Students' mathematical communication ability using 7E learning cycle based on students thinking style

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Abstract. The aim of this research is to find out the effect of learning models, students thinking style, and interaction between the learning model and students thinking style on students' mathematical communication ability. This research was quasi-experimental research with factorial design 2×4. The population of research was all students of the eighth-grader in the Nganjuk regency of Junior High School in academic year 2018/2019. The sample of research consists of 184 students. The data in the research were two ways of analysis of variance with unequal cells, with the 5% level of significance. The results of the research were as follow: (1) The 7E learning cycle provides better mathematical communication ability than the direct learning; (2) Students with SK and SA thinking style was better mathematical communication ability than AK and AA; (3) In each type of learning model, students with SK and SA thinking style have mathematical communication ability that was better than AK and AA; (4) In each students thinking style, students taught using the 7e learning cycle provide better mathematical communication ability than direct learning. 7E learning cycle can be used to improve the mathematical communication ability of junior high school students based on their thinking style.

1. Introduction
The one of basic sciences whose important role in various life aspects is mathematics [1]. Mathematics is one of the subjects that has an important role in education. Almost, at every level of education, mathematics is always taught. The higher the level of education pursued, the more discussed mathematical subjects are more complex. The content standard for elementary and secondary education units in mathematics subjects states that one of the objectives of mathematics learning is so that students have the ability to communicate mathematical ideas clearly [2]. These objectives are in accordance with the general objectives of learning mathematics that must be achieved by students which are formulated in the five main standards, namely problem solving, reasoning, communication, connection, and representation [3].

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 [4]. This shows that mathematical communication skills are very important reflected in learning.
The 2015 Program of International Students Assessment (PISA) survey which surveyed the fields of mathematics, science and language showed Indonesia ranked 62 out of 70 participating countries with a score of 403 from the average international score of 493 [5]. This shows the ability of Indonesian students to solve questions in the form of study questions, give reasons, communicate, and solve and interpret various problems are still low, so that the mathematical communication ability of Indonesian students are still not as expected.

The importance of mathematical communication ability makes an educator must understand the factors that can affect the students' low mathematical communication ability. Factors that can influence these include internal factors (in students) and external factors (outside of students) [6]. In this study internal factors such as students' thinking styles, while external factors such as the accuracy of the teacher in choosing the learning model.

Internal factors such as thinking styles that can affect student learning, this must be understood by the students themselves and the teacher. Basically the way children think in understanding, mastering, and communicating information is different. The dominance of the brain and how information is processed between students is also different. Antony Gregorc in concluded that there were two dominance of the brain namely [7], (1) concrete and abstract perceptions, and (2) the ability to regulate sequentially (linear) and random (nonlinear). This can be combined into four combinations of thinking style behaviour groups. Gregorc calls these styles with (1) concrete sequential (SK), (2) abstract sequential (SA), (3) concrete random (AK), and (4) abstract random (AA) [6].

Not only students, an educator must also know each student's thinking style to maximize learning. Students' mathematical communication ability are low because there are external factors such as the learning process that is less interesting because of the inappropriate choice of learning models. Therefore, learning needs to be arranged in schools that can develop and improve students' mathematical communication ability [8]. One of the lessons that can be used to improve mathematical communication is constructivist learning [9].

In constructivism learning, teachers can design teaching in accordance with learning subject so that students' understanding of the subject will last long [10]. One model of constructivism learning is the 7E learning cycle. The 7E learning cycle model is a student-centered learning model consisting of seven phases. They are elicit, engage, explore, explain, elaborate, evaluate, and extend [11-22]. This is evident from the Jati's research which shows that the 7E learning cycle model is effective in improving students' mathematical communication ability geometry subject [12].

The other research shows that the 7E learning cycle model is better than other learning including Balta's research shows that the 7E learning cycle is useful for science curricula [23]. Khaskan's research shows that 7E learning cycles are better than traditional methods on student mathematics learning achievement [24]. Shaheen's research that shows student achievement in biology lessons taught with 7E learning cycles is better than traditional learning [25].

