Improving Mathematical Communication Skills of SMP Students Through Contextual Learning

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Abstract. Mathematical communication skills (MCSs) are necessary skills for everyone to face lots of challenges in life. With these skills, mathematical ideas can be exploited in various perspectives. At the same time, students’ thinking can be sharpened, consolidated and organized. Their growth can be measured; their mathematical knowledge and development can be constructed; students’ reasoning can be improved, and their communication can be formed. In fact, students’ MCSs have not developed well. Contextual learning (CL) is expected to trigger the development of students’ MCSs. The study aims to examine the improvement of students’ MCSs through CL. This study used quasi experiment with pretest and posttest control group design. This study used a set of MCSs tests. Data were analyzed by two-line Anava. The results show that there is an increase in students' MCSs through CL which is higher than conventional learning (CVL); overall: 0.81 > 0.68, school category: 0.87 > 0.76 (above), 0.74 > 0.60 (middle); the increase, both overall and the upper level through CL are high, but moderate through CVL. While at the middle level, both CL and CVL are moderate; and there is a significant interaction effect between learning and school level on improving students’ MCSs.

Keywords: contextual learning, improvement, Mathematical communication skills.

1. Introduction

The 2013 curriculum states that the purposes of mathematics learning are to enable students to (1) understand mathematical concepts; (2) use reasoning on patterns and traits, make mathematical manipulations in making generalizations, compile evidence, explain mathematical ideas and statements; (3) solve problems, including the ability to understand problems, design mathematical models, complete models and interpret solutions obtained; (4) communicate ideas with symbols, tables, diagrams, or other media; (5) have an attitude of appreciating the usefulness of mathematics in life; (6) have attitudes and behavior according to mathematical values and learning; (7) do motor activities using mathematical knowledge; and (8) use simple teaching aids and technological results to carry out mathematical activities [1].

From one of the goals of mathematics learning above, it is reflected that mathematical communication skills (MCSs) are essential skills that students must achieve in learning mathematics [2]. This is because through communication mathematical ideas can be exploited in various perspectives; students’ thinking can be sharpened, consolidated and organized; growth can be measured; mathematical knowledge and development of students' problems are constructed; students' reasoning can be improved; and students' communication can be established [3]. In addition, Meriam [4] suggests that MCS deals with both verbal communication and written communication. In other
words, MCS is not only the ability of students to express ideas through writing but also the ability of students to communicate, explain, describe, listen, ask and collaborate.

Considering the importance of MCSs in mathematics learning, teachers should improve the students' MCSs. However, the reality in the field shows that students' MCSs is still low. The low MCSs is explained by Rohaeti [5] stating that students’ MCSs is in low quality on average. Similar data is also reported Whatma [6] stating that communicating mathematical ideas is included in a very low category. Furthermore, Firdaus [7] states that the MMCs of students who learn in small groups based on problem-based Team Assisted Individualization (TAI) are still relatively low (unsatisfactory). This can be seen from the achievement of students’ MCS scores of ± 60% of the ideal score. From these three studies, it was found that the low level of MCSs was likely because the students did not really communicate their mathematical ideas in mathematics learning.

To develop MCSs among students; Barody [8] suggests that learning should be able to help students communicate mathematical ideas through five aspects of communication: representation, listening, reading, discussion and writing. Furthermore, students’ MCSs can be improved through group discussions. This is consistent with the findings of Brenner's study [9] that the formation of small groups facilitates an improvement in MCSs. With the existence of small groups, the intensity of students in expressing their opinions will be higher, because students have a great chance to improve their MCSs through group discussions.

Barody [10] argues that there are at least two important reasons why communication in learning mathematics needs to be developed among students. First, mathematics as a language, meaning that mathematics is not just a thinking tool, a tool to find patterns, solve problems or draw conclusions; but mathematics is also an invaluable tool for communicating ideas clearly, precisely and carefully. Second, mathematics learning as a social activity, meaning that mathematics learning is also a means for interaction among students, as well as communication between teachers and students. These are two important reasons why students' mathematical potential needs to be maintained and developed.

