Mathematics communication skill of student in junior high school based on students thinking style

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Abstract. The characteristics of thinking styles that students have are different, among those characteristics were sequential concret (SK), sequential abstract (SA), random concret (AK), and random abstract (AA). These different in characteristics can further affect learning achievement, confidence, communication, and other activities. This research aims at analyzing student’s mathematical communication skills along with all four of thinking styles. This research is descriptive qualitative research. The data obtained from 32 students of junior high school in Nganjuk region with heterogeneous abilities by using the research instruments of written test, questionnaire, and interview. The result of mathematics communication skills revealed that students who were with SK and SA thinking styles, were capable of arranging similar conjecture, making arguments, exploring ideas, formulating generalization, however, they were having difficulty presenting mathematics in their own language. Meanwhile, students with AK and AA thinking styles were able in expressing ideas and formulating generalizations, however, they were having difficulties in establishing conjecture. In order to improve mathematics communication, the mathematics learning students are trained to work on math problems related to mathematics communication and the teachers are expected to deeply understand of student’s thinking styles characteristics which in turn enable teachers to provide appropriate treatment.

1. Introduction
Mathematics as a scientific discipline holds an important role in the development of world knowledge, technology and education. Nearly every level of education, mathematics has always been taught and becomes the standard for learner’s competence, especially those who are at the higher level of education where more complex mathematical material is begun to introduce. Therefore, mathematics education as commonly taught at schools is a typical mathematics education which enables the learners regulate their reasoning capacities, shape their personalities, in addition to solve problems, carry out tasks, and instill mathematical values in shaping student's character.

The main standards of mathematics subjects in primary and secondary education units indicates that one of the core objectives in learning mathematics is to enable students communicate mathematical ideas clearly [1]. The purpose of this learning is in accordance with common learning objectives of mathematics that students should achieve, these are formulated in the five main standards among others; problem solving, reasoning, communication, connection, and representation [2]. The standard curriculum process emphasizes that the objectives of mathematics identified as follows: (1) solving the existing problems including the ability to understand problems, design mathematical models, solve
models, and interpret solutions; (2) to communicate ideas with symbols, tables, diagrams, and other media as part of identifying specific situations or problems; and (3) to have an attitude in respecting the practical cases of mathematics in everyday life, which consists of having curiosity, concern and interest in learning mathematics, along with tenacity and trust in solving mathematical problems [3]. This shows that mathematics communication skills are very important as reflected in learning. Despite the fact that students' mathematics communication skills have not yet achieved the expected targets.

Student's low mathematics communication skills indicated from results of the 2015 International Student Assessment Program (PISA) survey which has surveyed the fields of mathematics, science, and language. In this case, Indonesia was ranked 62nd out of 70 countries. The 2015 PISA report notes that the average mathematics score of Indonesian students remains at very low of 386 compared to the international average score of 490. This shows that Indonesian students are still weak in solving non-routine questions. One of the fundamental skills requires to overcome such problem is mathematics communication skills.

Another study revealed that 58.54% students confront difficulties in working with student's worksheets (LKS), where this is closely related to student's competence in expressing mathematical sentences in addition to students’ lack of courage in asking for questions and responding to problems. Bearing the importance of the role of communication in mathematics learning and mathematical skills, which accordingly are relatively low in Indonesia. It should take into consideration that students' mathematics communication skills are highly necessary and important, it certainly makes easier for educators to determine the proper methods and models in coping with various problems which can ultimately lead to a positive impact on the improvement of students’ learning outcomes [5,6].

Bearing the importance of mathematics communication skills mastery to students, educators should at least comprehend factors underlying the student's low mathematics communication skill. These factors cover among others; internal factor (in students) and external factor (beyond students). Internal factor includes interest, motivation, learning style, thinking style and other factors affecting students, while external factor includes learning facilities and infrastructure, learning processes that tend to be less attractive, teacher's accuracy in selecting both learning approach and learning model, government policy, social environment, family and other affecting factors beyond the students.