There is also a Siribunnam's research which states that the 7E learning cycle model is better than conventional towards learning achievement in chemistry learning [26]. Sarac’s research about evaluating multimedia applications uses the design of the 7E learning cycle model on student opinions [14]. Firdaus's research on the implementation of the 7E learning cycle model to improve students' self-esteem which shows there are significant differences in students learning with the 7E learning cycle model compared to students who get conventional learning [15].

Based on previous studies, it has been shown that the 7E learning cycle model is effective for improving mathematical communication ability and learning outcomes, so the researchers intend to try to apply the 7E learning cycle model in their research to improve mathematical communication skills based on their own student thinking styles.

Indicators of mathematical communication ability in this research were synthesized from Hodiyanto [27] and Yang, Chang, and Cheng [28]. These indicators analyse and write information obtained into mathematical symbols; understand a mathematical equation and express it in the language of a mathematical model; express mathematical ideas and situations graphically; arrange conjectures,
compile arguments or formulate definitions of generalization; and re-express a mathematical sentence into its own language.

Based on the previous explanation of the problem formulation in this research are as follows: (1) which learning model provides better mathematical communication ability between 7E learning cycle learning model or direct learning model ?, (2) which students' SK and SA thinking style AK, and AA that have better mathematical communication ability ?, (3) In each type of learning model, which students with thinking styles have better mathematical communication ability between students with SK, SA, AK, and AA thinking style? (4) In each characteristic of thinking style, which one has better mathematical communication ability between students taught using the 7E learning cycle learning model or direct learning model?

2. Experimental method
This research is a quasi-experimental research with a 2 × 4 factorial design. The population of this research is all eighth grade students of SMP in Nganjuk Regency in the 2018/2019 academic year. In the population three school samples were taken using the stratified cluster random sampling technique. Each of these two schools was chosen as the experimental class and the control class as the research sample. The research sample consisted of 184 students. The experimental class was given learning with a 7E learning cycle model and the control class was given direct learning.

The method of data collection includes 2 methods, namely the test method used to obtain the initial and final data on students' mathematical communication ability, while the thinking style questionnaire is used to determine the students' thinking styles. The instrument was validated by the mathematics education lecturer at Sebelas Maret University and several lecturers from the Kediri State Islamic Institute (IAIN Kediri). The instrument has been tested and analysed. Instrument analysis consisted of reliability testing using the Kuder-Richardson technique or KR-20 technique. Reliability values are used to describe the use of an item in a measurement. The results of the instrument analysis were \( r_{11} = 0.854 \). This means that the measurement results have a reliability index of 0.70 or more so the instrument can be used for measurement [12].

The initial analysis was conducted to determine whether the two samples came from the same initial conditions. In the initial analysis using the normality test by Liliefors, homogeneity test with Bartlet test, and balance test with T-test. In the final analysis before variance analysis, Liliefors normality test was used, homogeneity test with Bartlet test, balance with T-test, and then testing hypothesis with an analysis of two-way variance with unequal cells.

3. Result and discussion
This research is about the application of the 7E learning cycle model in mathematics learning subject in straight line equation 8th-grade junior high school based on his thinking style. Before conducting research, researchers first take the initial data mathematical communication ability from the test scores of the first mathematical communication ability using the test method and students' thinking styles using the questionnaire method. The final data of mathematical communication ability obtained by the test method after the two classes were treated with different learning models. The initial and final data analysis of mathematical communication ability is explained as follows:

3.1. The preliminary data analysis of mathematical communication abilities
In this research, the analysis of the initial data was taken from the results of the results of the first mathematical communication ability test before the class was given treatment with different learning models. Usually tests are used to find out whether the sample data from the population is normally distributed or not. The results of the normality test in the experimental class and control class are in Table 1 with a significance level of 5%.
Table 1. The result of normality test of mathematics communication ability.

| Group                        | L_{obs} | L_{table} | Decisions       | Conclusion |
|------------------------------|---------|-----------|-----------------|------------|
| Experimental (Learning cycle 7E) | 0.060   | 0.090     | H_{0} accepted  | Normal     |
| Control (Direct learning)    | 0.090   | 0.094     | H_{0} accepted  | Normal     |

Based on Table 1 shows the L_{obs} of the experimental class normality test of 0.060 and the control class of 0.090 no more than L_{table}. In both L_{obs} values obtained are no more than L_{table}, so the decision taken was to accepted H_{0}, meaning that data from both sample classes of the population are normally distributed.