One of the international assessments of MCS is in the Trends in Mathematics and Science Study (TIMSS). Wardhani [11] explain that TIMSS is an international study on junior high school students' mathematics and science achievements conducted four times a year. Mathematical questions in TIMSS measure the level of a student's ability from just knowing facts, procedures or concepts to using them to communicate and solve problems. From simple problems to more complex problems that require high reasoning. In 2015 the Indonesian mathematics lesson was ranked 44th out of 49 countries with a score of 397, while the international average score was 500 [12].

In addition to the decline in the average score on TIMSS, in 2017 the average score of the national exams (henceforth: UN) for junior high school students in Indonesia also decreased by 4.28 compared to 2016. The average score for junior high school students in the National Exams (UN) was 58.85 in 2016. It fell to 54.57 in 2017 [13]. The decline in the total score for Math subject in the national exam in 2017 also occurred in Riau Province (2.76). The national average for 2016 was 54.14; whereas it fell to 51.38 in 2017 [14].

In this study, researchers assume that junior high schools in Riau Province, especially in Pekanbaru, have the same standard of facilities from the government so that the facilities and infrastructure in supporting learning activities are assumed to meet established standards. With this assumption, researchers took two schools in Pekanbaru as a research site: SMPN 8 and SMP 17 Pekanbaru. Based on the data obtained, the average scores of the National Examination in 2017 for SMPN 8 Pekanbaru is classified as a high level, and SMPN 17 is classified as a middle level.

Considering the importance of MCSs for students, it is necessary to strive for learning with approaches that can provide opportunities and encourage students to train their MCSs. The reality in the field shows that learning activities are still dominated by teachers. In other words, students still tend to be passive in learning, both individually and in groups [15]. At the same time, fewer students are given the opportunity to see the real relationship between what is learned and the real world experienced by students, so that the learning process takes place less meaningfully [16].
Soedjadi [17] states that linking real-life experiences of children with mathematical ideas in classroom learning is important to make learning meaningful.

Kurniawan [18] states that one of the inhibiting factors in training students' MCSs is the fact that learning is still conventionally implemented; the teacher only transfers the knowledge, while students tend to only as recipients of knowledge by recording, listening and memorizing, practicing, and working on the questions the teacher asks. The teacher also gives less opportunity to students to reinvent, construct their own mathematical ideas, express ideas about something related to the context being discussed, and use their reasoning power to solve a problem with various strategies. In this case, the teacher only provides problems with the solution which is in accordance with the question sample. So, many times students tend to just accept what is said by the teacher without really understanding what it actually means.

It is less likely that passive learning can improve students' MCSs. Therefore, the teacher should strive for active learning so that students can actively communicate their mathematical ideas when dealing with images, graphics, tables, mathematical models and symbols either in writing or using their own language. Furthermore, Ansari [19] states that some of the abilities classified in the written MCSs are; the ability to state a problem situation into a picture and solve it (drawing); the ability to state problem situations into mathematical models and solve them (mathematical expressions).

Contextual learning is one of the learning models that can increase the students' involvement to actively construct and find their knowledge, both individually and in groups. This contextual learning also allows students to have the ability to see the real relationship between what is learned and the real world experienced by students. Contextual learning can also improve students' MCS. This is because the steps of contextual learning (constructivism, searching, asking, learning society, modeling, reflection, and actual assessment) enable students to actively learn, construct, and discover their knowledge, both individually and in groups. The steps can further enable students to reflect or respond to what has just been learned; and finally, the development of students' knowledge and skills can be measured and assessed through actual assessment [20].

To improve MCSs, students are given the opportunity to practice how to solve problems with various strategies, such as modeling, graphics, images or logical arguments in accordance with concepts they understand [21]. In addition, through contextual learning students get the freedom to think, submit ideas, questions and problems. Doing this makes learning mathematics to be more effective and meaningful. Furthermore, the steps of contextual learning can provide opportunities for students to respond and solve problems freely and creatively. The teacher acts more as a facilitator and mediator to encourage students to do their own problem-solving activities and activities to communicate mathematical concepts that they have obtained through mathematical problem-solving.

