The students’ problem solving abilities in science, technology, engineering and mathematics (STEM) based on lesson study for learning community (LSLC)

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Abstract. This research was a development research that aimed at finding out the students’ problem solving abilities in mathematics using LSLC-Based STEM learning. This research used multiphase mixture method. This research was started by the development research using 4D, while the quasi experimental research using interpretest-posttest control group design. The research subjects were 32 students of IXth grade in MTsN 2 Jember in 2019/2020. The research sample used three classes, which were the IXF as a control class, the IXG as the first experimental class (1), and the IIXH as the second experimental class (2). The research data were collected and tested for its validity. After the instrument was valid and the data were homogeneous and normally distributed, the research data were tested statistically using one-way ANOVA. The results showed that (1) the instrument had fulfilled the validity, practicality, and effectiveness criteria, and (2) the significance value (2-tailed) was 0.000 (p<0.05) which indicated that the application of LSLC-Based STEM learning had a significant effect on the students' problem solving abilities.

1. Introduction

Humans are faced with more complex problems in this 21st century, both problems in local and global levels. As the next generation, the students need to be prepared in facing those problems. Problem solving ability becomes an ability which the students must learn and have to face the challenges in 21st century, in addition to critical thinking skill, communication skill and collaboration. In facing life in the 21st century, “students also have to learn the essential skills for success in today’s world, such as critical thinking, problem solving, communication and collaboration”[1].

Mathematical problem solving ability itself was not only the goal of mathematics learning, but also very meaningful in everyday life [2] and in the work of world, became a problem solver provided benefits [3]. Therefore, the learning must be developed to educate students to realize and solve the problems they face [4]. Even though, mathematics was a very important subject in formal education and closely related to human’s life, mathematics was not an interesting subject for students and Indonesian students’ problem solving abilities was still low [5,6,7], in their studies reported that many students were afraid in facing problems in learning mathematics. Generally, mathematics problems are made very complex so it is difficult for students to solve them. Related to this, there needs an effort so that the students’ problem solving abilities experiences the significant improvement.

To improve the students’ problem solving abilities especially on mathematics learning, the role of teachers are very essential. Teachers must be able to facilitate students so that the learning can make students more actively work and think. So, students are not bored and monotonous just by hearing the teacher’s explanation. One of learning approaches which stimulated the students to think and work actively and creatively was STEM learning approach [8]. STEM learning was an integration of science, technology, technique and mathematics learning suggested to help success of 21st century
skill [8]. STEM developed when it was associated with environment, so the learning which presented real world experienced by students in everyday life was realized [9]. This means that through STEM approach, students do not only memorize the concept, but rather how students understand the science concepts and its relation to everyday life.

To improve the interaction between students, students with teachers can be done by implementing LSLC. LSLC is an implementation of lesson study intended to build the learning community. Learning community was formed on 2 main pillars, namely: 1) the values of cooperative character in togetherness and equality or collaborative learning, 2) the values of caring character and enthusiasm to move forward together or caring community [10]. Based on research by Hobri and Susanto[11], the existence of a scientific-based worksheet combined with the LSLC concept, will have an impact on student activity that is very good and overall student learning outcomes are very high. Likewise in discussions, completing material, and solving problems very well.

Through this LSLC, learning is oriented to form a learning situation which learn from one another, particularly between teachers and students, among students and all teachers. Even, this system is also oriented to strengthen the character values of teachers and students through caring community situation created through collaborative learning that is between teachers and students, among teachers and between students because in the collaborative learning, there is no competition between students but “learning from one another”, awakens a sense of responsibility for every student to help one another.

2. Method

2.1 Research Scope

This research used mixed methods that combining qualitative and quantitative methods [12]. According to qualitative method, the model developed was Thiagarajan model that was known as 4-D model consisting of defining, designing, developing and disseminating [13]. The development of LSLC-based STEM learning instruments to improve the students’ problem solving ability, the instruments developed by the researcher were the lesson plan, students’ worksheets and test of the students’ learning achievement. The instruments were then tested to determine or fulfill the validity and reliability criteria of the instruments [13].