Mathematical homogeneity test used to determine whether population data has the same variant or not. This variance homogeneity test uses the Bartlett test. The results of homogeneity tests are shown in Table 2 with a 5% significance level as follows.

Table 2. The result of homogeneity test of students’ mathematical communication ability.

| Learning Model | K | X_{obs}^2 | X_{(0.05; k−1)}^2 |
|----------------|---|-----------|--------------------|
| 7E             | 3 | 3.596     | 5.991              |

Table 2 show X_{obs}^2 homogeneity test of 3.596 no more than X_{table}^2. The value of X_{obs}^2, \((\neq DK)\), so that the decision taken is to accept H_{0}, meaning that the data from the two sample classes have the same variance. The results of the t test are obtained by t_{obs} = -1,298 while t_{table} or t_{(0.025;182)} = 1.960. The value t_{hitung} < t_{table} so t_{obs} \((\neq DK)\). That the decision taken is to accept H_{0}, it can be said there is no difference in the two classes. Both classes have the same initial abilities. Furthermore, both classes were treated for the experimental class given 7E learning cycle learning and for the control class were given direct learning.

3.2. Final data analysis mathematical communication ability

In this research, the analysis of the final data was taken from the second mathematical communication ability test after the class was given treatment with different learning models. The test is used to determine whether the sample data after being treated is data from a population with normal distribution. In this research, the normality test used the Lilliefors test. The results of the normality test samples after being given treatment are in Table 3 using a 5% level of significance.

Table 3. Normality test of communication mathematics ability on final test.

| Group                        | L_{obs} | L_{table} | Decisions       | Conclusion |
|------------------------------|---------|-----------|-----------------|------------|
| Experiment (Learning cycle 7E) | 0.085   | 0.090     | H_{0} accepted  | Normal     |
| Control (Direct)             | 0.092   | 0.094     | H_{0} accepted  | Normal     |

Based on Table 3 shows that L_{obs} for each sample were no more than L_{table}, so that \((\neq DK)\). The decision taken was accepted H_{0}, meaning that the final test data for mathematical communication ability for each sample from the population was normally distributed.

The homogeneity test is used to determine whether the population data has the same variant or not. The homogeneity test of the variants of the two classes used the Bartlet method. The homogeneity test results of variance with a significance level of 5% are shown in Table 4. Based on Table 4 X_{obs}^2 < X_{table}^2 is seen, so that \((\neq DK)\). The decision taken is to accept H_{0}, meaning that population data has the same variance or homogeneity.
Table 4. Homogeneity final test of communication mathematics ability.

| Groups            | K | $X^2_{obs}$ | $X^2_{(0.05;k–1)}$ | Decisions | Conclusion                      |
|-------------------|---|-------------|---------------------|-----------|---------------------------------|
| Learning Model    | 3 | 2.354       | 5.991               | $H_0$ accepted | Various Homogeneity Population |
| Thinking Style    | 4 | 0.026       | 7.815               | $H_0$ accepted | Various Homogeneity Population |
| SK                | 3 | 2.856       | 5.991               | $H_0$ accepted | Various Homogeneity Population |
| SA                | 3 | 0.249       | 5.991               | $H_0$ accepted | Various Homogeneity Population |
| AK                | 3 | 1.262       | 5.991               | $H_0$ accepted | Various Homogeneity Population |
| AA                | 3 | 2.098       | 5.991               | $H_0$ accepted | Various Homogeneity Population |

The results of the t-test are obtained by $t_{obs} = 6.795$ while $t_{table} (0.025;182) = 1.960$. Value of $t_{obs} > t_{table}$, so that $DK$. The decision taken is to reject $H_0$, it can be said that there are differences in the two classes. Both classes have mathematical communication ability that are not the same. Next, the hypothesis testing is carried out by analyzing the variance of two paths with unequal cells as follows.

