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Mathematical Communication Profiles on Learning Styles in Solving High School Level Mathematics Problems

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Abstract

This study aims to see the mathematics communication of students in terms of learning styles in solving high school mathematics problems. The focus of this research is: students' mathematics communication in terms of visual learning styles, mathematics communication in terms of auditory learning styles, mathematics communication in terms of kinesthetic learning styles. The subjects of this study were students at SMA Negeri 1 Gowa who were grouped based on their learning styles. The research instrument is the researcher himself, because the researcher himself plans what to ask the research subjects. Data collection techniques are carried out by providing learning style questionnaires, carrying out written tests to see mathematical communication skills, and interview guidelines. This study used technical triangulation with data analysis techniques, namely data presentation, data reduction, and conclusions. The results of this study indicate that the level of mathematics communication can be seen from the learning styles of students. Students with visual and auditory learning styles are able to solve mathematical problems completely and in detail, are able to use mathematical ideas, are able to use mathematical notations and symbols to determine answer conclusions. Students who have a kinesthetic learning style are also able to solve mathematical problems in their own style and way, namely a shorter way, being able to use mathematical ideas, symbols and mathematical notations in solving problems, but they do not provide conclusions from the answers that are done

Keywords: Mathematical Communication; Learning Style; Visual; Auditorial; Kinesthetic

INTRODUCTION

The improvement of the quality of education in Indonesia has been carried out continuously and has been continuously implemented until now. One of the efforts to improve the quality of education that is currently being carried out by the government is to improve the quality of teachers and lecturers through the certification program. The increase in teachers and lecturers is reflected in the educational environment. Education will only be meaningful and can improve the quality of human resources as a whole if it is able to prepare a generation that is able to face all the challenges of the times, has high skills that involve critical, systematic, logical, creative thinking, and a willingness to work together effectively.

Mathematical communication of a student can be seen from the learning style. Each student has a different learning style. Such as visual, auditory and kinesthetic learning styles. Mathematical communication is one of the abilities that must be provided to students in education in Indonesia as stated in Government Regulation Number 19 of 2005 concerning National Education Standards. It is also listed in the Mathematics Education Process Standards document in the United States, which includes (1) problem solving, (2) reasoning and evidence, (3) communication, (4) connection, and (5) representation (NTCM, 2000). According to Izzati (2010), he gets a picture of the weak communication skills of students because mathematics learning has not paid much attention to the development of these abilities. Given the importance of mathematical communication competence for students, but the fact is

that this competency is not sufficient, it is necessary to conduct in-depth research on the profile of students' mathematical communication skills. Based on the information above, the researchers conducted research related to the Mathematics communication profile in terms of learning styles in solving high school mathematics problems.

Mathematics is a subject that has many meaningful terms and symbols that students must master. Because there are many activities every day related to mathematics lessons, so this lesson is a subject that must be mastered by students. Mathematics, which was originally known as arithmetic, has many facts, concepts, and procedures related to each of its materials. The ability of students to understand mathematical symbols, mathematical concepts, and mathematical solving procedures is the ability of students to communicate mathematically.

As with research conducted by Rumellan (2012, 78) which examines mathematics communication in interactive learning, it is suggested that students have good mathematical communication skills if the learning is interactive because it emphasizes that students construct their own knowledge in presenting mathematical problems.

Sumarmo (Sinaga, 2017) states that abilities that are classified as mathematical communication include (1) the ability to express a situation, picture, diagram, or real object into language, symbols, ideas, or mathematical models, (2) explain ideas, situations , and mathematical relations orally or in writing, (3) listening to, discussing, and writing about mathematics, (4) reading with the understanding of a written mathematical representation, (5) making conjectures, formulating definitions, and generalizations, and (6) restating a mathematical description or paragraph in language.

Mathematical communication for each student varies according to their learning style. Given that each mathematical solution has a different solution but the same result. This is related to the learning style of each student who does it. One math problem can be solved in short steps or detailed steps, depending on the way students communicate a given mathematical problem.

Learning style is the tendency for a person to choose and like to think, receive, and process information in order to gain knowledge and experience. According to Bandler & Greinder, and Messick (Sari, 2017), learning styles are divided into three, namely visual, auditory, and kinesthetic learning styles. Visual learning style is the ability to learn by seeing. Students with a visual learning style have difficulty copying writing from the blackboard, their writing looks messy and is not easy to read. Auditory learning styles have a better sense of hearing and are more focused. Students with this learning style are able to understand things better by listening. Kinesthetic learning styles, which involve movement forces. Related things, for example, playing music, dancing, and laboratory experiments. This learning style is effective for children who like motion and imagery based on movement. People or children with this kinesthetic learning style tend to be restless.

