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Exploration Mathematical Communication Skills: A Comprehensive Analysis of Students' HOTS Problem-Solving Based on Learning Styles

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Abstract

This research explores students' mathematical communication skills in solving Higher Order Thinking Skill (HOTS) problems, considering visual, auditory, and kinesthetic learning styles. The study aims to describe students' mathematical communication abilities and understand how learning styles influence these capabilities. A qualitative descriptive research method was employed, involving second-semester seventh-grade students at MTs Negeri 1 Pacitan. Data collection comprised learning style questionnaires, mathematical communication skills tests, and interviews. Results indicate that students with visual learning styles effectively conveyed situations and explained problem-solving strategies but lacked precision in validating arguments. Auditory learners demonstrated proficiency in all four indicators of mathematical communication skills, including argument validation. Kinesthetic learners, while capable of stating situations, encountered difficulties in elucidating problem-solving strategies and did not engage in argument validation.

1. Introduction

Mathematics is a scientific discipline focusing on comprehending concepts, solving problems, and communicating solutions. This is in line with the opinion Baroody (1993) that mathematics is not only a tool that helps think, identify patterns, or solve problems, but is also an invaluable tool in communicating ideas clearly, accurately, and concisely. Mathematical communication plays an important role in developing students' understanding, because through the communication process, they can express and sharpen their thinking about mathematics. Mathematical communication skills provide opportunities for students to solve a mathematical problem through mathematical ideas, language, and symbols (Astuti & Leonard, 2015). This not only helps students strengthen their understanding, but also allows them to interact and collaborate with classmates and teachers in solving math problems together.

Based on Regulation of the Minister of Education and Culture number 21 of 2016, one of the objectives of mathematics subjects is that students are expected to have the competence to communicate through clear mathematical ideas. Communication skills are very important for students to have so that students can understand the mathematical problems given and students are able to express ideas and ideas in solving mathematical problems and create students to think critically, logically, creatively and independently (Rahmawati et al., 2019).

In addition, mathematical communication skills have an important role in mathematics learning as Clark argues in (Asikin & Junaedi, 2013), namely (1) A means to explore mathematical ideas and improve students' ability to see various relationships in mathematical material, (2) Tools to measure the development of understanding and reflect on students' understanding of mathematics, (3) Tools to regulate students' mathematical thinking, and (4) Means to build mathematical knowledge, develop problem-solving skills,

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improve reasoning, increase self-confidence, and improve social skills. Furthermore, mathematical communication also plays a role in determining student learning outcomes, this is in accordance with research Arimurti & Setyaningsih (2017) which shows that student mathematics communication has a contribution to student learning outcomes where the better student mathematics communication, the better learning outcomes.

From the explanation above, it shows that the importance of mathematical communication skills that must be possessed by students when learning mathematics. But in fact, students' mathematical communication skills are still quite concerning. This is in accordance with some researches that junior high school students have low mathematical communication skills, as seen from the total percentage of their achievements that are in the low category (Khusnudin & Bharata, 2022; Nurlaila et al., 2018; Pertiwi et al., 2021; Wijayanto et al., 2018). This condition is supported by the results of preliminary research conducted by researchers at MTs Negeri 1 Pacitan. From the results of this preliminary research, it shows that students have not been able to make a definition and provide arguments in their own words or language, students have not been able to convey everyday events in mathematical symbols, students have not been able to convey their mathematical ideas through writing in the form of real objects or pictures.

Indicators of mathematical communication skills in mathematics learning include: 1) Expressing situations, images, diagrams or real objects into language, symbols, ideas, or mathematical models. 2) Explain an idea, situation or mathematical relation through pictures. 3) Present solutions to mathematical problems in detail and correctly. 4) Check the validity of an argument (Nofrianto et al., 2017). Meanwhile, based on Ramellan's opinion (Anggraini, 2018) said that indicators of mathematical communication skills are: 1) Expressing language or mathematical symbols into an image. 2) Explain the strategy of solving a mathematical problem. 3) Check the validity of an argument. 4) Present solutions to problems in detail and correctly.

One way to find out students' mathematical communication skills can be through problems with the Higher Order Thinking Skill (HOTS) approach. Newman and Wehlage (Hamidah, 2018) stated that higher order thinking skills (HOTS) have a significant role in supporting students' academic achievement. Through HOTS, students can be effective in solving problems, sorting ideas and opinions, formulating hypotheses, presenting arguments wisely, and overcoming complex situations. The use of questions containing HOTS not only requires memorization of information, but also trains higher-order thinking skills, including students' ability to analyze, evaluate, and create. Therefore, it is very important to train students' abilities so that they not only remember but also be able to implement them on new problems.

