Analysis of Students' Mathematical Communication Ability Based on Kolb's Learning Styles of Converger and Diverger Type

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Abstract. Mathematical communication ability is an ability that every student must have. Without mathematical communication ability, students will not be able to convey their mathematical ideas to others. This research aims to describe a mathematical communication ability of students who have Kolb’s Learning Styles of converger and diverger type. This study used a qualitative descriptive method. The subjects of this research are 8th grade Junior High School students who were selected using purposive sampling. The data from this research were obtained from Kolb’s learning style questionnaire, mathematical communication test, and an interview. The data validity used the triangulation method. The data analysis was performed through data reduction, data presentation, and conclusion. The result shows that the converger type student can express mathematical ideas through writing and to visually describe it, able to interpret the ideas by writing steps of problem-solving sequentially and systematically, and able to use mathematical notations in writing problem-solving. While the diverger type student is able to express mathematical ideas through writing and to visually describe it, and able to use mathematical notations in writing problem-solving.

1. Introduction
Mathematics is a fundamental science, therefore, it is important to learn it. Mathematics is considered as beneficial for students to follow higher-level learning or to solve everyday life problems [1]. There are concepts, facts, understanding, as well as a principle in mathematics which have ordinary to concrete characters of problem-solving. Learning mathematics means learning how to think systematically, analytically, and logically. The success or failure of a person in learning mathematics is indicated by the ability to solve the problems they face. Mathematical ability according to the National Council of Teacher of Mathematics (NCTM) is a problem-solving ability, reasoning and proof ability, communication ability, connection ability, and representation ability [2].

Mathematics is not only a thinking aid, finding patterns, solving problems, or drawing conclusions, but also as a language or a tool in communicating various kinds of ideas appropriately, concise, and clear [3]. In mathematical learning, mathematical communication ability is an important thing that
students must have. If students have good mathematical communication ability, they could be able to present ideas and strategies for solving math problems clearly [4]. The student will be able to use their mathematical ideas and will be able to understand problem-solving explained in both written and oral. Aside from that, mathematical communication ability can help students to construct meaning, when students must provide reasons and express their ideas [5].

In reality, students' mathematical communication ability is not maximal. This can be seen when researchers conducted observations in SMP Negeri 3 Kalasan. When students were faced with questions, it appeared that some students actually understood the meaning of the given questions but faced difficulty in communicating their mathematical ideas. As a result, students couldn't solve the problems and explain the right answer. Students' ability in communicating their mathematical ideas presumably related to the learning way or style of students in absorbing, processing, and arranging the information obtained during learning. Teachers could see the communication ability of students based on their learning styles because in communicating mathematics, students have different styles [6].

Learning style is a way for an individual to start to concentrate, process, internalization, and retain new and difficult information, students use a different approach in observing and processing information [7]. Learning styles have been shown to play an important part in the learning process [8]. Learning styles are considered as one of the most important factors which must be taken into account when designing teaching and learning environments [9]. This is because everyone has their own learning styles that determine how they interact with their learning environment. Learning styles affect students' mathematical communication ability [10]. Different kinds of learning styles of students have different mathematical communication abilities as well.

In the learning process, a teacher must understand and knows the learning styles of each of his/her students, so the learning can be appropriate and meaningful. Students who learn by their learning styles will receive the taught materials faster. On the contrary, if students' learning styles are not by the learning process, it will be hard for students to understand the materials. As a result, it will be hard for students to concentrate, be bored, and lazy to learn. According to David Kolb, there are four types of learning styles, which are converger, diverger, assimilator, and accommodator [11]. Fatkhiyyah in her research stated that the mathematical communication of students in each learning style has significant differences between one learning style to the others [12].

This research is focused on 8th grade students of SMP Negeri 3 Kalasan who had previously obtained 'circle' material, so it is easier for researchers to conduct the research that aims to describe the mathematical communication ability of students with converger and diverger types of learning style.

2. Method
This research uses a descriptive qualitative method. The research was conducted on 8th grade students of SMP Negeri 3 Kalasan in the 2019/2020 school year. The selection of subjects used purposive sampling since not all of the samples have criteria that match the studied phenomenon. The sample in this study consisted of four students, namely two students with a converger type of learning style and two students with a diverger type learning style.

