Students' mathematical communication abilities in solving geometry problems viewed from learning styles

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Abstract. The purpose of this research is to describe student mathematical communication abilities in solving the problem of material transformation (reflection and rotation) in terms of student learning styles. This research is a qualitative descriptive study. The subjects consisted of 6 classes of IX students in Wonogiri 7 Junior High School who were selected by purposive sampling. Data collection tools used were written tests of communication abilities and questionnaires to categorize students based on their learning styles and interviews. The data validity of the data used triangulation method. Analysis of this data shows that the communication of visual students can meet indicators: 1) Reflecting and answering about mathematical concepts; 2) Connecting daily news with language mathematics symbols; 3) Expressing and evaluating into mathematical theory; 4) Using mathematical opinions to make detailed conjectures. The mathematical communication of the auditory students can meet the indicators: 2) Connecting daily news with language mathematics symbols; 3) Expressing and evaluating into mathematical theory; 4) Using mathematical opinions to make detailed conjectures. The mathematical communication of kinesthetic students can meet indicators: 1) Reflecting and answering about mathematical concepts; 3) Expressing and evaluating into mathematical theory. This shows that dominant students have mathematical communication abilities with visual learning styles caused by students who were being able to communicate their mathematical ideas connected in their daily lives.

1. Introduction
Success in the learning process depends on the factors of learning activities. Values that are taught explicitly and not implicitly are important components in improving the quality of learning. According to Pimta S & Nuangchalem [1], education is a basic science that has an important role in the process of development of science and technology. [2] Mathematics education is one source of education that cannot be separated from learning. Efforts to make students learn so that changes in behavior must go through the learning process because of the interaction of students with their environment [3]. Students can enhance effective learning if they study inside and outside the classroom. To overcome this many methods can be used by the teacher to recognize the characteristics of their students and apply the use of appropriate learning models [4].

Social relations between students and teachers will lead to a learning process on the lessons taught by the teacher. Communication will make it easy for students to express opinions, ideas they have. Communication is a social behavior to establish a fundamental life [5]. Statement by Elizabeth [6] that mathematical communication is considered as an important component in building mathematical ideas...
and developing fluency in students' mathematical concepts. Another opinion regarding mathematical communication is the thought to express mathematical ideas with diagrams, symbols, and tables to explain mathematical problems and convey them with mathematical language [7]. Previous research on mathematical communication conducted by Arifin Z et al [8] shows that the lower the position of students' mathematical communication abilities, the reduced their communication abilities. Students' mathematical communication is predicted from the development of students' mathematical knowledge over time so that through mathematical communication students can explain their ideas, understandings, and opinions to others. As a statement by Barwell [9] the correct solution to the use of everyday language is very important in communication. Students' communication abilities through worksheets can be developed through written communication such as conveying ideas and solutions during discussions and students can show results of their solutions to problems in worksheets [10]. In fact, mathematics influences values related to their interests, behavior towards problem-solving. Problem-solving is a more creative activity, which includes the formulation of possible conjectures, the sequence of testing, modification and refinement activities to create and produce official evidence from a source obtained [11]. Communication abilities can be developed through the habits of students to give responses and explain their answers to others [12]. Students in learning mathematics are required to be able to communicate opinions and ideas so that understanding can be understood by others. The idea of mathematics as a role model in student practice in a variety of specific ways [13] shows that "mathematical communication takes place in a social context." [14] Through communication abilities, students can convey their opinion to other students and teacher which is one aspect that influences the success of learning in the form of interaction by teachers and students. The same thing is stated by [15] that communication their opinion, and ideas to others can be expressed through daily discussion activities.

Based on the absorptive capacity taken from the educational assessment center of the ministry of education and culture that the percentage of students who answered questions correctly in the UN mathematics in geometry material is still below the average of where discussions on geometry are quite large, and geometry is a part of mathematics that has uses in daily activities. As stated by [16] in the psychology of education that in learning an educator is obliged to carry out the initial phase of learning, which is the phase where an educator knows and understands the initial stock owned by students. The initial stock included in this stage is knowing how students learn or student learning styles.

