The effect of STEM-based (Science, Technology, Engineering, and Mathematics) learning model toward the students’ mathematical problem-solving ability in SD Muhammadiyah Condongcatur, Yogyakarta

K A Pasaribu¹, W Suyanto²

¹ Technology and Vocational Education Study Program, Graduate Program, Yogyakarta State University, Indonesia
² Technology and Vocational Education Study Program, Graduate Program, Yogyakarta State University, Indonesia

Abstract. This study aims to determine (1) the students’ mathematical problem-solving ability taught using STEM-based (Science, Technology, Engineering, and Mathematics) learning model, (2) students’ mathematical problem-solving ability taught using expository learning models, (3) whether there is a difference in the effect of STEM-based learning model with expository learning models in improving students' mathematics learning achievement. This research was an experimental research design with quasi experimental design (Quasi Experimental Design). The population in this study was all grade V SD Muhammadiyah Condongcatur Yogyakarta. The sample in this study was class V-1 as an experimental class with 33 students and class V-2 as a control class with 33 students. The findings in this study indicate that the class taught using STEM-based learning model has Mean 31.9697 and the class taught using the expository model has an average value of 28.5758. The results of the hypothesis test show that $T_{\text{count}} > T_{\text{table}}$ is 2.925 > 1.996 with the conclusion that the mathematical problem-solving ability of students taught with STEM learning model is better than the class which is taught with expository learning models.

1. Introduction
The most important aspect in developing country is education. The implementation of Kurikulum 2013 (K13) is an effort made by the government to develop education in Indonesia, bearing in mind that the competition in 21st century demands the competitive human resources in science, technology, engineering design, and mathematics. This is the reason why education is expected to be able to integrate four scientific disciplines. As a developing trend, STEM (Science, Technology, Engineering, Mathematics) is used to overcome the real world situations through a design-based process of problem-solving as commonly used by the engineers and scientists (William, 2011). STEM-based learning model is the type of learning that integrates four disciplines: Science, Technology, Engineering, and Mathematics in one learning. Stohlmann, Moore, & Roehrig (2012: 30) state that STEM learning model is an effort to combine science, technology, engineering, and mathematics into one class based on relationships between the subjects and real world problems.

Breiner, Harkness, Johnson & Koehler (2012: 14) explain that some people define STEM as integrating the science, engineering, and mathematics science curriculum, so that it’s closer and more
parallel with the works of scientists or engineers in real life; others understand STEM as an effort to encourage more students to graduate from their schools, especially those whose interest in science, technology, engineering, and mathematics. Kelly, et al (2016) state that integrated STEM learning model is an learning to teach two or more STEM learning subjects by involving STEM practices in connecting each STEM learning subject. The purpose is to improve the students. From this, STEM can be defined as a learning integration of science, technology, engineering, and mathematics with increasing the students learning through the process of solving problems in real life as the main purpose. STEM learning can not only be applied in elementary and secondary schools, but can also be applied in lecture and even doctoral programs. This learning connects learning with four learning components named science, technology, engineering, and mathematics. STEM can also be implemented at the level of formal education (in classroom) and non-formal education (outside the classroom) (Gonzales & Kuenzi, 2012). Lencher defines mathematical problem-solving as the “process of applying the mathematical knowledge previously got into a new unknown situation” (Yusuf Hartono, 2014). Low capability of students’ mathematical problem-solving is caused by several factors; one of them is the learning process is still focused on memorizing the definitions, theories of mathematical formulas. According to Poyla, there are four important stages that must be taken by the students in mathematical solving problems: understanding the problems, compiling a settlement plan, implementing a settlement plan, and rechecking. With these stages, the students will get optimal results and benefits from those problem-solving. The capability of solving the problems is very important for the students and their future. Learning experts agree that the capability of solving problems within certain limits can be formed through the subjects of study and disciplines taught. The problems of how to teach the problem-solving will never be solved without regarding to the types of problem you want to solve, suggestions and the form of the programs prepared, and the students’ innate variables.

According to Mulyono Abdurrahman (2009) problem-solving is the application of concepts and skills. It usually involves several combinations of concepts and skills in a new or different situation. For example, when students are asked to measure up the area of a piece of board, several concepts and skills are involved. Some of the concepts involved are rectilinear, parallel lines, and sides; while the skills involved are the skill of measuring, adding, and transferring.

Based on the description above, one of the efforts that must be implemented to improve the students’ skills of problem-solving is by applying STEM learning. It is meant to provide a practical reinforcement of education in STEM study subjects separately, as well as to develop more learnings that can integrate science, technology, engineering, and mathematics by focusing the learning process on solving the real problems in real life or professional life (Septiani, 2016).