The same research related to learning styles conducted by Anas and Munir (2016) states that there is an influence of learning styles on students' mathematics learning outcomes, differences in student learning styles also affect their mathematics learning outcomes. The existence of differences in student mathematics learning outcomes in terms of learning styles indicates that between each type of learning style there is a learning style that is better than the other learning styles. Students' mathematics learning outcomes will also be high depending on how learning styles him.

Research conducted by Auliana (2017) also examines the analysis of mathematics communication in terms of learning styles, based on this research there are differences in how students answer based on learning styles. Students with visual learning styles tend to answer questions briefly, students with auditory learning styles provide long and detailed answers, while those with kinesthetic learning styles pay less attention to steps and immediately write down what the answer points.

Several studies related to this research, namely on mathematics communication and learning styles, provide a brief description that mathematics communication skills can be seen from the differences in learning styles of students. The ability of students to solve mathematical problems is closely related to the style of students in doing it as well as the way students communicate and share mathematical ideas

in solving mathematical problems.

RESEARCH METHODS

This research is a qualitative research with a descriptive approach, which describes the mathematics communication of students in terms of learning styles. This research was conducted online (in a network) on students of SMA Negeri 1 Gowa. This research was conducted within two weeks in collecting data on the subject under study. Determination of this research subject begins with giving questionnaires to students in one class. Then choose each student who is classified into visual learning styles, auditory learning styles, and kinesthetic learning styles. Each subject will be given a written test to measure students' mathematical communication, then interviewed. The research subjects selected in this study were 3 subjects categorized based on their learning styles.

This type of research is qualitative research with a descriptive approach, so the instrument in this study is the researcher himself. This is because the researcher himself plans what is asked of the research subjects in the interview, then the researchers themselves will compile the indicators that are the focus of the research. As for the supporting instrument with the type of instrument in the form of a learning style questionnaire that is given to one class then it will then be classified into 3 different subjects, 1 subject belonging to the visual learning style, 1 subject belonging to the auditory learning style, and 1 subject belonging to the kinesthetic learning. Furthermore, to see the communication skills of students, students are given a written test so that it can be explained how the mathematics communication skills are written on the answer paper of each subject. As well as the next instrument is an interview with the three subjects so that the data obtained related to the mathematics communication profile of students is more accurate.

This study used technical triangulation, which was carried out by examining data from several subjects using different techniques, namely by using a learning style questionnaire, a written test in the form of a test of mathematical communication skills, and to make the data more accurate, interviews were conducted with each subject. The data that has been collected will be analyzed using the Milles and Hubberman model (Sugiyono, 2017). Activities in data analysis are data reduction, data presentation (data display), and conclusion (verification).

RESULT AND DISCUSSION

Result

Research conducted in class XI IPA 4 SMA Negeri 1 Gowa by distributing a learning style questionnaire showed the number of students including visual learning styles, auditory learning styles, and kinesthetic learning styles. Based on the data above, it shows that there are 11 students who belong to the visual learning style, 9 students who belong to the auditory learning style, and 16 students who belong to the kinesthetic learning style. From the data, one student who belongs to the visual learning style, one student who belongs to the auditory learning style, and one student who belongs to the kinesthetic learning style are taken from the data.

Mathematical Communication in terms of Visual Learning Style

Learning style is the character of an individual or student in learning. This learning style is related to the process of activities that students often do so that it is easy to learn the material. The first subject is the Visual subject, this subject better understands the subject matter by using a sharp and meticulous sense of vision. The visual subject analyzes a math problem by simply looking at the problem and solving the problem immediately.



Based on the results of the work of the visual subject, it indicates that the subject is able to express mathematical ideas or problems through writing, this can be seen from the answers above, the subject is able to describe everything that is known in the question, explains what is asked in the question, describes the form of question instruction and is able to solve the problem with precision. In addition, the results of interviews with visual subjects add data that this subject solves questions carefully.

Q: From the results you did, I saw in number 1 you drew a triangle, why did you draw the triangle?