Set is one of the main materials in mathematics for junior high school students in the odd semester. This material is related to everyday life. For seventh grade students, this material is new material; yet, the material has a relationship with the real world experienced by students in their environment. Therefore, it is hoped that students can easily understand it. The reality in the field shows that students' mathematics learning outcomes are still low. One possible reason is that students are still having difficulty in expressing the problem situation in the form of a picture and unable to complete it. They also have a difficulty stating the problem situation into a model and unable to solve the problem the story is given which is actually an MCS indicator.

Because of the importance of MCSs for students in mathematics learning, the teacher needs to strive for improving his or her students' MCSs. Within this context, research has been carried out on improving the MCSs of junior high school students through contextual learning in Pekanbaru on set material. This study is intended to build or form effective students' MCSs with the formulation of the problem as follows: (1) how is the achievement and improvement of MCSs of students who get contextual learning compared to students who get conventional learning in terms of (a) overall students and (b) students' school levels (upper and middle)?; and (2) how is the interaction between learning (contextual and conventional) and school levels (upper and middle) towards improvement of students' MCSs?
2. Research Method

This is quasi-experimental research with the control group, pretest, and posttest design, described as follows.

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\begin{array}{ccc}
O & X & O \\
O & O & [22]
\end{array}
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In the implementation, researchers used two levels of school, namely the upper level and middle-level schools. Two classes were chosen from each school: one class for experiment and one class for control. The experimental group was given a treatment (X), namely contextual learning; while the control group was not given any special treatment. Research sample groups on the experimental group and control group were selected by considering students grouping in their study groups at each school. Each research class was given a pretest and posttest (O) to measure the students’ MCS. The scores of the pretest and posttest results were taken as the research data used to test the proposed research hypothesis.

The population of this study was all Junior High School students of Pekanbaru in the academic year 2018/2019. The sample was selected using stratified sampling, which was chosen because the samples drawn from different groups would represent the characteristics of each group population. The research sample was Year 7 students of junior high schools at the upper and middle-level schools in Pekanbaru City. The sample selection was based on the data of the National Exam for Junior High School in 2017. After the data was ranked, the school level categorization was determined using the criteria; (1) upper level school: total of national examination score > \( \bar{X} + SD \); (2) middle level school \( \bar{X} - SD \leq \text{total score of UN scores} \leq \bar{X} + SD \); and (3) lower level school: total score of UN score < \( \bar{X} - SD \). After school level categorization was determined, based on consideration it was finally determined that the upper-level school was represented by SMPN 8 and the middle-level school was represented by SMPN 17.

Data and information were collected through using materials and learning documents in the form of lesson plan (RPP), students worksheet (LKS), media and syllabus; and learning tools, such as MCS tests and observation sheets (teachers and students activities). Before conducting experiments, the learning and research instruments were validated and tested.

The data in this study were obtained from a test instrument (description test) to measure the students’ MCSs before and after being the learning treatment. The tests were prepared and developed by researchers based on the procedure for preparing good and correct instruments. Before use, the test was first validated and then tested. After testing, instrument reliability and item validity were then calculated. The results of the reliability calculation of 6 items of the MCS test (Cronbach’s Alpha = 0.70; high; \( \alpha = 0.01 \); N = 40 with r-table = 0.31); 5 items of MCS tests (numbers 2, 3, 4, 5, and 6) were declared valid. Thus, the MCS test can be used for this research.

Data were analyzed using KS-Z test, Levene, Mann-Whitney, Kruskal Wallis and ANOVA one and two lines with the help of SPSS 17 program; and normalized gain formula (N-Gain), namely:

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g = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal maximum score} - \text{pretest score}}
\]

whose results were interpreted based on Hake’s classification [25] to find out the average increase in students’ MCSs.

| Size of g | Interpretation |
|----------|----------------|
| \( g > 0.7 \) | High |
| \( 0.3 < g \leq 0.7 \) | Medium |
| \( g \leq 0.3 \) | Low |

Table 1. Gain (g) Classification according to Hake
3. Results and Discussion
The results of data descriptive analysis on students’ overall achievement of mathematical communication skills (MCSs) and school level (upper and middle) in the learning group (contextual and conventional) are presented in Figure 1.