Basically, internal factors such as student’s thinking style characteristics vary from one another and students’ personal abilities in being able to both master and understand the subject matter. The difference affects the way students think and communicate. In regard with how human’s brain master information and how the process takes over, Antony Gregorc in [7] noted that there are two possibilities of brain mastery, namely (1) concrete and abstract perceptions, and (2) sequential (linear) and random (nonlinear) regulation capabilities. These could be further integrated into four major groups of behaviors called thinking styles. Gregorc called it (1) concrete sequential (SK), (2) abstract sequential (SA), (3) concrete random (AK), and (4) abstract random (AA). Students should be able to know their thinking style for it is highly important to maximize students potential and modality of learning. The thinking style also greatly influences students’ success in determining steps to complete the learning goals. In solving problems, students who share different thinking styles shall have different ways of solving problems. This is not merely applicable to students; an educator should synergistically understand each student's thinking style to optimize the learning process. Thus, students can be properly educated through appropriate methods and models in overcoming various learning concerns and in turn can improve the learning outcomes [6].

The results [8] show that the junior high school student's weakness in visualizing mathematics ideas makes them feel difficult in overcoming the learning constrains, easily making mistakes in demonstrating mathematics ideas, much often found doing errors at the time of exploring mathematics terms and thus difficulties in expressing mathematics ideas in addition to use mathematics structures in part of presenting mathematics ideas. In this research, the researchers found interesting to conduct the research on junior high school student's communication skills from the students' thinking style characteristics point of view, as other researchers who came up with various research results regarding the influence of communication on student's mathematics learning achievement on mathematics lesson
[9,10]. In addition, there are also other researchers who decided to do studies on the influence of mathematics communication from the mathematics teacher's point of view at the time of teaching geometry [11]. In this research, the straight-line equation question is used. In addition to prospective teachers of mathematics' profile on mathematics written communication in mathematics proving [12], the mathematics teacher's profile and their ways in undertaking the classroom communication and guiding student's discussions [13], hence this study focuses on student's mathematics communication skills. Other researchers examined the comparison of learning models from student's styles point of view [14] and the research [15] thinking determines student's mathematics abilities on thinking style-based, while this research focuses on analyzing mathematics communication skills based on student's thinking style.

In this research, indicators of mathematical communication skill synthesized by Hodiyanto [16], Yang, Chang, and Cheng [17]. indicators to measure the mathematical communication skills level follows Hodiyanto’s model [16], Yang, Chang, and Cheng [17]. These indicators have attempted to analyze and provide ease in writing information obtained from mathematical symbols; understand mathematical equation and explore it in the mathematics language model; expressing idea, the situated mathematical objects of either oral or picture, graph and algebra; arranging conjecture, argument or formulating generalization on definitions; revealing mathematics sentence into the proper language.

2. Method
This research was designed through a descriptive-qualitative method. The method used in this research is a model in analyzing student's mathematics communication skills classified into SK, SA, AK, and AA thinking styles. Before choosing a subject, the subject was given a questionnaire related to thinking style in order to classify students based on patterns of thinking styles such as SK, SA, AK, and AA. Then, besides that, the subjects were given essay written tests with an allocation of 40 minutes and then interviewed them. This research was conducted at Junior High School 1 Nganjuk of Sukomoro under students heterogeneous-based abilities. The subjects in this research were four students from grade 8, selected using purposive sampling taken from 32 students with different thinking styles. Through this procedure, the researcher obtained data from the answer sheet in the completion of a written mathematics essay test that was narrowed down based on a particular topic namely 'straight line equations' in addition to the results of interviews with research subjects. Furthermore, to verify the credibility of the data, the triangulation method is used. Then the data were analyzed descriptively. Data analysis techniques in this study include: (1) reducing data, (2) presenting data, and (3) conclusion.

3. Result and Discussion
The results based on the questionnaire showed that of the 32 students who filled out questionnaires on thinking style, only seven students (21.88%) were characteristically SK-style, three students (9.38%) had SA thinking styles, eleven students (34.38%) have an AK thinking style, and eleven students (34.38%) have AA thinking styles. Based on the results of the analysis of 32 students, one of each thinking style was deliberately chosen as the subject of the study. The results of this study indicate the scores and percentages of students' mathematics communication indicators based on each student's thinking style as can be seen in Table 1 below.

