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Analysis of Mathematical Communication Skills of Grade VIII Students in Solving Statistical Problems Based on Learning Style

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***Abstract*— Mathematical communication skills are very important for students' success in understanding and solving mathematical problems. However, this ability can be affected by a variety of factors, including the student's learning style. This study aims to analyze the mathematical communication skills of grade VIII students in solving statistical problems based on students' learning styles. This study uses a qualitative descriptive method, with 36 students and three students from Class VIII D at SMPN 7 Cirebon City, each representing a different dominant learning style: visual, auditory, and kinesthetic. Data were collected through learning style questionnaires, written tests, observations, interviews, and documentation. The results of the study revealed that students with visual learning styles met all indicators, students with auditory learning styles met three out of four indicators, while students with kinesthetic learning styles only met two indicators. These findings suggest that students' mathematical communication abilities vary depending on their learning style, with visual and auditory learners showing stronger mathematical communication abilities compared to kinesthetic learners. The implications of these results emphasize the need for different teaching strategies to accommodate different learning styles in mathematics learning. By addressing these differences, educators can further support the development of mathematical communication skills across different learning styles of students, ultimately improving academic performance and overall mathematical comprehension.**

Keywords— ***Learning Style; Mathematical and qualitative communication skills; statistics; Qualitative Research***

I. INTRODUCTION

Paper reveal the contribution of the research. Revealed the relevance of the theory to the context of the research. Revealed relevant previous research. State the objective or importance of the research. Background presents issues related to the research focus. Presented novelty explicitly and had a significant impact on the practice and development of the topic under study. Mathematics is one of the disciplines that is the basis for the development of knowledge in various other fields, not just arithmetic. Mathematics also plays an important role in training critical, logical, and systematic thinking skills. Mathematics is a very important subject in supporting human life [1]. Mathematics is studied in the world of education because mathematics plays a very important role in all areas of life [2]. Therefore, Mathematics has a very important role in various disciplines and advances human thinking [3]. Regulation of the Minister of National Education of the Republic of Indonesia Number 20 of 2006 concerning Content Standards emphasizes that one of the main objectives of mathematics learning is to develop students' ability to communicate mathematical ideas through the use of symbols, tables, and diagrams that can clarify concepts and solve problems. Research conducted by [4] that in the United States supports the importance of mathematical communication as a tool to deepen conceptual understanding, where learners who engage in active mathematical discussions demonstrate better understanding and stronger problem-solving skills.

However, the reality on the ground is often different from these ideal goals, many studies show that the mathematical communication skills of students in Indonesia are still at an unsatisfactory level. However, the reality in the field shows that students' mathematical communication skills are still low

[5] [6]. The low mathematical communication ability of students is caused by students' negative views on mathematics [7]. According to [8] found that most students do not pay enough attention to the importance of recording information, solving steps, or explanations in the process of solving mathematical problems. They tend to consider it unimportant, so their mathematical communication skills are hampered.

Mathematical communication skills, as described by the National Council of Teachers of Mathematics [9], include the ability of learners to express mathematical ideas clearly and coherently, both orally and in writing. In addition, this ability also includes skills in reading, interpreting, and evaluating mathematical ideas presented by others [10]. Mathematical communication is one of the abilities in which students are challenged to understand mathematical ideas and symbols and convey the results to others both verbally and in writing [11]. In other words, mathematical communication is not just about answering problems, but also about how learners can describe their thought processes and defend mathematical arguments effectively [12]. [13] mathematical communication skills are also important in the context of daily learning, where students must be able to discuss, explain their ideas, and use visual aids such as images, graphs, and tables to convey their understanding.

In the context of educational research, mathematical communication skills are often the focus because they are one of the competencies that are needed by students. Without this ability, students will have difficulty understanding and solving complex mathematical problems. [14] adds that a math problem can be considered a problem if the learner does not have an idea of how to solve it, but still has a strong desire to find a solution. This is in line with the view [15], which shows that learners with good mathematical communication skills tend to be more successful in articulating their understanding and more effective in solving complex statistical problems. Thus, mathematical communication skills are an important element in supporting students to gain a conceptual understanding of mathematics. In addition, research by [16] shows that mathematical communication can take the form of verbal and written responses to the material and activities given to learners which will provide them with greater opportunities to strengthen their understanding of complex mathematical concepts. In this case, mathematical communication skills are key to assisting learners in explaining solution steps, identifying problems, and evaluating and articulating solutions they find.