Figure 1: Students’ MCSs achievement: overall and school levels in learning groups

Figure 1 shows that students’ average pretest score of MCSs both at overall and school level in the learning groups (CL and CVL) is relatively the same. After learning during the research treatment the average achievement of students’ MCS of the CL group is higher compared to the CVL group students, both at overall and each school level (upper and middle). Figure 1 also shows that the students’ average achievement of MCSs for the upper school level in the CL group is higher than the students’ average achievement of MCSs for the overall middle school level.

The results of the descriptive analysis of data on the students’ overall MCSs score improvement and at school levels (upper and middle) in the learning groups (contextual and conventional) are presented in Figure 2.

Figure 2: Average score improvement of students’ MCSs: overall and school levels in learning Groups

Figure 2 shows that the average score improvement of students’ MCSs, both overall and school level (upper and middle) in the CL group is higher than the average score improvement of MCSs in CVL group students. This can be seen from the overall students’ average score improvement in MCSs which is 0.81 (more than 0.68) for CL and this is higher than the average score improvement of MCS of students who received CVL. The average score improvement of students’ MCS for the upper school level who obtained CL is 0.87 (more than 0.76) and this is higher than the average score of students...
who received CVL. Likewise, the average score improvement of students' MCS for the middle school level who obtained CL is 0.74 (more than 0.60) and this is higher than the average score improvement of students for the middle school level who received CVL.

Furthermore, to test the overall improvement of students’ MCSs in the learning group, the data normality test (KS-Z) was first carried out with the results of the sample being abnormally distributed; this can be seen from the score of asymp value. sig. (2-tailed) which is smaller than α, both at CL and CVL (0.00 < 0.05). So H₀ is rejected. The results of the significance test of students' MCSs score improvement in the learning group using the Mann-Whitney test show that there is a significant improvement in students' MCSs, both at those who were treated by CL and those who received CVL; but the MCSs improvement of students who received CL is higher than those who received CVL.

The results of the Levene test on data of overall improvement score of students’ MCSs in the learning groups (CL and CVL) show there has been non-homogeneous data variance (sig-2 tailed < 0.05). T-statistics (equal variances not assumed) was used to test the difference in students’ MCSs overall score improvement in the learning groups. It was found that there are significant differences in the students' MCSs score improvement in the learning groups. Students treated using CL have higher average improvement score in MCSs compared with students who got CVL. This can be seen from the differences in the overall average improvement score of students’ MCSs in the learning groups by 0.13. Referring to Hake criteria [26], the students’ average improvement score of MCSs is categorized high (gain = 0.81), while the average improvement MCSs score of students who get CVL is classified as moderate (gain = 0.68); this is due to differences in the learning approaches used.

Next, the test on students' MCSs improvement for each school level in the learning group was carried out by first performing a data normality test (KS-Z). The test shows that the sample was not normally distributed. This can be seen from the asymp values. sig. (2-tailed) which is smaller than α, both at the upper and middle school level, at those who get CL and CVL (0.00 < 0.05). Based on this result, H₀ was rejected. The results of the significance test of students' MCSs score improvement in the learning group using the Mann-Whitney test show that there is a significant improvement in students' MCSs, both at those who were treated by CL and those who received CVL; but the MCSs improvement of students who received CL is higher than those who received CVL.

The results of the Levene test on data of students’ MCSs improvement score at each school level in the learning groups (CL and CVL) show there has been non-homogeneous data variance (sig-2 tailed < 0.05). Kruskal Wallis was used to test the difference in students’ MCSs score improvement at each school level in the learning groups. It was found that: (1) there are significant differences in the improvement score of students' MCSs s for each school level in the learning group, and (2) students treated by CL have higher average improvement score of MCSs than students who get CVL. This can be seen from the average improvement score in MCSs of students for the upper school level in the learning group which has 0.11 of average difference, and 0.14 for the middle school level of the learning group.