SV: Ooh, this is how my mother drew a triangle because according to the instructions for the problem and in the question there was also an elevation angle known and also the child's height and distance so I thought of drawing a triangle.

The interview fragment above shows that the subject solved the problem by analyzing what was seen on the question before working on it. This subject explains what is known and describes the shape that is desired in the problem. This shows that this subject is able to express problem ideas through writing. In the second indicator, namely expressing ideas or mathematical problems in the form of graphs, pictures and diagrams, it is also seen that the completion of the subject in the previous number 1 problem is seen. The subject is able to draw a triangle in accordance with the instructions for the question.



Based on the results of the subject's work above, it shows that the subject is able to determine the steps for solving mathematics in accordance with what is desired in the problem. This visual subject appears to be using the correct mathematical terms, notations and symbols, namely solving problems by starting to look for the value of sin A to find the area of the triangle so that it is able to determine the volume of the shape in question. Subjects are able to arrange solutions accurately and precisely by using mathematical notation and symbols.

The problem solving above also shows that the subject is able to interpret mathematical ideas in their own language. This indicates that the subject is able to explain the problem solving carefully according to examples in the material. The subject's answer is reinforced by the results of the interview based on the completion of question number 4 on the mathematics communication test

Q: Can you see number 4 on the math communication test? Why deduce using the sine rule first from the cosine rule?

SV: I chose the sine rule because what we know in the length problem of AD and the two angles is angle and angle. and to find the length of BC beforehand you must know the length of BD first. BD is obtained with the sine rule because there are two angles known to be 1 side then find BC using the cosine rule because in the image there are 2 sides 1 known angle.

Based on the results of interviews with the subject, it shows that the subject is able to explain again from the written completion of the mathematics communication test. The subject is able to explain the reasons for using the sine rule and the cosine rule in a problem. The subject is also able to explain the conditions thus using the sine rule and the cosine rule. This shows that visual subjects are able to interpret mathematical ideas in solving mathematical problems.

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The results of the communication test above explain that in each answer the subject does not forget to provide conclusions from what is being asked, because providing conclusions from the answer to the question is a form of mathematical communication on the problem that has been resolved. This subject provides detailed solving of mathematical problems. One of the things that shows that this subject has a visual learning style is its accuracy in providing answers according to the form of examples in the material. As well as in terms of writing that does not pay much attention to neatness, it can be seen in the line drawings depicted.

P: OK, after solving the questions on the mathematics communication skills test, what conclusions can you draw?

SV: My conclusion is that the sine rule is known to be two angles of one side and if the cosine rule is known to be two sides of one sideand to solve trigonometric problems, you must observe the figure of the shape and understand the problem that is a clue in solving the problem.

The subject interview fragment above shows the level of visual mathematics communication subject, namely the subject is able to explain the conclusions after completing the questions on the mathematics communication test. The conclusions given by the subject cover all the questions on the mathematics communication test, namely those related to the sine rule and the cosine rule. So it can be said that subjects with visual learning styles have a high level of mathematical communication skills seen in the results of solving all the questions on the communication test which were completed correctly and the results of interviews with visual subjects that support the subject's answers on the mathematics communication test.

Mathematical Communication in terms of Auditorial Learning Style

Auditorial learning styles tend to be seen in students who have a better sense of hearing. This subject tends to understand the lesson by listening to the teacher's explanation. The following are the results of solving the auditorial subject questions on the mathematics communication test.

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Based on the results of the answers of the auditorial subjects on the mathematics communication test, it shows that the auditorial subjects tend to have neat writing, this subject also writes the answers using colored ink so that it is easier to remember the answers to the questions given. The auditorial subject writes a detailed solution that can be seen from the results of the subject's answers explaining what is known and asked in the questions and completes the questions briefly and accurately, it's just that the subject does not write the pole height symbol at the end, the subject immediately writes the formula and results and does not write a conclusion the answer asked. This shows that the subject tends to memorize the completion steps taught by the teacher.

P: From the results you did, I saw in number 1 you describe the triangle, why did you draw the triangle?

SA: Ooh yes, I drew a triangle because from what you know in the problem there is a height and an angle so that you can draw a suitable triangle

SA: And as far as I remember, the teacher always drew a shape according to the question's wishes if there was a story problem that didn't provide a picture

The interview fragment above with the auditory subject shows that the subject tends to solve the problem by remembering the teacher's explanation. The subject wrote down the steps for completion in accordance with the example questions the teacher had given. In the above interview, the auditorial subject was able to provide reasons why he described the triangle as a pointer to find the height of the flagpole. This shows that the subject better understands the problem by remembering.