The quantitative research in this research used quasi-experimental design with control group design was given the pre-test and post-test which were analyzed by using SPSS version 19 One Way Anova test. The first stage that must be done before using One Way Anova test was conducting the normality and homogeneity tests as well as Levene statistical test with the significance level of 0.05 (P<0.05). If the normality test was normally distributed then One Way Anova was performed. While, if the data were not normally distributed then non-parametric test by using Mann-Whitney test was done. The design conducted in this research can be seen on the table below.

| Group            | Pretest | Treatment              | Posttest |
|------------------|---------|------------------------|----------|
| Experimental Class 1 | $X_1$   | STEM                   | $X_2$    |
| Experimental Class 2 | $Y_1$   | STEM based LSLC        | $Y_2$    |
| Control Class    | $Z_1$   | Conventional           | $Z_2$    |

2.2 Population

The population of this research was the students class XI of MTs Negeri 2 Jember in 2019/2020 academic year. The researcher selected three classes as the research samples that were chosen through cluster random sampling namely two experimental classes and one control class. Class IX G as the first experimental class, class IX H as the second experimental class and class XI F as the control class. The first experimental class used STEM learning, the second experimental class used LSLC-based STEM, while the control class used conventional learning model. The design conducted in this research can be seen on the table below.
2.3 Sample
The sample of research obtained from cluster random sampling were IX F as the control class consisting of 32 students, IX G as the experimental class 1 consisting of 32 students, and IX H as the experimental class 2 consisting of 32 students. In this research, both experimental and control classes had 4 meetings that were three meetings to conduct treatment and the last meeting to administer post-test.

3. Task
In this study, the students, on the 3 classes, gave different learning/treatment. The first experimental class gave a task to make tape (a fermented sticky rice) including the STEM activities. The Second experimental class gave a task to make fermented sticky rice including LSLC-based STEM activities. On the other side, the control class still used conventional methods. The implementation of STEM for making fermented sticky rice can be seen in every field. The field of science requires students to know the chemical concept of the fermentation process of fermented sticky rice and acidity. The field of technology requires students to find out and measure the acidity using a pH meter. The technical field of making fermented sticky rice is the process of fermentation. The field of mathematics requires students to calculate levels of acidity. It can be seen in Table 2.

| Table 2, The implementation of STEM |
|-------------------------------------|
| Science                             | Chemistry, Acidity, Fermentation |
| Technology                          | Biotechnology                    |
| Engineering                         | Yeasting Process                 |
| Mathematics                         | Logarithms                       |

3.1 Science
The reaction in fermentation of sticky rice into fermented sticky rice is glucose (C6H12O6) which is the simplest sugar, through the fermentation will produce ethanol (2C2H5OH). This fermentation reaction is carried out by yeast and used in food production. Chemical Reaction Equations: C6H12O6 + 2C2H5OH + 2CO2 + 2 ATP. The description: Sugar (glucose, fructose, or sucrose) + Alcohol (ethanol) + Carbon dioxide + Energy

Changing the sticky rice into fermented sticky rice, the first step is to put white or black sticky rice into washbasin to wash thoroughly and soak for ± 12 hours. The second steps, draining thoroughly, put sticky rice into a boiling pot, then steam steamed sticky rice until it is half cooked. The third steps, the sticky rice move into a basin and add 2 cups of hot water while stirring until the sticky rice is exposed to the hot water evenly, then move it back into the pan and cooking until the sticky rice cooked. After the sticky rice cooked, move the sticky rice into the tray, drain and leave the sticky rice for a few hours to cool. The last step is the fermentation process. When rice and yeast powder are mixed evenly, it should wrap tightly using 3 layers of banana leaves. Thurs, it stored in the same place for 3 days of fermentation.

In this fermentation process, the banana leaves are used because banana leaves provide an atmosphere suitable for microbial fermenters to give an active role in the process of carbohydrate fermentation into ethanol. As according to the literature, making fermented sticky rice is usually being sprinkled with yeast, it will be closed tightly to make sure no air enters to the container. It is because of making the fermented sticky rice utilizes anaerobic bacteria, which are bacteria no need in the fermentation process. In the second day, it is the process of anaerobic to form the taste of alcohol by yeast, so it needs to be covered. Besides, if there is air, the alcohol will be oxidized to acetic acid, so that it becomes acidic. After 3 days, unwrap the fermented sticky rice and measure the pH of the fermented sticky rice using a pH stick.