Every individual has a unique way of processing and remembering information, and this can influence in communicating about mathematical concepts that we commonly call learning styles. Student learning style is an important factor in addition to the application of the use of HOTS questions. According to De Porter & Hernacki (Sundayana, 2018) the diversity of learning styles in students can be grouped into three types, namely visual, auditorial, and kinesthetic learning styles. Understanding of student learning styles is the main consideration for mathematics teachers in designing learning strategies. Given the diversity of learning styles, teachers need to analyze these variations to obtain information that supports a deeper understanding of differences in the classroom. Thus, teachers can carry out appropriate learning and have significance for each student.

From the preliminary presentation, the researcher intends to combine elements of mathematical communication skills and student learning styles in a study. More teacher knowledge of students' ability to learn in class when solving math problems has more potential to prepare learning and prepare students to be more productive in learning mathematics in the future. The indicators of mathematical communication in the research we use include: (1) Stating situations, images, diagrams or real objects into language, symbols, ideas, or mathematical models (2) Explaining strategies for solving a mathematical problem. (3) Present the solution to the problem in detail and correctly (4) Check the validity of an argument.

Based on this description, this study aims to describe mathematical communication skills in solving Higher Order Thinking Skill (HOTS) problems in terms of student learning styles. The results of the study are expected to provide information as an inspirational preliminary study for teachers in developing students' mathematical communication through mathematics learning.

2. Methods

This type of research is descriptive research using a qualitative approach. The subject of this study was a grade VII student in semester 2 MTs Negeri 1 Pacitan. Data collection techniques use questionnaires, tests, and interviews. Questionnaires are used to determine the level of student learning styles, tests are used to determine students' mathematical communication skills and interviews are used to ask for confirmation of test answer results. The data analysis process involves collecting raw data through field notes, recordings, and documents, followed by data reduction to maintain relevance and focus on problem-solving, culminating in drawing conclusions through a review and comparison of the data to address the research problem formulation (Hardani et al., 2020). The validation test of the data results in this research analysis is using triangulation techniques, namely describing students' mathematical communication skills using tests and then checked with interviews.

3. Results & Discussions

Based on the results of the class VII learning style questionnaire, students were grouped into three groups, namely students with visual, auditory, and kinesthetic learning style types. This learning style questionnaire was filled out by 89 students, the following are the results of filling out the student learning style questionnaire.

Table 1. Research Subject Data

No	Learning Style	Students
1	Visual	30
2	Auditorial	30
3	Kinesthetic	29

From the grouping results from Table 1. The above is then carried out the determination of the subject. Determination of research subjects for each learning style group by looking at the learning style scores of students who have the highest scores and on the recommendation of the teaching teacher for students who are considered capable of solving HOTS problems as follows.

Table 2. Research Subject Data

No	Student	Student Code	Learning Style
1	HN	SV	Visual
2	ZS	SA	Auditorial
3	SW	SK	Kinesthetic

Based on Table 2 above, the selected subjects will be analyzed for the results of mathematical communication skills test answers on each learning style and gender. Analysis of students' mathematical communication skills, based on test results on HOTS questions, as well as in-depth interviews. The HOTS questions given to students consist of one question which contains two sub-questions as follows.

Mother has a steaming pot with a cone-shaped lid, with a diameter of 28 cm and an overall height (pot and lid) of 25 cm. Mother wants to steam a tubular cake with a height of 7 cm and a diameter of 4 cm. It is known that the height of the lid of the pan is 4 cm, if one third of the pan is filled with water, then determine:

a. Illustrate an image of a steaming pot filled with water before the cake is put into the pan
b. Count the number of cakes that you can steam in one cook (arrange the steps to complete it)

The results of student answers and interviews will be presented based on indicators of students' mathematical communication skills as follows.

3.1. Indicator 1: Expressing a situation, image, diagram or tangible object into language, symbols, ideas or mathematical models.

In this indicator, students are expected to be able to describe the shape of the pot and lid, as well as the height and diameter that have been known using mathematical symbols (numbers).

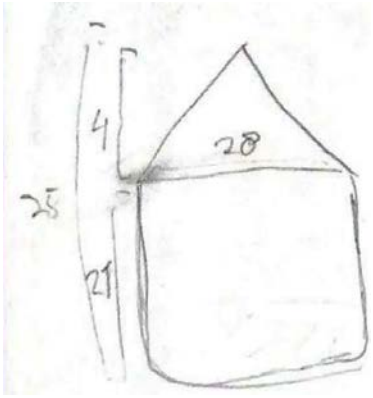

Figure 1. Visual Student Answers to Indicator 1

Based on Figure 1, the SV subject illustrates the pot and lid according to the description on the problem. SV also writes down numbers that represent the height of the known part of the problem. However, SV has not described the water contained in the pot and the illustration of the pot is still two-dimensional.

