure 1. The KZ's answer

According to Figure 1, the KZ subject's answers were able to write down complete information about the Pythagorean theorem problem, where students were able to translate the information contained in the problem into the form of a mathematical model. Furthermore, students were able to express ideas or situations in mathematical form and solve them. This is consistent with the report of the study by Rezky et al. (2022) and Ugi et al. (2023).

Medium Communication Ability with Visual Characteristics

The RR subject correctly answered all of the mathematical communication ability test results, but there were errors in the symbols used. The results of the RR subject's mathematical communication ability test will be analyzed as question number 3 with the question: "A child will pick up a kite that is stuck on a wall directly adjacent to a gutter." The child wishes to retrieve the kite by placing the ladder's foot on the river's edge. If the width of the ladder is 9 cm and the length is 15 cm. Determine the height of the walls that meet at the end of the ladder where the kite has become entangled!

Dik = tembok

Dit = tinggi tembok

Jawab = misalkan

$a = 15$

$b = 9 \text{ m}$

$a^2 = b^2 + c^2$

$15^2 = 9^2 + c^2$

$c^2 = 15^2 - 9^2$

$c = \sqrt{15^2 - 9^2}$

$= \sqrt{225 - 81}$

$= \sqrt{144}$

$= 12$

Figure 2. The RR's answer

According to Figure 2, the RR subject can write down known information, where students have been able to translate the information contained in the problem into a mathematical picture but have not been able to make a statement about the picture. Furthermore, students have been able to respond in writing by explaining ideas or situations in mathematical form. With a total score of 21, RR subjects can also write down information using writing, pictures, or other mathematical models. This is consistent with the report of the study by Rezky et al. (2022).

High Communication Ability with Auditory Characteristics

Subject YD correctly answered all of the questions on the mathematical communication ability test, but there were still errors in the symbols used. The results of the mathematical communication ability test on subject YD will be analyzed as question number 2 with the question: "A ship sails from port C to the south towards port A as far as 90m." Then return to the east, towards port B, for another 120m. Determine the shortest distance between ports B and C!"

Diketahui =

Ditanya = jarak BC

Jawab:

$BC^2 = AB^2 + AC^2$

$BC = \sqrt{AB^2 + AC^2}$

$BC = \sqrt{(120m)^2 + (90m)^2}$

$= \sqrt{14400 + 8100}$

$= \sqrt{22500}$

$= 150$

Figure 3. The YD's answer

Figure 3 shows that YD subjects can write down known information using pictures, and that students can translate the information contained in the problem into mathematical pictures and make statements about these pictures. Furthermore, students were able to write down and explain ideas or situations in mathematical form. This is not different from the study report by Nugroho et al. (2021). Besides that, YD can also write down information using writing, pictures, or other mathematical models, but in this problem, YD still makes mistakes in the symbols he uses when solving Pythagorean theorem questions, and his total score is 23, thus these findings differed from the study by Rezky et al. (2022).

Low Communication Ability with Auditory Characteristics

The FRH subject correctly answered all of the mathematical communication ability test results, but there were errors in the symbols used. The results of the FRH subject's mathematical communication ability test will be analyzed as question number 1 with the question: "If the lengths of the sides of a right triangle are x , 15 and $x+15$, respectively, determine the value of x !"

$$\begin{aligned}
 &1. \text{ Diket: misalkan } A = x \\
 &B = 15 \\
 &C = x + 5 \\
 &\text{Ditanya: Nilai } x \\
 &\text{Jawab:} \\
 &A^2 + B^2 = C^2 \\
 &x^2 + 15^2 = (x + 5)^2 \\
 &x^2 + 225 = x^2 + 10x + 25 \\
 &10x = 225 - 225 \\
 &10x = -200 \quad x = -20
 \end{aligned}$$

Figure 4. The FRH's answer

Figure 4 shows that FRH subjects can write down known information using examples to help them solve problems involving the Pythagorean theorem. Students were able to translate the problem's information into the form of a mathematical model. This is not different from the study report by Nugroho et al. (2021) and it was in contrast to the findings in the study by Rezky et al. (2022). Furthermore, students were able to write down and explain ideas or situations in mathematical form. With a total score of 23, FRH subjects continue to make errors in the symbols used when solving Pythagorean theorem questions.