Based on Table 1, students who have the thinking style characteristics of SK, SA, AK and AA can be classified into high, medium, and low categories based on the obtained percentage. It is including high category if the percentage is between 70.01%-100%, while medium category between 30.01%-70.00% and low category between 0% -30.00%. The following description is research result consisting of public description about students’ mathematics communication skill which has characteristics of thinking style SK, SA, AK and AA. However, students’ answers followed by interview to determine the subjects in solving mathematics communication skills describeable in the following:
### Table 1. Mathematics Communication Skill of Students Thinking Style

| No | Mathematics Communication Skill Indicators                                                                 | SK Score | %   | SA Score | %   | AK Score | %   | AA Score | %   |
|----|----------------------------------------------------------------------------------------------------------|----------|-----|----------|-----|----------|-----|----------|-----|
| 1  | Analysing and writing information obtained into mathematical symbols.                                      | 50       | 83.33% | 46       | 76.67% | 18       | 30.00% | 12       | 20.00% |
| 2  | Understand a mathematical equation and state it in the language of a mathematical model.                   | 47       | 78.83% | 50       | 83.33% | 23       | 38.33% | 17       | 28.83% |
| 3  | Expressing idea, mathematical situation oral or with picture, graph and algebra form.                        | 45       | 75.00% | 39       | 65.00% | 36       | 60.00% | 27       | 45.00% |
| 4  | Arranging conjecture, argument or formulating generalization definition.                                    | 50       | 83.33% | 43       | 71.67% | 43       | 71.67% | 45       | 75.00% |
| 5  | Revealing a mathematical sentence into its own language.                                                    | 10       | 16.67% | 8        | 13.33% | 8        | 13.33% | 25       | 41.67% |

![Figure 1](image-url)

**Figure 1.** Student’s answer with concrete sequential (SK) thinking style

On Figure 1 shows that the student was able to analyze and write information obtained into a mathematics symbol accurately by assuming $x =$ the number of hours of use and $y =$ the cost required (in thousands). This student found his thought quite systematic in expressing his ideas by using his own understanding on the mathematical model. The student can also express his ideas into graphs of straight line equations based on known points. Student can set expectation and formulate a definition of generalization by substituting the known $x$ value to find its $y$ value. However, the student is in difficult
of expressing his conclusion through his own language. This is in line with his opinion who says that: "I am confused about having to write what sentence to conclude, and I just write down the final results of the required costs". This means that this student was not able to express mathematical sentences in his language.

Figure 2. Student’s answer with abstract sequential (SA) thinking style

Figure 2 shows that student was able to analyze and write information obtained into a mathematical symbol by assuming \( x \) = the number of hours of use and \( y \) = the cost required (in thousands) accurately well. Student was quite good in expressing his ideas by stating what is known in the mathematical model. At this point, students are able to express their ideas into a graph based on straight line equations obtained. However, this student was found not to draw charts based on the known point. This is in accordance with the student statement which says: "I do not use the known point to draw an equation graph of a straight line for I think to draw a graph of a straight-line equation by determining in advance the intersection of each axis". This means that the student is able to explore his ideas in graphical form using different ways. The student can set expectations and formulate a definition-based generalization by substituting the known \( x \) value to seek its \( y \) value. However, this student was not able to express his
conclusion through his own language. This is according to the student’s expressed statement: "I think finding the $y$ value is the final conclusion of the solution to this problem". Means this student thinks that by finding the value of $y$ then it becomes the conclusion of the problem solving. Simply, this student was not able to express mathematical sentence in his language.