The success of students in achieving learning achievement is influenced by the process of student learning or commonly known as learning styles. Learning style as a processing structure of possibilities or patterns of transactions between individuals and their environment [17]. Learning styles have a level of consistency in a discipline as a whole depending on the attitude that stands out in students. As student understanding improves, this will help solve each problem with students with different learning styles. Learning style as an important determinant for effective education can significantly contribute to improving the quality of education [18]. Development is further strengthened by the popular interpretation of progress in various versions of the learning styles students have in the classroom [19]. This study discusses visual, auditory and kinesthetic learning styles. The reason for using these three learning styles is because in student learning activities can be observed through all five senses. Based on these learning styles, visual students have learning styles through something they see, auditory students have to learn styles by listening, and kinesthetic students have learning styles with movement, work, and touch. Learning styles must also be taken into account when designing teaching and learning environments according to students' character [20]. The teacher must design and prepare teaching techniques according to student learning styles [21]. Previous research by [22] said that learning styles have a relationship with the progress, one of which is the aspect of personality. The concept of learning styles illustrates students' differences in learning based on their preferences to use various ways of the learning cycle [23].

The NCTM standard supports the idea that all students can grow in geometric abilities and understanding that are consistent with their thinking [23]. One of the Geometric content that applies at
all grade levels is Transformation which includes studies of reflection (mirrored), rotation (rotated), a study of symmetry, and the concept of similarity. This refers to the coordinates of the geometry or how to determine objects that are outside the location. Transformation is the change in the position or size of a shape. The movement does not change the size or shape of objects that move rigidly.

Based on the previous presentation, researchers need to research mathematical communication in solving mathematical problems viewed from visual, auditory and kinesthetic learning styles which are considered as one of the important factors that must be considered during the learning process.

2. Methods
This research is qualitative descriptive, which aimed to determine the abilities of mathematical communication in solving the problem of material transformation (reflection and rotation) seen from student learning styles. The subjects of this study were 6 students in class IX SMP 7 Wonogiri. Subjects were selected by purposive sampling. Creswell [24] explains that the purpose of selecting subjects by purposive sampling is the researchers can choose individuals as research subjects and understand phenomena at the focus of their research. The researcher made a mathematical communication abilities test instrument consisting of 2 items of transformation material, student learning style questionnaire, and interview guidelines before being tested validated by expert lecturers. Written test questions were used to determine the level obtained by students in working on the problems. Each learning style questionnaire item contained 4 optional answers and subjects marked the answers that best described their reaction to their favorite learning style situations [25] which immediately catch their attention. Learning styles were usually felt by individuals as clear, routine and habitual processes, satisfying them, in some cases even optimal procedures for themselves [26].

The interviews used in the study were semi-structured interviews conducted to strengthen the results obtained from the mathematics communication abilities test. After conducting tests and interviews the next step was to conduct data analysis. Data analysis was performed through data collection, reduction, data presentation by correcting in detail student answered and adjusted mathematical communication indicators. The final step was to conclude mathematical communication abilities with each student’s learning style. The research method described above is illustrated in figure 1 below.

Figure 1. Flowchart of research methods
3. Results and Discussions
Based on the learning style questionnaire data results, the analysis was carried out on the results of each student's questionnaire which was then grouped into categories of visual learning styles, auditory, and kinesthetic. Following the learning style indicators below:

a. Visual Learning Style Indicators
1) Have the ability to draw and record something in detail
2) Like neat and orderly things about numbers and pictures in learning mathematics
3) Carry out mathematical tasks following the provisions and theory

b. Auditory Learning Style Indicators
1) Learn by listening to other people's explanations
2) Good in verbal activities to obtain information
3) Tend to a calm atmosphere of learning

c. Kinesthetic Learning Style Indicators
1) When memorizing that is by walking or making movements
2) Understand the application of mathematics or games in everyday learning
3) Use real objects as a tool

A summary of the number of students can be seen in Table 1.

Table 1. Results of Analysis of Learning Styles

| No | Category | Number of Students |
|----|----------|--------------------|
| 1. | Visual | 2 students |
| 2. | Auditory | 2 students |
| 3. | Kinesthetic | 2 students |

The results of the visual learning style questionnaire showed that most students wrote information including symbols in the form of coordinate points and calculated answers to the questions according to formulas, correct concepts, and details according to the questionnaire statement, namely students made detailed drawings of space after observing. The results of the auditory learning style questionnaire showed that students did not like memorizing formulas so that in expressing their ideas that were not too detailed and incorrect according to the questionnaire statements students had difficulty understanding story problems and the students' comprehension of information was very slow without other people's explanations. The results of the kinesthetic learning style questionnaire showed that students in drawing shapes were not neat and lacking in detail because students liked objects that were directly rather than writing on worksheets. Identify the combination of learning styles depended on the objects of the learning style [27].

3.1. Subject Subsection
Taking subjects from each category is the result of questionnaire data according to the instruments provided. The subjects can be seen in Table 2.