Syukri, et al (2013) have examined the integration of STEM education in teaching and learning science in primary and secondary schools that have been run by the Faculty of Education, UKM (Kebangsaan Malaysia University) in collaboration with Aceh. The STEM education program is in the form of integrating entrepreneurial thinking into the teaching and learning of science through the science process skills. Elsa Efwani (2013) has conducted research on the application of STEM-based modules (Science, Technology, Engineering, and Mathematics) to environmental pollution and damage material to improve the independent learning of Grade VII students of MTsN Tungkop. Based on observations of student worksheet activities an average percentage of 77.73% was obtained in the high category. Based on questionnaires and interviews obtained student responses to the application of the STEM module showed a positive response of 89.38%. The percentage of completeness of student learning outcomes in the experimental class was 90% while the control class was 31.58%. Significant differences in learning outcomes from the two classes are seen based on the t-test, where tcount ≥ ttable at dk 76 is tcount = 7.92 and ttable = 2 so Ha is accepted and Ho is ditolek means there are differences in learning outcomes between the experimental class and the control class.
2. Method

The method used in this study was a quasi-experimental with one group pretest and posttest design. The study used two classes for pretest and posttest group design. The research samples were one class with STEM learning implementations and one class with expository models. The samples had the initial test (pretest) before getting STEM or expository learning model, then finally took the final test (posttest). The data obtained was in the form of pretest and posttest scores and they were processed by using normalized gain \(<g>\) to illustrate the value of posttest increase.

The instruments used in this study were the written tests in the form of essays and observation sheets. The test used in this study is useful for identifying the students’ problem-solving ability in understanding mathematical concepts in integer material. All instruments were validated by experts to measure their feasibility. Pretest and posttest were used to determine the learning outcomes of problem-solving. Initial test (pretest) was given to determine the students’ initial ability, while the final test (posttest) was given to determine the students’ final ability after receiving the treatment.

Data analysis techniques of the study included (1) Univariate Analysis (Mean, Median, Mode, and Standard Deviation), (2) Normality Test, (3) Homogeneity Test, and (4) Hypothesis Test.

3. Result

3.1. Descriptive Data

The mathematical problem-solving ability test is conducted to find out the mathematical problem-solving ability in integer material by using STEM (Science, Technology, Engineering, and Mathematics) and expository learning models.

The population of the study was all fifth grade students of SD Muhammadiyah Condongcatur, Yogyakarta. It consisted of 66 students from two different classes (the first class is the experimental class and the second one is the control class). The experimental class used STEM-based learning model and the control class used expository learning model.

After the treatment, the students were given a posttest to determine the mathematical problem-solving ability. The results of the second class showed as follow:

| Group          | N   | Mean  | Varians  | Standard Deviation | Max | Min |
|----------------|-----|-------|----------|--------------------|-----|-----|
| Experimen A₁   | 33  | 31.970| 25.531   | 5.053              | 38  | 19  |
| Control A₂     | 33  | 28.576| 18.940   | 4.352              | 35  | 18  |

Based on the table 1, Mean of students’ problem-solving ability of experimental class A₁ is 31.970, while Mean of students’ problem-solving ability of control class A₂ is 28.576. The variance value of experimental class is 25,531 and the control class is 4,352. The highest value of experimental class is 38 and the control class is 35. The lowest value of experimental class is 19 and the control class is 18. From this, the researcher concludes that the mathematical problem-solving ability of students’ with STEM-based learning models is greater than those whose expository learning models.

3.2. Results of Students’ Mathematical Problem-solving with STEM-Based Learning Model in Experimental Class

Based on the data obtained from the results of test of students’ mathematical problem-solving with STEM-based learning model, the research shows that Mean of the data is 31,970; Standard Deviation (SD) is 5,053; Varian is 25,531. According to data obtained from students’ mathematical problem-solving with STEM-based learning model, there are 30 students passed the test (91%) and 3 students do not pass the test (9%). In this study, STEM-based learning model involves the student participation directly during joining the process of learning. The data above also shows that the students have various or even different value.
Furthermore, the assessment category of mathematical problem-solving ability of students’ with STEM-based learning model can be seen as follow:

**Tabel 2. Assessment Category of Mathematical Problem-solving Ability of Students’ with STEM-Based Learning Model in Experimental Class**

| No | Score Internal | Number of Students | Percentage | Assessment Category          |
|----|----------------|--------------------|------------|-----------------------------|
| 1  | $0 \leq \text{SKPM} < 45$ | 0                  | 0%         | Very less than satisfactory |
| 2  | $45 \leq \text{SKPM} < 65$ | 3                  | 9.09%      | Less than satisfactory      |
| 3  | $65 \leq \text{SKPM} < 75$ | 6                  | 18.18%     | satisfactory                |
| 4  | $75 \leq \text{SKPM} < 90$ | 16                 | 48.48%     | Good                       |
| 5  | $90 \leq \text{SKPM} \leq 100$ | 8                  | 54.55%     | Very good                  |

Based on the table 3, the students’ highest score with STEM-based learning model in experimental class is 33.5 to 36.5 (10 students). In the four description questions, the number of students who receive **very less than satisfactory category** is 0 (0%), **less than satisfactory category** is 3 (9.09%), **satisfactory category** is 6 (18.18%), **good category** is 16 (48.48%), and **very good category** is 8 (54.55%).

From the results above, it can be concluded that 27 from 33 students in the experimental class are able to solve the problems correctly, including how to solve mathematical problems at the first and third level (level of understanding problems and level of solving problems) with Mean of data 31,970.

Results of Students’ Mathematical Problem-solving Ability with Expository Learning Model in Control Class

Results of students’ mathematical problem-solving ability on integer material in SD Muhammadiyah Condongcatur, Yogyakarta, with expository learning model show that the lowest score is 18 and the highest score is 35. Based on data obtained from students’ mathematical problem-solving test with expository learning model in control class, it shows that Mean of data is 28,516, Standard Deviation (SD) is 4.352, and Variance is 18,940. The data also explains that the students who pass the test are 26 students (79%) and those who do not pass the test are 7 students (21%). Learning process with expository learning model has involved the students directly. From the data, the study identifies that the students’ mathematical problem-solving ability with expository learning model has various or even different value from one student to another.

Furthermore, the assessment category of mathematical problem-solving ability of students’ with expository learning model can be seen as follows:

**Tabel 3. Assessment Category of Students’ Matematical Problem-solving Ability with Expository Learning Model in Control Class**

| No | Score Internal | Number of Students | Percentage | Assessment Category          |
|----|----------------|--------------------|------------|-----------------------------|
| 1  | $0 \leq \text{SKPM} < 45$ | 0                  | 0%         | Very less than satisfactory |
| 2  | $45 \leq \text{SKPM} < 65$ | 7                  | 21.21%     | Less than satisfactory      |
| 3  | $65 \leq \text{SKPM} < 75$ | 10                 | 30.30%     | Satisfactory                |
| 4  | $75 \leq \text{SKPM} < 90$ | 16                 | 48.48%     | Good                       |
| 5  | $90 \leq \text{SKPM} \leq 100$ | 0                  | 0%         | Very good                  |

Table 5 shows that the students’ highest score in control class is 26.5 to 29.5 (8 students) and 29.5 to 32.5 (8 students). In the four descriptive questions, no one gets the lowest score (0%), 7 students get **less than satisfactory category** (21.21%), 10 students get **satisfactory category** (30.30%), 16 students get **good category** (48.48%), and no one gets very good category (0%). From the description
above, it can be concluded that there are 22 from 33 students in control class are able to solve the mathematical problems correctly, including how to solve mathematical problems at the first and third level (level of understanding problems and level of solving problems) with Mean of data 28.516.

3.3. Test Analysis pre-Requisites
In processing the advanced analysis to test the hypothesis, it’s necessary to test the data requirements including: (1) source of the data is from the randomly selected sample, (2) the sample comes from populations which are normally distributed, and (3) data groups have homogeneous variance. Then, the normality and homogeneity analysis requirements test will be performed from the distribution of the collected test results.

3.3.1. Normality Test
One of the analysis techniques in normality test is Lilliefors Analysis Technique. It is a requirement analysis technique before drafting a hypothesis test. The sample comes from a normally distributed population and a rival hypothesis. The results of normality analysis for each sub-group can be explained as follows:

3.3.2. Results of Students’ Mathematical Problem-solving Ability with STEM-Based Learning Model in Experimental Class
The study was conducted on fifth grade students of SD Muhammadiyah Condongcatur, Yogyakarta. The samples were 66 students consisted of 33 students of experimental class and 33 students of control class. Both types of classes were purposed as the samples of this normality research. The sixty six students were asked to answer the questions drafted on the test instrument. The instrument test consisted of 4 descriptive questions in which the tested data was those related to the effect of STEM learning model toward the eight-grade students’ mathematical problem-solving ability in SD Muhammadiyah Yogyakarta.