3.2 Technology
This conventional Biotechnology Practicum of making fermented sticky rice aimed to determine the effect amount of yeast on pH in making fermented sticky rice. This practicum was held for three days, the results of the practicum that has been carried out, it can be known that when the yeast mass of 0.22
grams is produced pH 4, the yeast mass of 0.44 grams is produced pH 4, the yeast mass of 0.66 grams is produced pH 4 and the yeast mass of 0.88 grams is produced pH 5. It can be seen simple as the following graph, it described the relationship between yeast mass and the result pH of the fermented sticky rice:

![Graph](image)

**Figure 1.** Relationship yeast mass (g) and pH

Based on the data above, it can be known that the amount of yeast is produced a fermented sticky rice with the highest pH (pH 5) is a fermented sticky ricemade by adding 0.88 g of yeast. While making a fermented sticky rice by adding yeast mass as much as 0.22 g, 0.44 g, and 0.66 g produces a pH tape of 4. This shows that a fermented sticky rice number 4 with adding of 0.88 g of acidity is low.

### 3.3 Engineering

The tools used to make fermented sticky rice are plastic basins, 4 spoons, pans, stoves, trays and pH sticks. While the yeasting process of fermented sticky rice by dividing the yeast into 4 parts which is divided of 0.22 g, 0.44 g, 0.66 g and 0.88 g. Yeast mass distribution is an independent variable in this practicum to determine the effect of the number (mass) of yeast on pH. It is not only yeast mass; all ingredients are made equal or in other words the quantity and quality are controlled as a control variable. After the sticky rice is cold, then take and move on the leaves. Thus, it added the yeast powder to sticky rice number 1 which is 0.22 g, number 2 which is 0.44 g, number 3 is 0.44 g, and number 4 is 0.88 g. The next step is to mix the yeast powder with sticky rice till spread evenly.

### 3.4 Mathematics

Logarithms are mathematical operations that are opposite of exponents or quadrating. Definition of logarithms arose as the inverse of an exponent. In chemical logs are used to determine the degree of acidity or pH. The measure range has a logarithmic scale from 0 to 14. when the scale < 7 belongs to the acid, and > 7 belongsto the alkali/basa. We can use logarithms to determine whether a solution in fermented sticky rice that has been produced is available for drinking, or not. The pH of a solution is defined as follows:

\[
\text{pH} = \log [H^+] = \log [H^+] = 10^{-\text{pH}} \\
\text{If } [H^+] = 1 \times 10^n, \text{ so } \text{pH} = n \\
\text{If } [H^+] = x \times 10^n, \text{ so } \text{pH} = n - \log x \\
\text{Conversely, if } \text{pH} = n, \text{ so } [H^+] = 1 \times 10^n
\]

### 4. Results

In this research, the learning instruments that had been developed were the lesson plan, students’ worksheets and test of the students’ learning achievement. The learning instruments developed by the researcher were validated by three validators covering two lecturers of mathematics education of University Jember and one mathematics teacher of MTs Negeri 2 Jember. The scores of validation obtained from three validators for each component of learning instruments had been analyzed to determine the mean score. The scores of validation of the lesson plan, students’ worksheets and test of the students’ learning achievement are shown on Figure 2.
On the above (Figure 2), we could see that the result of validation from three validators of learning instruments showed score of $3 < V_r \leq 4$. Therefore, the learning instruments that had been developed fulfilled the criteria of valid, and it meant that the learning tool was proper to be implemented. After conducted validation and stated as valid, the sample of research was determine by using normality and homogeneity tests with SPSS version 19. The data used were pre-test score. From the results of normality and homogeneity tests, the ability of IXth grade students were normal and homogeneous.

The students’ activities were done in group of the experimental class 1, experimental class 2, and control class (one group activities were taken as the sample).