In addition, mathematical communication skills are also influenced by various factors, both from within students (internal factors) and from the surrounding environment (external factors). One of the factors that is quite significant is the learning style. Learning style, [17], refers to the way individuals absorb, process, and apply information. Each learner's learning style can be different, and these differences can affect how they interact with the subject matter, including math. [18] classify learning styles into three main categories: visual, auditory, and kinesthetic. Students with a visual learning style tend to understand information conveyed visually, such as through diagrams or graphs. Students with auditory learning styles are better at understanding information conveyed orally or through discussions, while students with kinesthetic learning styles are more comfortable learning through physical activity and hands-on experience. The research conducted [19] also shows that learning styles affect students' ability to understand and communicate mathematical concepts. Learners with a kinesthetic learning style, for example, tend to be more active in learning that involves practicum or simulation activities, which allows them to internalize mathematical concepts through hands-on experience. In research conducted by [20] said that students with a kinesthetic learning style use physical and movement during the learning process, they tend to have bad writing but always learn through practice and cannot sit still for a long time. This is supported by the opinion [21] that kinesthetic learners will find it difficult to focus if they sit still for a long time during learning.

In this study, the author seeks to explore how learning styles affect students' mathematical communication skills. This research is important because knowing the mathematical communication skills of students based on different learning styles can provide new insights into how learning strategies can be adapted to different learning styles, so as to improve the effectiveness of mathematics learning in schools. This study uses indicators adapted to measure students' mathematical communication skills, both written and oral, in accordance with research needs and refers to the NCTM indicators listed in Table I.

TABLE I. INDICATORS OF MATHEMATICAL COMMUNICATION ABILITY (ARNANDA ET AL., 2021)

No	Indicator NCTM	Indicator description	
		Written Communication	Oral Communication
1.	Ability to express mathematical ideas through oral, written, and demonstrate them and illustrate them visually.	Express mathematical ideas by writing down the information that exists in the problem by writing down what is known and asked	Expressing mathematical ideas by mentioning the information that exists in the problem by mentioning what is known and asked
2.	Ability to understand, interpret, and evaluate mathematical ideas both verbally and in other visual forms	Understand and interpret ideas by writing down strategies and solution steps in a coherent and systematic manner	Explain strategies and steps to solve problems in a concise and systematic manner
		Evaluate ideas by writing conclusions at the end of the problem solving	Evaluate ideas by expressing conclusions at the end of problem solving
3.	Ability to use terms, mathematical notations and their structures to present ideas, describe relationships and model situations	Using mathematical symbols in writing down problem solving	Revealing the use of mathematical symbols in problem solving

Several studies show that students who learn according to their learning style tend to show better and more varied mathematical communication skills [22] In a study conducted by [23] it was found that students with visual learning styles can meet three of the four indicators of mathematical communication skills, while students with auditory and kinesthetic learning styles are only meet two indicators.

This research is important considering the low mathematical communication skills of students in Indonesia, especially in solving statistical problems. By understanding the relationship between learning styles and mathematical communication skills as well as differences in the way students process information, their mathematical communication skills also vary, therefore this study aims to analyze the mathematical communication skills of grade VIII students in solving statistical problems based on visual, auditory, and kinesthetic learning styles. This research is focused on students of class VIII D SMPN 7 Cirebon City who have studied statistical material before, so as to facilitate research in describing students' mathematical communication skills with visual, auditory, and kinesthetic learning styles.

II. METHOD

This research uses a qualitative approach and this type of research is descriptive research. The subject of this study is 36 students of class VIII D SMPN 7 Cirebon City where 3 students were selected as a sample who have a dominance of different learning styles, namely visual, audiotory, and kinesthetic learning styles. The first step is to determine the subject of the research. The researcher identified the learning styles of students in class VIII D SMPN 7 Cirebon City. From all students in class VIII D who have been given a learning style diagnostic test, 3 students are randomly selected with different learning styles.

The data collection method was carried out using questionnaires or learning style questionnaires, communication ability tests, observations, interviews, and documentation. The data analysis used in this study consists of two types. First, the analysis of students' learning styles, Second, the analysis of students' mathematical communication skills in solving mathematical problems.

III. RESULTS AND DISCUSSION

A test of mathematical communication ability with statistical problems is given to research subjects to complete. The results of the study showed that students who had visual and audiophile learning styles were able to meet 3 out of 4 indicators of mathematical communication skills. Meanwhile, students with kinesthetic learning styles are able to meet 2 of all indicators.

1. Learning Style Diagnostic Test Sheet Results

Data collection was carried out by providing learning style diagnostic test sheets to 36 students in class VIII D SMPN 7 Cirebon City. Furthermore, they are categorized according to their respective learning styles. The following is a circular diagram of the results of the diagnostic test sheet for the learning style of students in grade VIII D SMPN 7 Cirebon City.