![Figure 3](image)

**Figure 3.** Student’s answer with concrete random (AK) thinking style

Figure 3 shows that the student’s lack of capability in both analyzing and writing information obtained into mathematical symbols. However, this student wrote down the known points. It is according to the student’s statement who said: "I am confused about what $x$ and $y$ are, however, I understand from the arrangement of numbers which make them seem to be the known points". In this regard, the student may not be was completely unable to write information into a mathematics symbol. The student was actually able to express her ideas by stating what is known to the mathematical model. The student may also express his ideas into graphs of straight-line equations based on the known points despite the fact it remains less accurate. Student can set expectation and formulate a definition of generalization by substituting the known $x$ value to find its $y$ value. However, this student cannot expressing his conclusion in his own language. It is according to the student’s statement who said: "I am confused about arranging the conclusion sentence, so I just wrote like that to answer it". This mean student cannot expressing mathematics sentence into his own language.
Figure 4 shows that students are less able to analyze and write down all the information obtained into a mathematical symbol systematically. However, this student only wrote down two known points. It is according to the student’s statement who said: “I am confused about what $x$ and $y$ are, but I understand from the arrangement of numbers that are known to be the points, and I only write two points because to determine the straight line equation requires only two points”. Student is less systematic in expressing his ideas by stating what is known into the mathematical model to determine the equation of the straight line. Students directly determine the equation of the straight line without writing the formula first. It is according to the student’s statement who said: "I directly determine the equation of the line, because I don't think it's necessary to write the formula first”. Means it can be said that this student is lacking in expressing his idea by stating what is known in mathematics models. Student can also expressing his ideas into graphs of straight line equations based on known points although less accurate. Student can set expectations and formulate a definition of generalization by substituting the known $x$ value to find its $y$ value systematically. Student can expression a conclusion back into their own language even if only a little, which means that student can a little express mathematical sentence into his language. It is according to the student’s statement who said: "I just write the conclusion that the $y$ value that is sought is 175 in thousands which mean 175,000, but I don't explain what the meaning of $y$ is”. This means student can expressing a little mathematics sentence into his own language.

From the analysis of student's answer sheets of SK, SA, AK, and AA, a conclusion can be derived that students with SK and SA thinking style were proven to be better in mathematics communication than those who were in AK and AA thinking style. Students who with SK thinking style were better than those with SA thinking style and students who with AK thinking style were better than those with AA thinking style. This is according to the research which states that "learning achievement of students
who have SK, SA, AK, and AA thinking styles are significantly different, students with SK thinking style have better learning achievement than students with SA thinking style [18]. This is also supported that “there is a significant difference between students thinking style and their proof writing [19]. In addition, there are differences in average mathematical abilities obtained from the IPK of students in each style of thinking and are in a very satisfactory category [15]. If we see in Table 1, every person had the high, medium, and low presentation. Student with AK and AA thinking style same expressing idea and formulate generalization, but having difficulty make conjecture. AK student was better at making arguments than AA student, while AA student was better at presentation of mathematics in own language than AK student. This is different from SK and SA students. Student SK and SA thinking style, can arrange conjecture same, make an argument, explore their ideas, formulate generalization, but be having difficulty in understanding a mathematical presentation and make an argument and presentation of mathematics in their own language. While SK student was better an exploring ideas and formulate generalization than SA student.

4. Conclusion
The analysis result above give an overview that student's mathematics communication skill with SK and SA thinking style were better than those with AK and AA thinking style. However, student with SK thinking style were better than those with thinking style and student with AK thinking style is better than those with AA thinking style. Basically everyone has advantage and disadvantage. Student AK and AA thinking style, same expressing idea and formulate generalization, but having difficulty make a conjecture. AK student was better at making arguments than those student with AA, while students with AA was better at presentation mathematics in their own language than those with AK. Student were SK and SA thinking style, can arrange conjecture same, make an argument, explore their ideas, formulate generalization, but be having difficulty in understanding a mathematics presentation and make an argument and presentation of mathematics in their own language. While SK was found better an exploring ideas and formulating generalization than students with SA. Therefore, those who are in charge of overcoming the weaknesses of students with SK, SA, AK, and AA thinking styles were firstly not only students, teachers too were expected to be able to understand each student’s thinking style characteristics, secondly students should be given training exercises in coping with the mathematics problems, and thirdly teachers need to privately report students’ work results and question them on the confronting difficulties, therefore, teachers need to approach each student personally and provide solutions to their difficulties. This is done in order that teachers can provide appropriate resolutions both each student’s difficulties and mathematics communication skills.

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