The test is conducted to identify whether the data provides is normally distributed or not. The results of the normality test for the sample of mathematical problem-solving ability of students’ with STEM-based learning model were the value of \( L_{\text{count}} = 0.185 \) with \( L_{\text{table}} = 5.923 \). Because \( L_{\text{count}} < L_{\text{table}} (0.185 < 5.923) \), it can be concluded that null hypothesis is accepted, meaning that the sample of mathematical problem-solving abilityof students’ with STEM-based learning model comes from normally distributed populations.

3.3.3. Results of Students’ Mathematical Problem-Solving Ability with Expository Learning Model in Control Class
Based on results of normality test of sample of mathematical problem-solving ability of students’ with expository learning model, \( L_{\text{count}} = 0.064 \) with \( L_{\text{table}} = 5.923 \). It can be concluded that null hypothesis is accepted, meaning that the sample of mathematical problem-solving ability of students’ with expository learning model comes from normally distributed populations.

The conclusion of all normality test data results say that all samples are normally distributed populations (\( L_{\text{count}} < L_{\text{table}} \)). The conclusion of normally test results from each group of data can be seen in the following table:

| Tabel 4. Summary of Results of Normality Test Using Lilliefors Analysis Technique |
|---------------------------------|-----------------|----------------|-----------------|
| **Group**                      | **L Count**     | **L table**   | **α= 0.05**    | **Conclusion** |
| (Science, Technology, Engineering, and Mathematics) Learning Model | 0.185           | 5.923         | Ho: Accepted, Normal |
| Expository Learning Model      | 0.064           | 5.923         | Ho: Accepted, Normal |
3.4. Homogeneity Test
The variants of mathematical problem-solving ability of students’ with STEM-based and expository learning models are follows: \( \alpha = 0.05 \) and \( d_{k_1} = 33 - 1 = 32 \) and \( d_{k_2} = 33 - 1 = 32 \). Then, by using the list of distribution critical value \( F_{0.05(36,35)} = 1.845 \), it shows \( L_{\text{count}} < L_{\text{table}} \) or \( 1.303 < 1.845 \). It means that the variant of both samples is homogeneous.

3.5. Hypothesis Test
To prove that STEM-based learning model is more influential than expository learning model, the researcher did the hypothesis tests. The hypothesis test can be conducted by using Tuckey Test \((t)\). It’s necessary because the second data of distributed class is normal and homogeneous.

By comparing \( L_{\text{count}} \) for \( \alpha = 0.05 \) with \( d_k = 33 + 33 - 2 = 64 \), it is obtained that \( t_{0.05(64)} = 1.996 \) (Ha is accepted and Ho is rejected), meaning that there is difference of STEM and expository learning models toward the students’ mathematical problem-solving ability in SD Muhammadiyah Condongcatur, Yogyakarta.

The results of students’ mathematical problem-solving in experimental class are better as the learning process runs well and creative. The teachers give the opportunities to the students to find out the concept, theory, and comprehension through the simple experiences in real life. Basically, STEM-based learning model is a learning model that relates the learning materials to the students’ real life. According to Kennedy, as said by Lovitt, he suggests four steps for solving the mathematical problems. The steps are:

a. Understand the problems
b. Plan how to solve the problems
c. Solve the problems
d. Do recheck

The ability to solve mathematical problems is an ability that requires students to be able to solve mathematical problems. By using STEM learning model, the students can see the meaning on learning materials, particularly the materials of Mathematics. They can also connect the materials to daily experience in real life. Or they can solve the mathematical problems by connecting them to daily life. Then, in group, the students can deliver the problem-solving they have found.

Hypothesis of the study is there is difference of the effect of STEM and expository learning models toward the students’ mathematical problem-solving ability in SD Muhammadiyah Condongcatur, Yogyakarta. Results of students’ mathematical problem-solving test with STEM are better than expository learning model.

4. Conclusion
The conclusions drafted by the researcher are based on the objectives and formulations of the study, and based on data analysis conducted by using Tuckey Test.
1. STEM-based learning model brings the effect to the students’ mathematical problem-solving ability in class V-1 SD Muhammadiyah Condongcatur, Yogyakarta (Mean 31.970)
2. Expository learning model does not bring the effect to students’ mathematical problem-solving ability in class V-2 SD Muhammadiyah Condongcatur, Yogyakarta (Mean 28.576)
3. There is significant effect between STEM-based and expository learning models toward the students’ mathematical problem-solving ability in SD Muhammadiyah Condongcatur, Yogyakarta.

It is based on statistical calculation using Tuckey Test. The calculation result says \( L_{\text{count}} = 2.925 \) and \( L_{\text{table}} = 1.996 \).

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