The main data sources in qualitative research are words and actions, the rest data such as documents and others are additional [13]. The data and the sources of data in this research are Kolb's learning style questionnaire data, the data test of mathematical communication ability, and students' interview data. Kolb's learning style questionnaire was used to find out the type of learning style for each student. While to find out the mathematical communication ability of students, they were tested with descriptive questions which consist of mathematical communication ability indicators. Kolb's learning style questionnaire instrument and mathematical communication ability test questions have been validated by three lecturers, so they can be used to measure students' learning styles and students' mathematical communication ability. The technique of data validation in this research used the triangulation method, which is to compare the results of mathematical communication tests and interviews. The technique of data analysis used in this study is data reduction, data presentation, and concluding. This research is
focused on written mathematical communication ability based on the indicators of NCTM [2], the indicator description shown in Table 1.

Table 1. Description of mathematical communication ability indicator

| No | The mathematical communication indicators | Description of indicator |
|----|-------------------------------------------|--------------------------|
| 1. | Ability to express mathematical ideas through oral and written, demonstrate, and describe them visually | (1) Express mathematical ideas by writing down the known information and the asked problem  
(2) Describe ideas visually based on the information obtained from the problem |
| 2. | Ability to understand, interpret, and evaluate mathematical ideas both orally and in other visual forms | (1) Understand and interpret ideas by writing strategies and steps for problem-solving coherently and systematically  
(2) Evaluate ideas by writing a conclusion at the end of problem-solving |
| 3. | Ability to use terms, mathematical notations, and structures to present ideas, describe relations, and model situations | (1) Using mathematical notations in writing problem-solving |

The steps in this research are as follows: distributing Kolb's learning styles questionnaire to students, classify students into two categories of converger and diverger type of Kolb's learning styles, distribute mathematical communication ability test to students, analyze the results of students' work, conduct an interview with students, and analyzing interview result.

3. Result and Discussion

The students were selected based on the results of the questionnaire and the consideration of the mathematics teacher. The results of the students' mathematical communication ability test for each type of Kolb learning style are as follows.

3.1. Converger

Converger type learning styles combine abstract conceptualization approaches and active experiments. Students who have a converger type of learning style tend to have good abilities in setting goals, solving problems, and making decisions [14]. Subjects with a converger-type learning style in this study were Subject 1 (S1) and Subject 2 (S2). The results of their work are as follows.

Based on Figure 1, the work result of S1 showed that the student does not experience difficulties in understanding and solving the problems given. The subject can write down what is known and asked, then describe it geometrically and write mathematical notations on the drawing made. The problem-solving strategy used is coherent and systematic. Starting from taking examples, then applying the common external tangent formula correctly. Furthermore, the subject applied the concept of elimination and substitution to find out the radius of the two circles. Lastly, the subject searched for the distance between the two circles using the correct formula, so that the result was also correct. The student with a converger type has a good ability in solving problems and making decisions based on solutions from their own thoughts [15].
Based on the interview, S1 confirmed their work result coherently and clearly. As written, the subject explained that the purpose of the problem is to determine the radius and the distance of the two circles. Aside from that, the subject is also able to appropriately describe the strategy and problem-solving steps used. However, the subject did not write a conclusion at the end of the problem-solving by writing the results of the radius length and distance of the two circles that have been obtained. When asked what the reason was, the subject said that they were not used to concluding the results of the solutions.

Figure 1. Converger type student’s work (S1)

Figure 2 shows that the work results of S2 are not much different from S1. The subject writes down information about what is known and asked about the problem. Then interpret the idea into a complete drawing by writing mathematical notations on the picture by writing mathematical notations on the
drawing. The subject uses the same concept, which is using the elimination and substitution in finding the radius of the two circles. The subject simplifies the results obtained by converting the fractions to whole numbers. However, in using the formula to find the distance between the two circles, the subject made a little mistake, which is on the $r_2$ operation mark, if it does not use brackets is supposed to be $- r_2$ not $+ r_2$. This resulted in an incorrect answer.

Based on the interview with S2, the subject explained the problem-solving process clearly and coherently. But when the subject asked how to find the distance between the two circles, the subject answered by applying the $L - r_1 + r_2$ formula, the same as what the subject wrote on the answer sheet. If you look closely at the explanation, the subject does not know the mistake in the formula the subject used. the formula is supposed to be $L - (r_1 + r_2)$. Although it only differs in the brackets, it has a major effect on the calculation. As a result, the answer is incorrect. The subject is not thorough at the final problem-solving stage. Converger types are generally better equipped to find technical ideas at the beginning of problem-solving [16]. This can be seen from the results of the subject's work who answered correctly on the first problem, namely finding the length of external common tangent.

3.2. Diverger

The diverger learning style combines the concrete experience approach and reflective observation. Divergers tend to use their imagination to gather information to solve problems [17]. Subjects with a diverger-type learning style in this study were Subject 3 (S3) and Subject 4 (S4). The result of their work is as follows.