Referring to Hake’s criteria, the average score of MCSs improvement of the students treated by CL in high school level is classified as high (gain = 0.87), while the average score of MCSs improvement of the students who got CVL is classified as moderate (gain = 0.76). The average improvement score in MCSs for middle school level students, both at those who get CL (gain = 0.74) and CVL (gain = 0.60) are classified as moderate; this is due to differences in learning methods used.

The results of the interaction test between learning and school level toward the improvement of students’ MCSs show that for learning parameters: \( F_{\text{count}} > F_{\text{table}} \); while for the interaction is \( F_{\text{count}} > F_{\text{table}} \). Details can be seen in Table 2.
Table 2. The interaction between learning and school levels for students’ MCSs score improvement

| Sources    | Number of squares | df  | Average of squares | F     | Sig. (2-tailed) | Ho   |
|------------|-------------------|-----|--------------------|-------|-----------------|------|
| Learning   | 1.185             | 1   | 1.185              | 2229.479 | 0.000           | Rejected |
| School level | 1.425             | 1   | 1.425              | 2681.985 | 0.000           | Rejected |
| Interaction| 0.134             | 1   | 0.134              | 252.879  | 0.000           | Rejected |
| Errors     | 0.082             | 155 | 0.001              |        |                 |       |
| Total      | 89.749            | 159 |                    |        |                 |       |

It can be seen from Table 2 that the differences in students’ MCSs score improvement are caused by differences in learning methods used (CL and CVL) and differences in school levels (upper and middle). There is a significant interaction effect between learning and school level on the improvement of students’ MCS score as clearly show Figure 3.

Figure 3 shows that the difference in the average improvement score of students’ MCSs between the upper and middle school levels in the CL and CVL groups is not much different (above = 0.11 and middle = 0.13). But the average improvement score of students’ MCSs in high school level in the CL group is higher than the students’ score at the high school level of the CVL group. While the average improvement score at the middle school level, both CL and CVL groups, is classified as moderate. This shows that CL is more suitable to be applied at the upper school level than at the secondary school level. This is because the difference in the students’ score improvement of MCSs at the upper school level is higher than the improvement of students’ MCSs score at the secondary school level. In other words, these findings indicate that students at the school level have greater benefits through CL in improving their MCSs.

This study was analyzed based on learning groups and school levels. Therefore, the results of research related to MCSs will also be discussed based on the learning groups and school levels. Students’ MCSs are measured based on the research instruments used, namely (1) stating the problem situation into the picture and solve it, and (2) stating the problem situation into a mathematical model and solve it. The diversity of situations presented to students will particularly attract them to show their MCSs. This can be done if the mathematics lessons presented can be understood or imagined by the students because it is related to their daily lives. If the mathematics lesson provided is not related to the students’ lives, it will be difficult for the students to understand the purpose of presenting the lesson to them. This condition causes a lack of interest in students to learn mathematics and
subsequently can reduce the process of students' thinking in utilizing all the potential they have. Therefore, it is necessary to conduct a learning process that utilizes contextual problems, such as story questions related to students' daily lives to improve the students' MCSs.

The results show that the increase in students' MCSs, both overall and between school levels treated by CL, is significantly higher compared to students who received CVL. This can be seen from the average improvement score in MCS of students who were treated by CL of 0.81 (more than 0.68). This is higher than the average improvement score in MCSs of students who received CVL. The findings of the study also indicate that CL can improve students' MCSs. Based on the Hake category, the result is optimal because the increase is high. This is possible because through CL students get freedom in: (1) constructing and discovering their knowledge; (2) communicating mathematical ideas in writing through drawings, graphics, tables, mathematical models, symbols or their own language; and (3) responding and resolving problems freely and creatively; so that students are accustomed to communicating by trying to understand and solve problems, both individually and in groups.