Table 5. Summary analysis test of two ways analysis of variance with unequal cells.

| Source             | JK | dk | RK | $F_{count}$ | $F_a$ | Decision Test |
|--------------------|----|----|----|-------------|-------|---------------|
| Learning Model (A) | 1246.378 | 1 | 1246.378 | 48.408 | 6,630 | $H_{0A}$ Rejected |
| Thinking Style (B) | 460.824  | 3 | 153.608  | 5.966  | 3,780 | $H_{0B}$ Rejected |
| Interaction (AB)   | 49.517   | 3 | 16.506   | 0.641  | 3,780 | $H_{0AB}$ Accepted |
| Galat             | 4531.492 | 176 | 25,747 |         |       |               |
| Total             | 6288.211 | 183 |         |         |       |               |

Table 6. The marginal average of communication mathematic ability.

| Learning Model | Thinking Style | Marginal Average |
|----------------|----------------|------------------|
|                | SK             | SA               | AK    | AA    |
| Learning Cycle 7E | 86,350 | 83,000 | 81,179 | 80,160 | 82,672 |
| Direct Learning   | 78,250 | 77,714 | 75,686 | 74,933 | 76,646 |
| Marginal Average  | 82,300 | 80,357 | 78,433 | 77,547 |        |

Based on Table 5, it can be seen that $F_a = 48.408 > F_{0.05;1;176} = 6,630$ so that $F_a \in DK$, in this case means $H_{0A}$ is rejected. This means that there are differences in mathematical communication ability between students who are treated using 7e learning cycle learning model or direct learning model. To answer the first hypothesis can be seen from the average value of mathematical communication ability in Table 6 showing the mathematical communication ability of students treated with 7E learning cycle learning better than direct learning. It can be concluded that the 7e learning cycle model provides better mathematical communication skills than the direct learning model.

In Table 5 show $F_b = 5.966 > F_{0.05;3;176} = 3,780$, so that $F_b \in DK$, in this case $H_{0B}$ is rejected. This means that there are differences in mathematical communication ability between students who have SK, SA, AK, and AA thinking styles. To answer the second hypothesis can be seen from Table 6 which shows the mathematical communication ability of students with SK and SA thinking styles better than students with AK and AA thinking styles. It can be concluded that students with SK and SA thinking styles have better mathematical communication ability than students with AK and AA thinking styles.

Table 5 shows $F_{ab} = 0.641 < F_{0.05;3;176} = 3,780$, so that $F_{ab} \notin DK$, in this case $H_{0AB}$ can be accepted. This means that there is no interaction between the learning model and students' thinking style towards students' mathematical communication ability. This shows that the influence of thinking styles on mathematical communication ability does not depend on the learning model. To conclude the third hypothesis can be related to the first and second hypotheses. Based on the first, second, and marginal hypotheses in Table 6 for each type of learning model (7E and direct learning) SK and SA thinking
styles have mathematical communication ability that are better than students with AK and AA thinking styles.

Because $H_{0AB}$ is accepted, it means there is no interaction between thinking styles and learning models on students' mathematical communication ability. This shows that the influence of the learning model on mathematical communication ability does not depend on the style of thinking. To conclude the fourth hypothesis and see the relationship of each style of thinking with the learning model refers to the first and second hypotheses. From the conclusion of the first and second hypotheses, it was found that the mathematical communication ability of students in each thinking style (SK, SA, AK, and AA) of the 7E learning cycle model produced better mathematical communication ability than the direct learning model.