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20	= 18 = 1	2
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The result of the subject's work in the third number of the mathematics communication test explains that the subject redraws the prism image that is on the problem in order to further clarify what is known from the problem. Then proceed to find sin A using the cosine rule as known to the problem. Next, the new subject looks for the area of the base and then the volume of the prism in question. All the solutions that the subject wrote show the use of mathematical notations and symbols in presenting mathematical ideas. This explains that the auditorial subject is able to explain and solve mathematical problems while still using mathematical symbols and notations.

P: So, for example, this is trigonometric material, then what is it related to?
SA: That trigon mother, as far as I remember, had the sin cos tan,
Q: What else is the basic formula for sin cos tan?
SA: Hm ... hm ...
Mother
Sin is tilted front huh
Yes, mother, sin is front per sloping
Cos side per slant
And tan it front by side

The interview fragment above shows that the subject still remembers the trigonometric terms and formulas that the subject can use in solving math problems. Although previously the subject seemed to remember the teacher's explanation and remember the basic material of trigonometry, the subject seemed to have memorized mathematical terms and notations. This shows that from the results of the interview the subject is able to explain mathematical terms and notations that are often used in solving mathematical problems.

P: In question number 5 there are two angles

Why is that?

SA: Hm... Hm....

The angle P and the angle Q lie in a straight line and I remember that the two angles on a straight line add up to 180°

The results of the interview which show that the subject is able to use their own language in solving math problems is also seen in the interview section above. The subject explains the reason why using

why the sum of the angles P and the angle Q is 1800 because these two angles are in a straight line. This shows the subject's ability to understand mathematical ideas in solving math problems.

Based on the answers to the results of the communication test that the subject completed, it did not show any conclusions about the answers to the questions. The subject only wrote down to the final result, and from all the answers to the questions the subject gave, the subject forgot to write down the conclusion of the answer. Even though in solving math problems the conclusion of the answer to the question is also important to clarify the answer to the problem. This shows that the subject knows how to solve math problems, it's just that it complements the answer, namely the conclusion is not added to the subject's answer.

Q: after solving the questions on the mathematics communication skills test, what conclusions can you draw?

SA: The conclusion that can be drawn from the problem solving is the sine rule and the cosine rule and all trigonometric solutions can be easily solved if you remember the values of special angles

The interview fragment above shows that the subject is able to provide accurate conclusions from what has been done on the mathematics communication test. The subject is able to remember the formula for the sine rule, the cosine rule, and even add the special angles that appear most often used in solving math problems. This explains that the subject is able to provide correct conclusions from mathematical statements.

Based on the results of the subject's work on the mathematics communication test and the results of interviews with the subject, it was explained that subjects who have an auditory learning style are able to solve mathematical problems appropriately and are able to explain reasons for using mathematical ideas and concepts in solving mathematical problems. This shows that the auditorial subject has a high ability to solve mathematics.

Mathematical Communication in terms of Kinesthetic Learning Style

Kinesthetic learning style is a learning style that involves movement styles. This learning style is effective for children who like motion and imagery based on movement. The results of research on subjects that are included in the kinesthetic learning style can be seen from the results of the subject's work on the mathematics communication test that has been given.



The work of the kinesthetic subject above shows that the subject gives the correct answer, but does not write down what the questions know and ask. Subjects tend to give short answers that point directly to what they are looking for in the problem. The subject gives a picture of the shape that the problem wants even though the image is not neat. The subject wrote down the steps to solve the problem until the final result and did not give a conclusion. Based on the subject's answers above, the subject with this kinesthetic learning style appears to be able to express mathematical ideas through writing in their own simple and precise style.

Kinesthetic subjects tend to show pictures that support the completion of a given math problem. The subject is able to describe the shape desired by the question. Subjects are able to describe mathematical ideas from story problems. Even though the image presented by the subject is not neat, the subject is able to determine the position of the angle and side that is known from the problem. Subjects are also able to solve mathematical problems with appropriate solving steps. Based on the subject's answer

above, it is explained that the subject is able to express mathematical problem ideas in the form of images.

P: Ok, what is being discussed is trigonometry, meaning there is a special angle, for example a special angle, to what angle do you know the value?