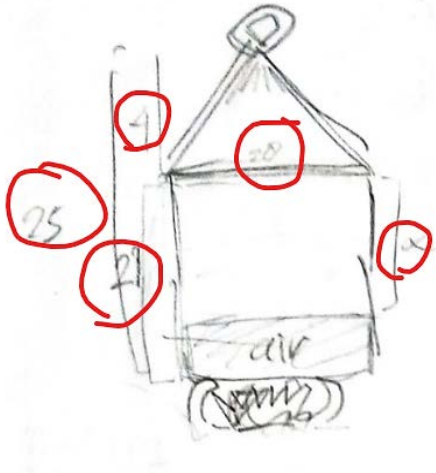

Figure 2. Auditory Student Answers to Indicator 1

Based on the above answer, it can be seen that the subject of SA can describe the pot and lid according to the description of the question. Students illustrate small things such as the hook on the lid of the pot, the water in the pot, even the stove at the bottom of the pot. In addition, students also symbolize the height of the tube, the height of the overall pot, and the height of the pot without water (x). However, as with SV subjects, the three-dimensional shape of the tube and cone is yet to be seen. As for the Kinesthetic Student answers as follows:

Figure 3. Kinesthetic Student Answers to Indicator 1

3.2. Indicator 2: Explain the strategy for solving a mathematical problem

In this indicator, students are expected to be able to explain the steps of solving problems orally through interviews. Based on the results of interviews with subjects, SV was able to explain problem solving strategies as follows:

Researcher : After reading the problem, what is the plan or strategy in solving the problem in the problem?

SV : Picture the pot and lid first, pay attention to known fingers, and what is being asked. Next draw the pot and lid. After that calculate the volume of the pan and divide it by three. Then look for the volume of the cake. And finally, divide the volume of the pan and the volume of the cake.

Based on the results of interviews with subjects, SA was able to explain the following problem-solving strategies.

Researcher : After reading the problem, what is the plan or strategy in solving the problem in the problem?

SA : Sketch the pot and lid, the water in the pot, then write the height and diameter. Write the formula to use. Then find the volume of the pot that has not been filled with water, because the water is filled by one-third, the volume of the pot was divided by three. Because what is asked is the volume of the pot that has been filled with water, so multiplied by two. After that find the volume of the cake, and divide the volume of the pan by the volume of the cake.

Based on the results of interviews with SK subjects, it was found that SK could not explain the following problem-solving strategies.

Researcher : After reading the problem, what is the plan or strategy in solving the problem in the problem?

SK : Find the volume of the cake, then find the volume of the pan. Because I was confused, then I just divided it according to the feeling. So get the result of 88 cookies.

3.3. Indicator 3: Present solutions to mathematical problems in detail and correctly

In this indicator, students are expected to be able to solve a problem using mathematical concepts that are written in detail and correctly.

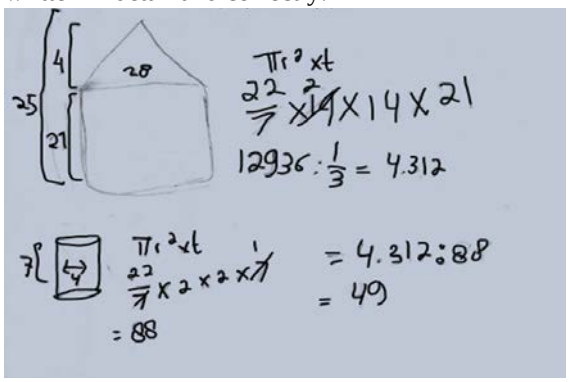

Figure 4. Visual Student Answers to Indicator 3

According to the answer provided by the SV subject, the first step after drawing the pan illustration is to note down the volume formula. The SV subject calculates the pan's volume and divides it by one-third. However, there was a typographical error in the interview and the correct meaning of 12.936: 1/3 is 12.936: 3, which produces 4.312. The next step for SV subjects is to calculate the volume of the cake, which is 88. To determine how many cakes can fill 2/3 of the pan, subject SV divides 4.312 by 88, resulting in 49 cakes.