In learning using 7E learning cycle, there are steps that can improve mathematical communication ability. These steps include: (1) elicit, where the teacher gives a statement that stimulates students' initial knowledge, students answer the teacher's statement according to their understanding; (2) engage, an interesting step that teachers use to motivate students by explaining the benefits of learning the straight line equation subject in real life. Students enthusiastically observe and listen to the teacher's explanation; (3) exploration, the teacher provides an opportunity for students to observe and analyse the position of two lines. The process of observing the position of the two lines, students independently observe two lines given by the teacher to find out their position; (4) explain, the teacher gives assignments to students to convey their findings in the exploration phase. Some students actively convey their ideas about the position of two lines to all students and teachers in the class, while some students express different opinions; (5) elaborate, the teacher gives students the opportunity to apply existing straight line equation formulas to answer some story questions. Students answer a number of questions given by the teacher in the matter of straight-line equations. Some students discuss to answer the problem; (6) evaluate, the teacher checks the understanding of students by giving assignments to students as a form of practice workmanship questions and assessment of learning. Each student works on the teacher's task of learning in the matter of straight-line equations; and (7) extend, the teacher provides several examples of applications for applying straight line equations to more complex problems. Students pay attention to the teacher about examples of the application of straight line equations. Next, students try to solve subject problems with straight line equations.

Based on the first and second steps students' initial knowledge begins to appear. Students with 7E learning cycle get initial knowledge that will help them build further knowledge [24]. Each student will be creative to find subject concepts based on students' initial knowledge. Students' initial knowledge makes it easier for students to receive information about the subject being taught and can solve problems based on their knowledge. Students can express mathematical ideas in writing.

In describing and evaluating the steps used by students to practice that is by applying learning subject that has been obtained to solve the problems given by the teacher. In the next step, students can learn more broadly and complex. Some steps of learning cycle 7E make students more active in learning, students are better able to communicate ideas about the subject being studied, and students better understand the subject being studied, so that students' mathematical communication ability become better. Polyiem states that the 7E learning cycle is beneficial for students. Student learning abilities can increase. Students gain new knowledge through various learning resources. Students become able to apply learning models in real life [26].

The control class is given direct learning to students. The steps in direct learning include: (1) the first step, the teacher prepares students to learn and conveys the purpose of learning the subject of straight-line equations. Students prepare to do learning and listen to explanations from the teacher; (2) the second step, the teacher explains to students about the subject of straight-line equations. Students see and listen to the teacher's explanation of the subject of straight line equations; (3) the third step, the teacher gives an example and guides students to work on the subject of a straight line equation. Students follow the example explained by the teacher; and (4) the last step, the teacher gives assignments to students as a learning assessment in the subject of straight line equations and students do the assignments given by the teacher. These learning steps make students passive, making students only take notes, listen and
rarely ask the teacher. Students don't have enough discussion with other friends. The teacher is very dominant and students are not asked to be active in the learning process. Some students experience saturation and not the spirit of learning in direct learning.

The results of this research are in line with Jati's research which shows that students' mathematical communication ability using the 7E learning cycle is better than students' mathematical communication ability with direct learning [13]. Khaskan's research is that the use of 7E learning cycles is more effective than traditional methods in mathematics learning [24].

4. Conclusion
The results of the previous research and discussion, it can be concluded as follows: (1) the use of the 7E learning cycle learning model is more effective than direct learning on students' mathematical communication ability on the subject of straight-line equations; (2) students with SK and SA thinking styles have better mathematical communication ability than students with AK and AA thinking styles; (3) in each learning model, students with SK and SA thinking styles have better mathematical communication ability than students with AK and AA thinking styles; and (4) in each of the SK, SA, AK, and AA thinking styles, students who were treated using the 7e learning cycle model had better mathematical communication ability than students who were treated using the direct learning model. This is because 7E learning cycle learning has effective learning steps to improve students' mathematical communication ability.

Based on the research findings, the researcher suggested that learning using 7E learning cycle can be used in subject learning in straight line equations. Teachers can use 7E learning cycle to improve students' mathematical communication ability based on their thinking style. Suggestions for further research are researchers conducting research using 7E learning cycle on other subject, and applying it to higher levels of education such as high school, and using 7E learning cycle learning to improve other mathematical ability.

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8

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