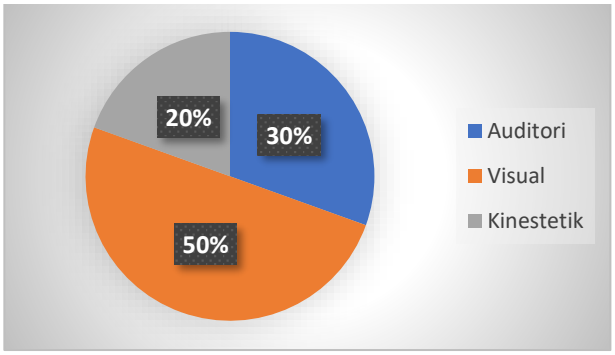

Diagram I. presentase hasil tes diagnostic gaya belajar peserta didik

Based on Figure 1, the percentage of results of the diagnostic test of students' learning styles shows that kinesthetic learning styles are the dominant learning styles in grade VIII D. Detailed data shows that the percentage of auditory learning styles is 30.5% with 11 students, the percentage of visual learning styles is 50% with 18 students, and the percentage of kinesthetic learning styles is 19.5% with 7 students, as shown in the table below.

TABLE II. RESULTS OF THE DIAGNOSTIC TEST OF LEARNING STYLES OF CLASS VIIID STUDENTS

Learning Style	Class VIII D	Percentage	Code
Auditory	11	30,5%	PDA
Visual	18	50%	PDV
Kinesthetics	7	19,5%	PDK
Sum	36	100%	

Based on Table 2, it can be seen that the auditory learning style is 30.5%, visual 50%, and kinesthetic is only 19.5%. Students were randomly selected as research subjects as many as 3 students with PDA (auditory students), PDV (visual students), and PDK (kinesthetic students) coding.

2. Analysis of mathematical communication skills in solving statistical problems.

a. Mathematical communication skills based on auditory subjects

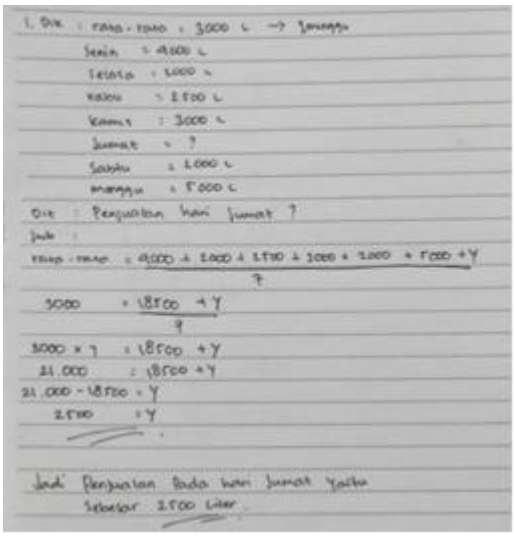

Figure 1. Answer to question no.1 auditory subject

In Figure 1, it can be seen that auditory subjects are subjects with PDA codes in solving problem number 1 In the first indicator, students are able to express mathematical ideas by writing down the information that exists in the problem by writing down what is known and asked. At the stage of understanding, PDA has been able to interpret ideas by writing strategies and solution steps in a sequential and systematic manner. PDA is not only able to read the problems contained in the questions, but also has been able to know what problems must be solved and PDAs write down what is known and asked. This is in line with the discovery [24] that auditorial learners are able to understand problems such as explaining what is known, mentioning what is asked and being able to connect what is asked with what is known. At the stage of evaluating, PDA has been able to evaluate ideas by writing conclusions. Meanwhile, at the stage of using PDA symbols, they are not able to use mathematical symbols in solving problems. This shows that the subject is less able to carry out written communication in the third indicator correctly. Based on the results of the interview, it shows that PDA has not been able to communicate verbally the third indicator correctly. Here are the results of the interview:

Researchers : Based on question number 1, what are the elements that are known?

PDA : What is known in question number 1 is the average gasoline sales in 1 week and sales details on Monday, Tuesday, Wednesday, Thursday, Saturday, Sunday.

Researchers : Do you know the symbol of the average?

PDA : Forget ma'am..