Table 2. Research Subject Based on Learning Styles

| No | Subject | Category Learning Style |
|----|---------|-------------------------|
| 1. | MM (S1) | Visual |
| 2. | RH (S2) | Visual |
| 3. | CN (S3) | Auditory |
| 4. | RF (S4) | Auditory |
| 5. | YIK (S5) | Kinesthetic |
| 6. | ZR (S6) | Kinesthetic |

Subject selection was taken with a total of 6 students including 2 subject with visual learning styles, 2 subject with auditory learning styles, and 2 subject with kinesthetic learning styles. The next step was to analyze the subject answers regarding mathematical communication abilities test that adjusted to the mathematical communication indicators which include:
a. Reflecting answers about mathematical concepts.
b. Connecting daily news with language or mathematical symbols
c. Expressing and evaluating into a mathematical theory
d. Using mathematical opinions to make detailed conjectures

The communication abilities of students would be analyzed based on the achievement of the four indicators of mathematical communication abilities. Communication abilities of students were categorized based on achievement indicators of communication abilities based on student learning style indicators.

3.2. Analysis of the Mathematical Communication Test.

3.2.1. S1 with Visual Learning Style.

Subject 1 reads the question and easily understands it, then writes the coordinate points and draws geometric shapes according to the coordinate points in problem number 1 and gives a letter description at each point.

Subject 1 interprets the idea of a problem by using a formula in its language and does not understand what formula is correct for the answer to the problem. But the first step is approaching the right answer.

Figure 2. The result of the completion of subject 1 to the question

3.2.2. S2 with Visual Learning Style.

Subject 2 in answering number 1 can use reading skills and interpret ideas in problems. Subject 2 draws geometric shapes with corresponding coordinate points and reflects each drawing according to the question.

In question number 2, Subject 2 uses its language, by writing symbols on "known", even though they do not understand the meaning of the symbols written on the answer sheet.

Figure 3. The result of the completion of subject 2 to the question
Results of researchers' interviews with S1 and S2

Q : What is known and what is asked about the problem?

S1.1 : In the questions are asked to describe the shape of the building then reflected and rotated by 90° towards the center point

Q : How do you answer the question?

S2.1 : I first drew a point in the coordinates according to the command about sis.

Q : What material was asked about the problem? Try to explain and give examples in everyday life?

S1.2 : The material is about geometry transformation sis. If I remember reflected is reflected and rotation is rotated. Previously I drew a triangle and a kite and then reflected the coordinate. For question number 2 you are asked point E and calculate the shadows that occur to produce the shadow point requested in the problem

Q : Are there any new symbols or terms in the problem?

S2.2 : Many sis, I work on problems and write answers according to my ideas. I first saw the problem using a formula that I knew of.

3.2.3. S3 With Auditory Learning Style.

Subject 3 in problem number 1, just read the question and draw directly the size of the coordinate points and connect between the points without a ruler, so the results of the solution are less precise and neat.

Subject 3 worked on question number 2 by writing a formula from a friend's opinion, Subject 3 did not understand what formula was used to answer the problem.

Figure 4. The result of the completion of subject 3 to the question

3.2.4. S4 with Auditory Learning Style.

Subject 4 in question number 1 is the same as Subject 3's work, just glance at reading the question and arranging randomly without seeing the size of the coordinate points and connecting between points without a ruler, so the results of the solution are less precise and neat

Subject 4 did the problem is not writing the formula correctly and the answer was incomplete

Figure 5. The result of the completion of subject 4 to the question
Results of researchers' interviews with S3 and S4

Q : What information is obtained from the problem?
S3.1 : Asked to describe the shape of the space and then reflected and rotated towards the corner of the center point
Q : How do you solve this problem?
S4.1 : I just drew sis and I have not finished yet, because I am still confused with the intention Reflected and rotated
Q : Are there any difficulties when working on the problems?
S3.2 : Yes, I still do not understand the purpose of the problem, I read the question over again as a result, I did not finish drawing it.
Q : Are there any new symbols or terms that you know from the problem and the material asked about the problem give examples in everyday life
S3.3 and S4.2: Many sis, in question number 2 the rotation is rotated at an angle, I first found a problem like that and there are triangle shapes and kites that I imagine are like children's kite toys.

3.2.5. S5 With Kinesthetic Learning Style.

Subject 5 in problem number 1 only illustrates the reflection of building space without writing down the names of the coordinate points

Figure 6. The result of the completion of subject 5 to the question

3.2.6. S6 With Kinesthetic Learning Style.

Subject 6 only wrote the picture with a dashed line, without understanding the command matter

In question number 2, Subject 6 says it is difficult to study questions related to symbols or questions that are compiled, so writing answers are not appropriate and good.