![Figure 3. Diverger type student’s work (S3)](image)

Figure 3 showed the work result of S3. The student can express ideas by writing down what is known and ask, and describe their ideas correctly. On the geometry image that has been made, there are mathematical notations written correctly. Nonetheless, the concept used by the subject in solving the problem is incorrect. The mistake occurs when using the $x^2$ symbols which are supposed to be $(x_1 - x_2)^2$, but because the writing is not spelled out, it resulted in the next step of problem-solving, where the final result becomes incorrect as well.
Based on the interview, S3 clearly described the problem-solving steps the subject used. When the subject was asked what the written \((x)\) variable means, the subject said that \((x)\) is an example for the diameter of the circles. When the subject asked if \((x)\) already represents the diameter of circle \(G\) and \(H\), the subject answered that \((x)\) is equal to the diameter of \(H\). If we look at the explanation, it can be seen that the subject does not understand the concept of the circle used to solve the problem. The problem-solving procedure in the initial step used was incorrect, so the subsequent problem-solving was also incorrect. The thinking process of diverger type students in solving mathematical communication problems has difficulty with concepts and procedures [18]. This agrees with Sharp who states that diverger are weak in solving knowledge problems that contain concepts, procedures, or principles [19].

\[
\begin{align*}
\text{Known:} & \quad d_G + d_H = 30 \text{ cm} \\
\text{The length of external common tangent:} & \quad P = 24 \text{ cm} \\
\text{The distance between the centers of two circles:} & \quad Q = 26 \text{ cm} \\
\text{Asked:} & \quad \text{radius and distance between two circles?} \\
\text{Answered:} & \quad P^2 = Q^2 - (R_G + r_H)^2 \\
& \quad 24^2 = 26^2 - (5 + 10)^2 \\
& \quad (R_G + r_H)^2 = 676 - 100 = 576 \\
& \quad (R_G + r_H)^2 = 100 \\
& \quad R_G + r_H = 10 \text{ cm} \\
\text{The distance between two circles:} & \quad 26 - 10 = 16 \text{ cm}
\end{align*}
\]

Figure 4. Diverger type student’s work (S4)

Figure 4 is the work result of S4. The subject wrote the problem information by writing down what is asked and known, then described it geometrically by writing mathematical notations in it correctly. In the initial steps of problem-solving, the subject is incorrect in applying the concept. The subject wrote the common external tangent formula with \(P^2 = Q^2 - (R_G + r_H)^2\), where the formula should be used to find the common internal tangent. The correct formula to find the common external tangent formula is \(P^2 = Q^2 - (R_G - r_H)^2\). Since the initial step is incorrect, when the subject searched for the distance between two circles, the result of the calculation was also incorrect.

Based on the interview with S4, the subject clearly explained the problem-solving steps they used. Starting from the example, which was the diameter example, the common external tangent, and the distance between the centers of two circles. Seeing the results of the subject's work, the subject did not write down the known diameter in the problem-solving step that the subject wrote down. When the subject asked what the reason was, the subject explained that they had difficulty understanding the problem. If we look closely, the result of the subject's work was incorrect since the first step in applying the formula for the problem was also incorrect. The subject drew it correctly, but the formula the subject used was incorrect. Hence, the subject had difficulty in problem-solving procedures.

Based on the results of the subject's work, researchers can see that the students' mathematical communication ability for circle material is not yet optimal. Students with a converger type of learning style can solve problems well but do not write conclusions at the end of problem-solving. While the diverger type of learning style students are unable to solve problems because of their lack of understanding of the circle material concept. According to Kolb, the diverger type is less able to identify problems correctly, only likes to collect information, and is interested in imaginative problems [20]. Rokhima in her research stated that students' converger type of learning style is better than the diverger
type of learning style. This is because the converger type learning style focuses more on applying ideas and concepts practically, to quickly get answers and make the right decisions [21]. This concurs with the results of Damavandi's study which showed that the converger group was superior to the diverger group [22].

4. Conclusion
Based on the research result and its discussion, we could conclude that the mathematical communication ability of students who have converger type and diverger type of learning styles are different. Students with a converger type of learning style able to express their mathematical ideas by writing down the known and asked information in the problem can describe ideas visually based on the information obtained from the problem, able to understand and interpret ideas by writing strategies, and steps of problem-solving coherently and systematically, and able to use mathematical notations in writing problem-solving. While the students with diverger types of learning styles are able to express their mathematical ideas by writing down the known and asked information in the problem, able to describe ideas visually based on the information obtained from the problem, and able to use mathematical notations in writing problem-solving.

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