Based on the results and the interview, it was shown that the subject had difficulties in the aspect of written communication, especially in indicators related to the proper use of mathematical symbols. This result is supported by research conducted by [25] showing that students with auditory learning styles have problems in expressing everyday events in mathematical symbols by writing down known information but not using mathematical symbols.

b. Mathematical communication skills based on visual subjects

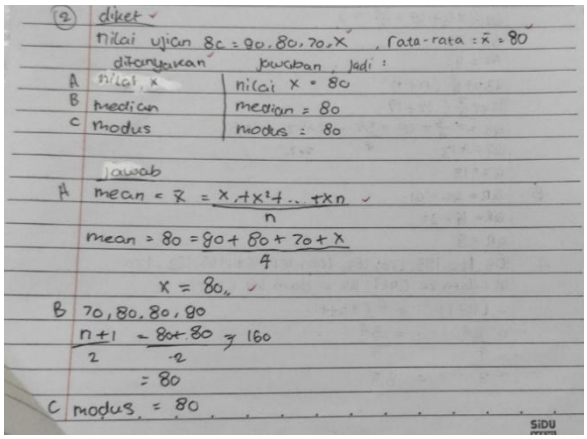

Figure 2. Answer to question no.2 visual subject

Figure 2 shows that the visual subject is the subject with the PDV code in solving problem number 2, In the first indicator the PDV has been able to express mathematical ideas by writing down the information that exists in the problem by writing down what is known and asked. At the stage of understanding PDV, they have been able to interpret ideas by writing strategies and solution steps in a coherent and systematic manner. PDV is not only able to read the problems contained in the questions, but also has been able to know what problems must be solved and PDV writes down what is known and asked. This is in accordance with research [26] which reveals that students with visual learning styles are able to provide explanations for the answers that have been given. At the stage of evaluating PDV has been able to evaluate ideas by writing conclusions. At the stage of using PDV symbols, they have been able to use mathematical symbols in solving problems. Students with a visual learning style are able to express mathematical ideas in the form of mathematical symbols in solving problems. This is supported by [27] that subjects who have a visual learning style are able to fulfill visual representation, mathematical expressions, namely being able to present in the form of images or illustrations, solving problems by involving mathematical expressions. This shows that the subject has been able to carry out written communication on all indicators, but the PDV has not been able to evaluate the idea by writing the conclusion clearly and completely. Here are the results of the interview:

Researchers : Based on question number 1, what are the elements that are known?

PDV : What is known in question number 2 is the 8C exam score and the average

Researchers : Do you know the symbol of the average?

PDV : tau miss, X bar mis.

Based on the results and interviews above, it can be concluded that a visual learning style (PDV) can meet all indicators of mathematical communication skills, which shows that PDV has a strong ability to express and understand mathematical ideas. PDV is able to write down the information known and asked from the question, as well as formulate a

systematic solution strategy. PDV also shows the ability to use mathematical symbols appropriately, such as the average symbol ($\bar{X}$).

c. Mathematical communication skills based on kinesthetic subjects

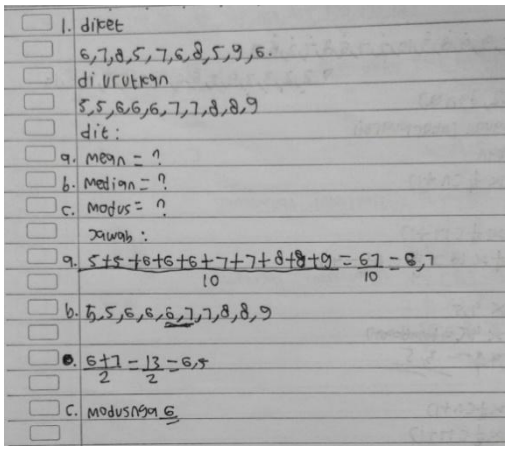

Figure 3. Answer to question no.3 kinesthetic subject

Figure 3 shows a subject with a kinesthetic learning style, namely a subject with a PDK code in solving problem number 3, In the first indicator the PDK has been able to express mathematical ideas by writing down the information that exists in the problem by writing down what is known and asked. At the stage of understanding PDK, they have been able to interpret ideas by writing strategies and steps to solve them in a sequential and systematic manner. As shown in figure 3, the PDK subject can write down the steps such as first sorting the existing data, then writing down the calculation steps, but the PDK does not write down the formula first before doing the calculation. At the stage of evaluating PDK, it is not able to evaluate ideas, this can be seen in figure 3 of the PDK subject does not write a conclusion at the end. However, when interviewed, the subject was able to mention the conclusion. Here are the results of the interview:

Researchers : Based on question number 3, what conclusion do you get?

PDK : In conclusion, the mean value is 6.7, the median value is 6.5, and the mode value is 6

At the stage of using PDK symbols, they are not able to use mathematical symbols correctly in solving problems. Subjects with a Kinesthetic learning style did not write down the average symbols. This suggests that although PDKs are capable of completing calculations, they are less familiar with common mathematical notation. This is in accordance with research [28] that students with kinesthetic learning styles have problems in writing symbols in expressing known information. Here are the results of the interview:

Researchers : Do you know the symbol of the average?