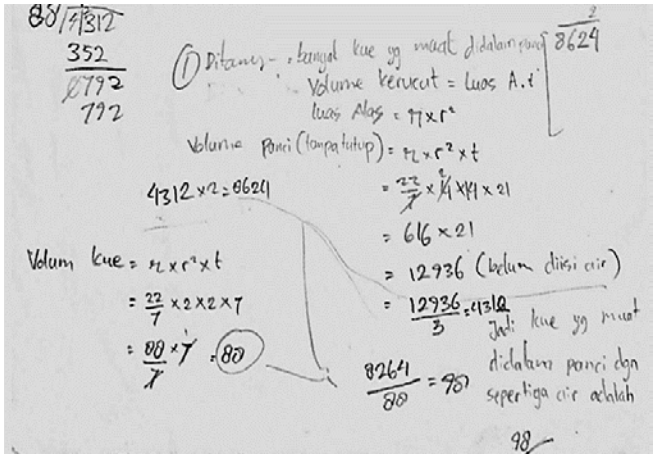

Figure 5. Auditorial Student Answers to Indicator 3

Based on the answers of the SA subject, the first thing to do is to write down the questions and formulas to be used. Next SA finds the volume of the pan without a lid using the tube volume formula which yields 12.936. SA emphasizes that the result is the volume of the pan when it has not been filled with water. Therefore, to find the part filled with water, SA divides 12.936 by 3 which gives 4.312. To find the volume in the part filled with the cake, SA multiplies 4.312 by 2 which is 8.624. The next step is for SA to find the volume of the cake using the tube volume formula which is 88. This result is further divided by 8.264 resulting in 98 pieces of cake.

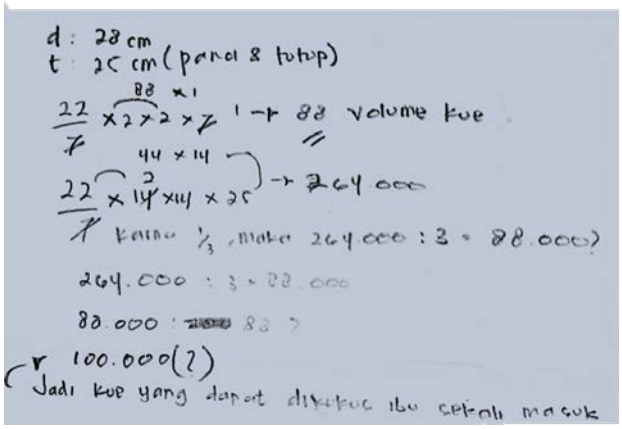

Figure 6. Kinesthetic Student Answers to Indicator 3

Based on the answer of the subject of the decree, the first thing to do is to write down the known diameter and height in the problem. Next, SK calculates the volume of the cake using the tube volume formula so that it produces 88. Then, SK calculated the volume of the pan also using the formula of the volume of the tube with a radius of 14 cm and a height of 25 cm which resulted in 264.000. Since one-third of the pan is filled with water, divide the pan's volume by 3, which is 264,000 divided by 3, resulting in 88,000. Finally, divide 88,000 by 100,000 to get 88 pieces of cake.

3.4. Indicator 4: Checking the validity of an argument

In this indicator, students are expected to be able to re-examine the answer to a problem. Based on the observations, SV subjects examined the final answer. However, the subject looks rushed and only skims. This is also in accordance with the results of interviews with SV subjects obtained as follows:

Researcher : When you're done, do you double-check your answers?
SV : Yes, I did that miss.

Regarding SA, the individual in question thoroughly reviewed their work from beginning to end after completing it. During this review, they discovered a miscalculation and promptly corrected it, ultimately arriving at the correct answer. This practice of reviewing work is consistent with feedback from interviews with SA subjects, who always double-checked their work when finished. On the other hand, SK subjects

struggle to complete the questions accurately. As a result, SK did not review their work after writing the answer, leading to potential errors.

3.5. Discussion

Based on Figure 1, SV has successfully conveyed a situation, image, diagram, or real object into language, symbols, ideas, or mathematical models. In other words, it can be interpreted that SV fulfills Indicator 1 of mathematical communication skills. This is evident from the results of SV's diagram, which has effectively represented a mathematical problem or question. Anintya (2017) also explains that students who have a visual learning style have the ability to describe shapes that are in accordance with the illustration of the problem, as well as provide information about its size. As for Indicator 2 SV can also explain how strategies and steps to solve problems verbally, even though the final results obtained are not quite right. This is in line with research Wijayanti (2019) that orally and in writing, subjects with a visual learning style can explain the process of solving problems from beginning to end, but calculations produce incorrect answers.