The results of this study are in line with what is suggested by [28] that teachers need to be able to make a connection between mathematics and language. Through CL, the teacher trains students to understand the interrelationships between mathematics and language concepts. According to Baroody, one reason why mathematics learning focuses on communication is because mathematics is essentially a language, meaning that mathematics is more than just a thinking tool, a tool to find patterns, to solve problems, or to make conclusions; but mathematics is also an invaluable tool for expressing and communicating various mathematical ideas clearly, precisely and concisely. In CL, students are trained to communicate their mathematical ideas (1) into a picture and solve them, and (2) into mathematical models and solve them.

The findings are also in line with the recommendations from NCTM which suggest teachers to encourage students to apply various strategies in solving problems related to mathematical communication. These strategies include manipulating things, doing trial and error, trying case by case, guessing and checking, registering various possibilities, collecting and organizing data in tables, looking for a pattern from a table, drawing a diagram, and working backward. It is even more explicitly stated that presenting various methods in learning is the first principle to improve MCSs matter.

It is further explained that communication is an essential part of mathematics and mathematics education. This shows that communication is important in learning mathematics because students can convey ideas to teachers and to other students through communication. This means that a successful learning program depends, among others, on the form of communication that the teacher uses when he or she interacts with students.

Based on the statistical test, it can be concluded that learning has a significant influence on students' MCSs. Similarly, the school level has a significant influence on students' MCSs. These findings are supported by an increase in the average of MCSs score of students treated by CL for school levels (upper and middle) which is always higher than the average improvement of MCSs score of students who received CVL. Students treated by CL at the upper school level have an increase in their average MCSs score of 0.87 (more than 0.76). This is higher than students who got CVL. Likewise, students at the middle school level who were treated by CL have an increase in MCSs mean value of 0.74 (more than 0.60) which is higher than students who get CVL.

As seen in the two-lane Anava test in Table 4, the results of the study show that learning and school levels have a significant influence on the difference in the improvement of students' MCSs. Table 4 depicts that there is an interaction effect between learning (CL and CVL) and school levels (upper and middle) on increasing students' MCSs. This means that there is a simultaneous influence between learning and school level on the improvement of students' MCSs. In other words, the effect of the interaction between learning and school level resulted in a significant difference in the increase of students' MCSs.

From the average improvement of MCSs, it can be seen that students at both school levels who were treated by CL have a higher improvement in MCSs score compared to students who received
CVL. The average improvement of MCSs in high school level students is also higher than the average improvement of MCSs in middle school level students after being treated by CL. So, there is a significant difference between the two school levels towards students' MCSs improvement. These results indicate that the higher the level of a school, the higher the cognitive ability of students at the school level.

4. Conclusion and Suggestion

Based on the results and discussion it can be concluded that students who get contextual learning (CL) have higher achievement and improvement in mathematical communication skills (MCSs) than students who get conventional learning (CVL) in terms of (a) overall students and (b) students at school levels (upper and middle).

Overall, based on Hake's criteria, the average MCSs improvement in students who get CL is high, while improvement in those who get CVL is classified as moderate. For the upper school level, the average MCSs improvement of students who get CL is high, while for those who get CVL is classified as moderate. For the middle school level, the average MCSs improvements in students, both those who received CL and those who received CVL, is classified as moderate. There is a significant interaction between learning (CL and CVL) and school level (upper and middle) towards students’ MCSs improvement. This means that there is a simultaneous influence between learning and school level on increasing students’ MCSs. This further can be understood that CL is more suitable to be applied to the upper school level than at the middle school level because there is a significant difference of students’ MCSs improvement between CL and CV. In other words, these findings indicate that students at the school level have greater benefits through CL in improving MCSs.

Considering the research findings, mathematics teachers and policymakers are suggested to use contextual learning as one of the learning alternatives that can significantly improve students’ MCSs, especially on set topics and generally on topics that contain story questions related to daily life that are contextual in nature.

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