PDK : No, ma'am, I don't know if there is an average symbol.

From the results and interviews above, it can be concluded that a group with a kinesthetic learning style (PDK) only meets two indicators of mathematical communication skills. This is in accordance with research [29] that students with a kinesthetic learning style master both indicators in mathematical skills, this is because PDK has not been able to evaluate ideas in writing, as seen from the inability to write the final conclusion on the answer sheet and PDK also shows weaknesses in the use of mathematical symbols, such as mean symbols. Overall, these results suggest that while learners with a kinesthetic learning style have the ability to understand

This study identified differences in mathematical communication skills among students with different learning styles, students with visual learning styles (PDV) showed the best mathematical communication skills, able to meet all the set indicators, including the effective use of mathematical symbols. Meanwhile, students with auditory learning style (PDA) were only able to meet three of the four indicators, with the main challenge being the use of mathematical symbols. Students with a kinesthetic learning style (PDK) only meet two indicators, experiencing difficulties in writing conclusions and using mathematical symbols.

The results of this study show that visual learning styles are better than students with auditory and kinesthetic learning styles. This is in line with research [30] that subjects who have visual learning styles have better learning outcomes than subjects who have auditory and kinesthetic learning styles. Students' mathematical communication skills with visual learning styles can be categorized as good Students' mathematical communication skills with auditory learning styles can be categorized quite well. Mathematical communication The skills of students with kinesthetic learning styles can be categorized as poor [31].

These findings show that there is a significant relationship between learning styles and mathematical communication skills. Visual learning styles are proven to support the ability to express and understand mathematical ideas comprehensively. In contrast, auditory and kinesthetic learning styles show limitations in some aspects of mathematical communication, especially in the use of symbols and written evaluations. This indicates that mathematics learning strategies need to be adapted to students' learning styles to improve the effectiveness of mathematical communication.

Based on the findings of this study, it is recommended that the development of mathematics learning strategies pay attention to the differences in students' learning styles. Periodic evaluations of students' mathematical communication skills with various learning styles also need to be carried out to identify their strengths and weaknesses in more depth, so that learning strategies can be adjusted effectively to support better understanding and solving mathematical problems.

IV. CONCLUSIONS

This study analyzes the mathematical communication skills of students in grade VIII D SMPN 7 Cirebon City in solving statistical problems based on learning styles. The results of the study show differences in learning styles in fulfilling mathematical communication indicators.

1. Learning Style Diagnostic Test Sheet Results

Based on the results of the diagnostic test, the most dominant learning style in class VIII D is the visual learning style with a percentage of 50%. Auditory learning style ranked second with 30.5%, and kinesthetic learning style was the lowest with 19.5%. Three learners with visual, auditory, and kinesthetic learning styles were randomly selected as research subjects for further analysis.

2. Mathematical Communication Skills Based on Learning Styles

Auditory subjects (PDAs) are able to meet three of the four indicators of mathematical communication. PDA demonstrates the ability to express mathematical ideas and understand the steps to solve problems in sequence. However, subjects have difficulty in using mathematical symbols correctly. The results of the interviews showed that PDA did not remember the mean symbol ($\bar{X}$), although it was able to complete the calculation correctly. This indicates that written communication, especially those involving mathematical symbols, needs to be improved in students with auditory learning styles.

The visual subject (PDV) successfully met all indicators of mathematical communication ability. PDV is able to express mathematical ideas clearly, use mathematical symbols appropriately, and arrange problem-solving steps in sequence. The results of the interviews reinforce the findings that students with visual learning styles tend to be stronger in aspects of visual representation and mathematical expression. PDV shows a good understanding of mathematical notation and symbols, and is able to correctly infer the results of problem solving.

Kinesthetic subjects (PDK) are only able to meet two of the four indicators of mathematical communication. PDK understands the steps to solve in sequence, but is not able to use mathematical symbols and evaluate ideas in writing. The results of the interview showed that PDK had difficulty using common mathematical notation and did not write the conclusion on the answer sheet, even though he was able to mention it orally. This is in accordance with previous research which showed that kinesthetic learners tend to pay less attention to symbolic aspects in mathematics.

The results of this study show that learning style affects students' mathematical communication ability in solving statistical problems. Students with visual learning styles tend to be better at meeting mathematical communication indicators compared to auditory and kinesthetic students. This study emphasizes the importance of adjusting learning strategies that suit students' learning styles to improve their mathematical communication skills.

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