Based on Figure 4, SV has written the steps for problem-solving; however, there are still errors in the calculations. Therefore, it can be inferred that the SV subject has not yet fulfilled Indicator 3, which involves presenting a solution to a problem. This is in accordance with research Islamiati (2018) that subjects with a visual learning style can plan and write down problem-solving steps, but there are subjects who make mistakes. After finishing writing down the problem-solving steps, the SV subject re-examines his work. But even though SV has double-checked, there are still errors in the work on the questions. This indicates that the SV subject does not meet Indicator 4 of mathematical communication skills, which involves verifying the validity of an argument. Sayuri (2020) in their research also said that students who use a visual learning approach check the truth of their work, but have not been able to present evidence showing that the solution provided is the expected solution.

The results of the work of the SA subject for Indicator 1 show that the SA can describe and illustrate the problems in the problem well. This can be seen in Figure 2 where the visualization of the pot and lid as well as their size are clearly written. Thus, it can be interpreted that SA meets indicator 1 of mathematical communication ability. Subjects with auditory learning styles can express real situations, images, diagrams or objects into language, symbols, ideas or mathematical models (Aliffianti et al., 2022; Anintya et al., 2017; Nugroho et al., 2021; Rosita et al., 2020). In Indicator 2, the subject of SA is able to explain the steps of solving mathematical problems correctly and in detail orally. Students with auditorial learning styles tend to express mathematical understanding through words and detailed oral explanations and apply the steps of completion better (Febriyanti & Pujiastuti, 2020).

Based on Figure 5, it can be seen that the subject of SA wrote down the problem solution in sequence and produced the correct final answer. This means that SA has fulfilled Indicator 3, which presents solutions to mathematical problems in detail and correctly. The observations and interviews also reinforce this statement, where SA has no significant difficulty in solving problems so that it can answer correctly. This condition is in accordance with research Nugroho (2021) that students with auditorial learning styles can solve problems to completion without any errors. After finishing working on the questions, based on the results of observations and interviews, SA checked his work. This is where SA finds errors and corrects them resulting in the correct answer. This implies that SA fulfills Indicator 4, which involves examining the validity of an argument. Subjects with auditorial learning styles always check back the results of their work (Jagom et al., 2021; Marwiyah et al., 2020).

Based on Figure 3, it can be seen that the SK subject can already visualize the image according to the problem. However, SK does not provide the pot's measurements and lid's measurements to facilitate problem-solving. This implies that the SK subject does not meet Indicator 1 in mathematical communication skills. Subjects with a kinesthetic learning style still have difficulty expressing situations in images (Nugroho et al., 2021; Rosita et al., 2020). Based on the results of observations and interviews, SK subjects could not meet Indicator 2 because SK could not explain how the steps were resolved in order orally. This is because SK finds it challenging to understand the problems in HOTS-based questions (Hartini & Setyaningsih, 2022; Wijayadi et al., 2021).

The results of the SK work for Indicator 3, shown in Figure 6, indicate that the SK needs to be able to solve the problem in detail and correctly. SK can already write the formula correctly but needs help understanding the meaning of the problem. In writing down the solution, SK only uses feelings without knowing the reason for solving the problem (Syarifah et al., 2017). For Indicator 4, students with a

kinesthetic learning style should have reviewed their work as they may have experienced difficulty in solving the questions. Therefore, such students fail to meet Indicator 4 of mathematical communication skills. Kinesthetic learners tend to be less attentive in solving and reading problems, which can lead to incorrect solutions. (Suyandi et al., 2022).

4. Conclusion

After conducting research and discussions, we have concluded that students with visual learning styles can achieve two out of four indicators of mathematical communication skills. These indicators include stating situations, images, diagrams, or actual objects into language, symbols, ideas, or mathematical models and explaining mathematical problem-solving strategies. On the other hand, students with auditory learning styles can meet all four indicators of mathematical communication skills. These indicators include expressing situations, images, diagrams, or actual objects into language, symbols, ideas, or mathematical models; explaining strategies for solving a mathematical problem; presenting solutions to problems in detail and correctly; and checking the validity of an argument. However, students with kinesthetic learning styles cannot meet the four indicators of mathematical communication skills, as they struggle to understand problems based on HOTS.

As per the suggestions from this study, teachers should be able to identify the learning styles of their students so that they can teach in a way that aligns with the students' habits. Furthermore, students should practice their mathematical communication skills, as they play a crucial role in understanding the material delivered by the teacher. This, in turn, affects the results of learning mathematics. For researchers who will conduct research using the same variables, it is recommended that they develop more innovative and varied approaches.

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