Figure 3. Group Discussion Activity in (Experimental 1) Class

Figure 3, group discussion in experimental 1 ran quite well. In this group discussion, student B explained to all of the members of the group so that student B had no chance to ask other members due to the questions had been addressed to student B. However, student A and C had been participated in explaining to student D. While in the next meeting the students were able to collaborate, caring to each other within the group in finishing the task given by the teacher. Student B and C asked to student D and student D had been tried to answer what he understood. Therefore, the students were familiar to collaborate and care with their study group.
Figure 4. Group activities in experimental 2 ran very well. Student D had explained to all of the members of the group because the questions were addressed to student D. Furthermore, student B helped explaining to student A and C. In the next meeting, the students exchanged their seat so that they could collaborate and build caring community. It was proved that their care to their friends was very high [14,15].

Figure 5. Discussion activities in the control group showed that student D had explained to all of the members of the group without any questions from other members, therefore the group discussion in the first control class did not run well. While in the second group, there was a student who had lack understanding that was student E, student E only gave an explanation to student D and F, however there were students who were questioning to each other namely student F and G. From the group discussion in control class, it can be concluded that the student only solved the problem given by the teacher without care whether their group members understood or not.

The following is the recapitulation results of the students’ activities conducted in the experimental class 1, experimental class 2, and control class on three meetings, can be seen on Figure 6.
Figure 6. Students’ activities conducted in the experimental class 1, experimental class 2, and control class on three meetings

Figure 6, the students’ activities in three meetings showed the assessment obtained by the control class was 75.77%, students activities in the experimental class 1 was 78.36%, while students activities in the experimental class 2 was 81.04%. It can be concluded that the results of students activities in the experiment class 2 where LSLC-based STEM learning was implemented proved to be able to improve students’ problem solving.

The effectiveness of the learning instruments was analyzed from the data of students’ responses toward the students worksheet, the following is the recapitulation results of the analysis on the effectiveness shown on Figure 7.

Table 3. Achievement score of statistic descriptive problem solving ability

|       | N   | Mean | Std. Deviation | Lower Bound | Upper Bound | Minimum | Maximum |
|-------|-----|------|----------------|-------------|-------------|---------|---------|
| Control | 32  | 77.28| 4.160          | 75.78       | 78.78       | 70      | 84      |
Experiment 1  32  80.75  4.273  79.21  82.29  75  90
Experiment 2  32  84.47  4.899  82.70  86.23  76  98

In finding out whether or not there was an effect of STEM learning based on LSLC on problem solving ability, the researcher provided it on Table 3. The researcher performed One Way Anova test after doing normality and homogeneity tests first. The data were found to be normally distributed as shown on normality test, while homogeneity test obtained the significance of 0.997; after a normal and homogeneous distribution were obtained. It is shown on Table 4 and 5.

| Table 4. | Tests of homogeneity of variances |
|----------|----------------------------------|
| Levene statistic | df1 | df2 | Sig |
| .003 | 2 | 93 | .997 |

| Table 5. | Normality test (Kolmogorov-Smirnov) |
|----------|-----------------------------------|
| Kias | Kolmogorov-Smirnov |
|----------------|------------------|
| Control | Statistic | df | Sig |
| .150 | 32 | .067 |
| Experiment 1 | .115 | 32 | .200 |
| Experiment 2 | .144 | 32 | .088 |

Based on the prerequisite test, obtained that post-test data were normally distributed and had the same or homogeneous variance. Therefore the data analysis used parametric test which was one-way ANOVA test. The results of data analysis are shown on Table 6.

| Table 6. | Problem Solving Ability (ANOVA) |
|----------|---------------------------------|
| Sum of Squares | df | Mean Square | F | Sig |
| Between Groups | 826.896 | 2 | 413.448 | 20.824 | .000 |
| Within Groups | 1846.438 | 93 | 19.854 | |
| Total | 2673.333 | 95 |

Based on the result of One Way Anova test, the significance value obtained was 0.000, so it can be concluded that there was a significant influence between the control class and the experimental class 2.

| Table 7. | Bonferroni Test |
|----------|-----------------|
| (I) Class | (J) Class | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |
| Control | Experiment 1 | -4.063 | 1.116 | .001 | -6.78 | -1.34 |
| | Experiment 2 | -7.781 | 1.116 | .000 | -10.50 | -5.06 |
| Experiment 1 | Control | 4.063 | 1.116 | .001 | 1.34 | 6.78 |
| | Experiment 2 | -3.719 | 1.116 | .004 | -6.44 | -1.00 |
| Experiment 2 | Control | 7.781 | 1.116 | .000 | 5.06 | 10.50 |
| | Experiment 1 | 3.719 | 1.116 | .004 | 1.00 | 6.44 |

* The mean difference is significant at the 0.05 level.