SK: Which special angle is it, Mother,

P: Yes, the special angle starts from 00 - 3600, now, how many points do you memorize?

SK: Ooh Iyye, mother, if the grades are normal, I'll check them again and see the notes first, then I'll remember

SK: But Madam, it's a special angle that I remember the most cos 0 is the same 1 as what was labeled in my notebook.

P: Well, why if cos 0 is easy to remember? And the special angle table in the book is easy to remember?

SK: Because I was then asked to write it in a book and put it on the front page of my notebook

The interview fragment with the subject above explains that the subject is able to use mathematical terms used in solving and presenting mathematical ideas. The subject above seems to be able to remember the problem if it has been carried out with the movement, namely when recording the special angle table. In addition, the subject appears to be able to use mathematical symbols in presenting mathematical ideas.



The completion of the mathematics communication test above shows that the subject writes the steps for the solution in his own language, the subject does not add what is known and the questions are asked. The subject describes the levels according to the instructions for the question even though the picture provided is not neat. The writing of the subject at the completion step also needs to be clarified, there are some numbers that are not clearly written. And the subject does not provide a conclusion about the question. This shows that the subject provides and writes mathematical ideas in their own language.

Based on all the subject's answers from the results of the mathematics communication skills test the subject does not write down the conclusions of the answers that have been completed. The subject completed the test quickly and did not add to a conclusion. The results of interviews with the subject in the subject's conclusion questions are able to explain conclusions after completing the mathematics communication skills test.

Q: after solving the questions on the mathematics communication skills test, what conclusions can you draw?

SK: In conclusion, the communication skill test, by drawing a shape according to the instructions for the question, we can solve trogonometric questions.

The interview fragment above shows that the kinesthetic subject provides conclusions that are right in accordance with what has been done on the mathematics communication test. The subject gives conclusions according to the character of the kinesthetic learning style, which is to prefer to describe what is known about the problem. Although all images presented by the subject still need to be clarified

and presented neatly. This shows that subjects with a kinesthetic learning style have a moderate level of ability to solve math problems

Discussion

The results of the research previously described inform the level of mathematics communication in terms of learning styles. The mathematics communication of each student has a level of difference according to the characteristics of these students to understand and interpret each mathematics teaching material given. The difference in the level of mathematics communication is basically seen from the learning styles of students. Based on the results of the research above, it explains the high level of mathematical communication in visual subjects and auditory subjects, while subjects with kinesthetic learning styles have a moderate level of communication.

There are five things that are seen to determine the level of mathematics communication skills of the subject, namely, the ability to express mathematical ideas through writing. Ability to express ideas on math problems in the form of pictures or diagrams. Ability to use mathematical terms, notations and symbols in presenting mathematical ideas. The ability to interpret mathematical ideas in one's own language and the ability to draw conclusions from what has been done. These five indicators are fulfilled by subjects who have a visual learning style, because visual subjects explain and present mathematical solutions in detail and accurately arrive at conclusions. The auditorial subject solves mathematical problems in detail, it's just that the subject's work does not write down the conclusions of the answers to the questions. However, the auditorial subject is able to convey the conclusions of the answers from the interview results. Likewise with the kinesthetic subject, solving mathematical problems in a short manner and steps in accordance with the wishes of the question, it's just that the subject's with the subject provide short answers so that subjects with visual learning styles and auditory learning styles have a level of mathematical communication. high medium subjects who have a kinesthetic learning style have a moderate level of mathematics communication.

CONCLUSION AND RECOMMENDATION

The learning style of students in solving math problems has a close relationship with the level of mathematics communication. Students who have a visual learning style tend to solve mathematical problems in detail and meticulously seen from the results of solving problems written with complete mathematical steps with a conclusion. Likewise with students who have an auditory learning style that provides complete answers with appropriate mathematical completion steps. Meanwhile, students who have a kinesthetic learning style tend to solve problems briefly and correctly. Although no conclusions are added to the answer, in the interview these students are able to explain the conclusions of what has been completed. This shows that students are able to communicate mathematics in their own ways and learning styles.

Suggestions for this research are in determining research subjects who are constrained by conditions during the COVID-19 pandemic, that is, it is better if the research is carried out face to face with students at the time of taking initial data in determining research subjects so that researchers are able to see firsthand the condition of students in filling out a style questionnaire learn.

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