Figure 7. The result of the completion of subject 6 to the question
Results of researchers' interviews with S5 and S6

Q : What is known and what is asked about the problem?
S_{5.1} : The coordinates are known and asked to draw shapes and then reflected and rotated towards the center point sis
Q : What are the steps you take to work on the problem?
S_{6.1} : I draw the points in the coordinates first and join the dots with dashed lines.
Q : Why combine it with dotted lines?
S_{5.2} : I don't really like drawing sis, I prefer practicing directly using the application.
Q : Are there any new symbols or terms in the problem?
S_{6.2} : There is sis, when I was asked about the angle, I immediately thought I would sin, cos, tan.
Q : Are things that are known can be used to answer what is asked of the problem?
S_{5.3} : I have not thought about sis, because I do not know much the latest symbols and terms in the problem
Q : After working on the problem, what is your conclusion?
S_{6.3} : All I know is told reflect and rotate the picture, but I have not finished answering it and still do not understand what the correct formula is for answering the problem.

Learning styles lead individuals to specific types of learning outcomes, but they can also complicate other achievements. The individual will learn better if they receive information with the learning style they have (for example learning style visual, auditory and kinesthetic) \[28\]. On the acceptance, various technologies of learning styles have been applied to fields such as education, programming, online learning which are used to investigate students’ abilities levels \[29\]. The existence of differences levels of students ability is used as a consideration of the learning process \[30\]

The results of the communication analysis showed that the subject of the visual learning style was able to understand the problem by reading the symbols connected in everyday language. The subject of the auditory learning style was able to analyze mathematical problems by conducting discussions that produce ideas, convincing conjectures, while the kinesthetic learning style subjects can clarify the results of answers by making arguments directly. The exposure to the communication test answer showed that dominant students can communicate with visual mathematical learning styles.

Students with mathematical communication skills of visual learning styles during interviews said that when understanding interesting material in the illustration of the images they saw. Following the opinion \[31\] that students with this visual learning style can see and watch demonstrations, prefer to gain knowledge through visual media, often have a clear image, and prefer to see images, slides, and graphics. Students communicate their mathematical ideas using diagrams and words. During the interview, students explained if it was difficult to understand the lesson without being delivered verbally. Subjects with auditory learning styles can explain several steps of the answers to illustrate the ideas obtained by listening to the explanations of others. The auditory learning style refers to listening. Statements such that these students excel in learning settings, usually very good listeners, can learn concepts by listening to the media, such as recording, can repeat verbal instructions with relative ease \[31\].

The results of student interviews with kinesthetic learning styles that are easy to understand the lessons taught if practiced directly, such as the learning process by practicing and connecting with the concept of the game. Kinesthetic learning styles refer to the movements of the whole body. Students focus on direct involvement in various things. They often look for reasons to move, and cannot sit still during the learning process and successfully find answers in physical response activities, use movements to help concentrate, it is usually difficult to listen and not pay attention to other people's explanations \[31\]. The results of the following mathematical communication skills analysis of students are presented in table 3.
Table 3. The Results of Analysis of Students' Mathematical Communication Abilities

| Learning Style | Subject | Indicator |
|----------------|---------|-----------|
| Visual         | S1 and S2 | a. Reflecting answers about mathematical concepts |
|                |         | b. Connecting daily news with language or mathematical symbols |
|                |         | c. Expressing and evaluating into a mathematical theory |
|                |         | d. Using mathematical opinions to make detailed conjectures |
| Auditory       | S3 and S4 | b. Connecting daily news with language or mathematical symbols |
|                |         | c. Expressing and evaluating into a mathematical theory |
|                |         | d. Using mathematical opinions to make detailed conjectures |
| Kinesthetic    | S5 and S6 | a. Reflecting answers about mathematical concepts |
|                |         | c. Expressing and evaluating into a mathematical theory |

4. Conclusion
The learning process will be easy if students communicate well in understanding material in building ideas and developing fluency in important components. The process of how to learn will succeed or run well if adapted to ways of learning or student learning style.

Based on the results of research through tests, questionnaires, and interviews, it can be concluded that the dominant student with a visual learning style and meets all indicators of mathematical communication of students, where students with visual learning style refer to seeing printed or written words capable of meeting communication indicators a, b, c, and d. Auditory learning style students refer to hearing can learn concepts by listening to the media able to meet the communication indicators points b, c, and d. Students with kinesthetic learning styles can explain solutions based on information from problems though not correct and able to meet the communication indicators points a and c.

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