High Communication Ability with Kinesthetic Characteristics

The MP subject correctly answered all of the mathematical communication ability test results. The results of the mathematical communication ability test, which will be analyzed on MP subjects, are question number one, with the question: "If the lengths of the sides of a right triangle are x , 15, and $x+15$, determine the value of x !"

Diket : Panjang sisi segitiga berturut-turut
 x , 15 dan $x + 5$,

Ditanya : nilai x

A = x
 B = 15
 C = $x + 5$

$$A^2 + B^2 = C^2$$

$$x^2 + 15^2 = (x + 5)^2$$

$$x^2 + 225 = (x + 5)(x + 5)$$

$$= x^2 + 225 = x^2 + 5x + 5x + 25$$

$$= x^2 + 225 = x^2 + 10x + 25$$

$$x^2 + 225 - x^2 = 10x + 25 - 25$$

$$200 - 10x = 0$$

$$-10x = -200$$

$$x = \frac{-200}{-10}$$

$$= 20$$

Figure 5. The MP's answer

Figure 5 shows that the MP subject can write down the known information by using an example to make solving problems involving the Pythagorean theorem easier. Furthermore, with a total score of 28, students were able to explain ideas or situations in written mathematical form. Such student abilities were also revealed in the findings of the studies by Rezky et al. (2022) and Abdillah et al. (2022).

Medium Communication Ability with Kinesthetic Characteristics

Subject H only responded to one result of the mathematical communication ability test by drawing pictures and writing captions on them. The results of the mathematical communication ability test that will be analyzed on subject H are question number 1 with the question: "If the lengths of the sides of a right triangle are x , 15, and $x+15$, calculate the value of x !"

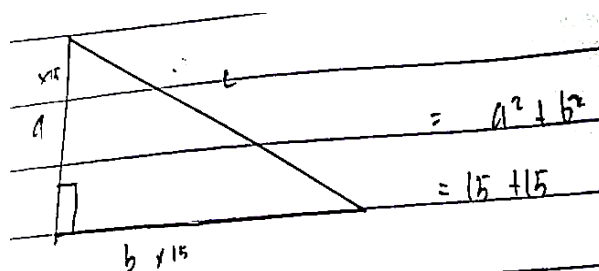


Figure 6. The H's answer

Figure 6 shows that subject H only took pictures and did not answer question number 1. As a result, the only ability fulfilled is the ability to express situations using mathematical writing and images on the Pythagorean theorem problem. Subject H did not work on questions 2 and 3, so his total score was 2. He only met the indicators of expressing situations using writing, pictures, or other mathematical models, as also stated by Rezky et al. (2022).

CONCLUSION

In accordance with research findings, the majority of students were in the visual learning style (47.83%), with a higher percentage than other types in the high

mathematical communication ability category (21.74%) and low ability category (21.74%), while in the medium ability category (4.35%), it was not higher than the kinesthetic learning style (8.70%) and was equal to the auditory learning style. Students with a kinesthetic learning style comprised 26.08%, where the low ability category (13.04%) and the high ability category (4.35%) both had the same percentage as students with an auditory learning style. Additionally, the auditory-kinesthetic learning style had a percentage of 4.35%, and that was with strong mathematical communication abilities. This study revealed that auditory students in both the high and low ability categories made errors in the symbols they used in the solving process. Students with an auditory learning style exhibited variations in mathematical communication skills, depending on the level of understanding and the use of mathematical symbols. Students with visual and kinesthetic learning styles generally demonstrated better abilities in articulating and solving problems.

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