Based on Table 7, it can be seen that the problem solving ability in the three classes was significantly different (indicated by *). The experimental class 2 had an average difference of 3,719 with the experimental class 1 and 7,781 with the control class. The experimental class 1 had an average difference of -3,719 with the experimental class 2 and 4,063 with the control class.

From these results, it can be concluded that the experimental class 2 has more significant influence than the experimental class 1 and the control class and experimental class 1 has a more significant effect than the control class.

After learning STEM based LSLC with material logaritma, researchers conducted interviews with students to find out students' perceptions about the implementation of STEM based LSLC learning. The researcher interviewed three students who had low, medium and high ability in the experimental class 2, the data obtained through the interview process were proposed below:
Researcher: How do you feel about STEM based LSLC learning activities?
Student: I like this learning because I get new experiences about the integration of science with mathematics and I can discuss with friends, so that when there are students who feel they don't understand the material, other students can help explain.

Researcher: What makes you happy or unhappy when doing learning activities using components of a STEM based LSLC learning model?
Student: I am very happy because doing marketing practice is a new experience for me.

Researcher: What is your understanding of the material that has been explained?
Student: initially did not understand but after being explained by the teacher and input from the group I finally understood and I could also explain to students who did not understand.

Researcher: How do you solve problems like on student worksheets?
Student: I follow the steps that are already on the student worksheet.

The indicators in this research aimed at measuring problem solving ability which refers to Polya’s opinion. The following figure 8 presents the students answer who have problem solving abilities and have shown the four indicators:

- **Polya Step 1**: The stage of understanding problems
- **Polya steps 2 and 3**: make a problem-solving plan and implement the problem-solving plan
- **Polya step 4**: recheck

![Figure 8: Student Work](image)

Collaboration chart between STEM and LSLC can be seen in the Figure 9.
5. Discussion

The class sample data were analyzed by using SPSS software version 19, which was conducted a prerequisite test in the form of a normality test and a homogeneity test normality used Kolmogorov-Smirnov test, while the test of homogeneity used Levene Statistical with a significance level of 0.05 (P <0.05). Related to the effectiveness of learning tools, it can be said that the learning tools was effective. (1) the results of the students' activity during the learning process were categorized as active, (2) there was a significant improvement of the students' problem solving ability in the experimental class. While, based on the observation results, it is known that the implementation of learning process in each aspect showed that it run well with. Whereas, from the questionnaire of the students' response, it was obtained that the students gave the positive response toward the learning tools on the implementation of LSLC-based STEM learning as much as 87.80%. Based on the data above, it can be concluded that the practicality test of the learning tools being developed fulfilled the criteria of: (1) the implementation level of the learning process was categorized as practical; (2) the students had a positive response toward the media as well as the implementation of LSLC based STEM learning. The results of the analysis of non parametric showed that there was a significant different on students problem solving ability in the experimental 1, experimental 2 and control classes. The results of this study show that there was a significant improvement in the experimental class.
6. Conclusion

Based on the results of this research and data analysis, the researcher drew the conclusions that the development of LSLC-based STEM learning instruments affected problem solving ability and was into valid, practical, and effective criteria. In the experimental class 2, the post-test data taken from the normality and homogeneity test revealed that the data were normally distributed and homogeneous, then One Way Anova test was performed, the Sig. value obtained was (2-tailed) of 0.000. (<0.05). If the Sig. value was (<0.05), then H0 was rejected and H1 was accepted. Therefore, the students’ learning outcomes in the experimental class 2 were said to be better than the experimental class 1; the experimental class 1 was also better than the control one.

The researcher suggests that the implementation of LSLC-based STEM learning and the worksheets used were the alternative learning that can be implemented in the classroom, so that the students are able to develop their creative thinking in solving the mathematical problems.

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