Improving Conceptual Understanding through STEM-Based Mathematics Learning

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ABSTRACT

This study aims to improve conceptual understanding through STEM-based mathematics learning. The research method was pre-experimental research with one-group pretest-posttest design. The population is grade 8 of one of school in Ternate City. The method of sampling is random sampling. Research variable in the research, the independent variable is STEM-based learning and the dependent variable is the conceptual understanding. The validity of test that will be used in this research is content validity. Data analysis technique are descriptive and inferential. A test given to measure conceptual understanding The indicators are (1) restating a concept and providing examples, (2) Implementing specific procedures or operations, (3) Use algorithm to solve a problem. The results of the study is that students' conceptual understanding is improving of the circle concept through STEM-based mathematics learning. The increase of conceptual understanding can be seen in the average value obtained, where for the pretest it is 40.41 then after the STEM is applied and the posttest is carried out the average value has increased to 83.73. Therefore, STEM-based mathematics learning is one of approaches that can improve conceptual understanding, and promotes the use of hands-on activities to solve problems in everyday life

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A. INTRODUCTION

In schools, mathematics is always considered a difficult subject for students. Factors that influence students to think that mathematics is difficult to learn because students are not actively involved and how teach teachers who only seek convenience and are always pursued by the target time to complete each subject regardless of student competence (Saragih, 2012). Teachers should be more creative in choosing and determining the learning to be used, so as not to cause monotony in every delivery of learning material, especially in mathematics learning that requires various learnings to be able to understand mathematical material well.

in the learning process at school, Teachers should select and implement ways, methods, strategies, and procedures that encourage students to participate actively in their learning on mental, physical, and social levels (Sudjana, 2011). Understanding concepts is a critical component of studying mathematics because it provides a solid basis for thinking about mathematical and everyday situations. According to Zulkardi (Sari, 2017), "mathematical learning stresses knowing concepts," which means that students must first grasp mathematical concepts in order to solve issues and apply what they've learned in the actual world. Conceptual understanding is very important because, in addition to being one of the objectives of mathematics education, understanding concepts can also help students not only memorize formulas, but can understand correctly the meaning of learning mathematics (Karunia, E. P., & Mulyono, 2017).

In Indonesia, mathematics education has mostly remained teacher-centered, with many teachers failing to stress parts of students' abilities to relearn mathematical concepts and structures in their classroom teaching and learning activities based on students' own experiences and according to their understanding. This is also in line with what have observed in one school in Ternate City. The teacher dominates learning and students' lack active learning. Teachers dominate the class and become the main source of knowledge, paying less attention to student activities, student interactions, and knowledge construction (Magdalena & Surya, 2018). In that school, the impact of the teacher-centered activity is a lack of conceptual understanding. Therefore, the students only solve problems algorithmically or procedurally but do not understand the concepts that exist in a problem. This is also in line with Andamon & Tan that students must have procedural and conceptual abilities if students want to understand mathematics more deeply (Andamon & Tan, 2018).

Indicators of conceptual understanding according to the 2006 curriculum the The Ministry of Education's Director General of Primary and Secondary Education Regulation No.506/C/Kep/PP/2004 lists seven (7) abilities as measures of mathematical concept knowledge (Asfar et al., 2019); (Tonra & Yuliyanti L, 2021), namely:
1. Restate a concept.
2. Sort objects into categories based on their characteristics (according to the concept).
3. Demonstrate examples and non-examples.
4. Using multiple mathematical representations to present topics.
5. Creating the conditions that are required or sufficient for a concept to exist.
6. Implementing specific procedures or operations.
7. Use algorithm to solve a problem. This study still has limitations including the breadth of the material and the large number of questions used, so this study only uses indicators 1, 3, 6 and 7.

A teaching method that encourages pupils to actively participate in their education and develop their knowledge. An effective learning technique is required to attain students' conceptual understanding. One of the learning approaches that can support conceptual understanding in STEM (Thahir et al., 2020). STEM is a 21st-century learning approach STEM is anticipated to meet the difficulties and learning requirements of the 21st century. With greater diversity in the world of work such as critical technical and personal skills, it is hoped

that schools will be able to produce people who are literate in the STEM approach until the term "STEM Education" appears.

Current educational reforms focused on the integration of STEM-based subjects are advocated by many because they are seen as methods of engaging students in real-world problems, promoting memory, and enhancing knowledge transfer (Smith & Moore, 2011); (Ostler, 2012). Treacy, P., & O'Donoghue (Fitzallen, 2015) state that The STEM learning approach provides a way to place mathematics in a meaningful context and promotes the use of hands-on activities related to real-world problems. The following is a study of 4 scientific disciplines that are referenced in STEM-based learning: (1) Sciences: Presenting daily life/real-life situation problems to students and asking what solutions can be used to solve the problem. Students can be grouped to discuss ideas for solving a given problem. Students exchange opinions (Gravemeijer et al., 2017). There is not only biological, physical, or chemical material in the learning process. However, the ability to solve issues mathematically and scientifically is the meaning of the term "sciences". In addition, teachers can provide tools and materials for students to explore and experiment with learning resources. (2) Technology: The use of new technology, making software, or it can also be the delivery of teaching materials by utilizing technology such as the use of animated videos, the use of audio, the use of mathematical software in visualizing images, graphics, or figures in mathematics. Students can also be invited to the laboratory or use their respective devices to open a certain website/learning platform as a learning resource (Kertil & Gurel, 2016). (3) Engineering: Hands-on activity and project-based learning/problem-based learning to solve problems. Teachers can facilitate students by utilizing objects around them in learning a concept. (4) Mathematics: Problem-solving using mathematical formulas. The teacher helps students to develop problem-solving skills, and numerical and graphic skills to demonstrate a mathematical of a problem, analyze data, and interpret data to provide an assessment of the results obtained (Handal et al., 2013)

Based on previous research, there has been a lot of study on using the STEM approach; however, the distinction between this research and prior research is in the dependent variable, which is conceptual understanding of the Circle concept. Then, this study aims to improve conceptual understanding through STEM Learning and describe students' conceptual understanding after implementing STEM Learning.

B. METHODS
1. Types of research
This is a pre-experimental study with no control group to compare to the experimental group, hence the pre-experimental design utilized in this study is a one-group pretest-posttest study. Where before the treatment is given, the pre-test is given first and after the treatment is given then final test (posttest).

2. Population and Sample
The population is all grade 8 students of one of the Junior High schools in Ternate for the 2022/2023 academic year. Students from class 8b made up the study's sample. Random sampling was used since, based on observations made at school, the ability of students in each class was on average the same.

3. Research variable

In the research, the independent variable is STEM learning and the dependent variable is the conceptual understanding in the circle material.

4. Validation Test

The validity that will be used in this research is content validity. To be able to determine the accuracy of the instrument to be used in this study, the instrument will first be validated by 2 lecturers at Khairun University, Mathematics Education Study Program.

5. Data analysis technique

There are two analyzes, namely descriptive and inferential. Conceptual understanding of students is qualified according to Criterion-Referenced Grading (CRG). CRG is organized around success criteria or passing grades. Lecturers can use CRG to determine the number of students who have a high, moderate, or low degree of mastery (Nurbayani, 2012). Inferential statistical analysis was used to answer whether STEM learning could improve conceptual understanding with hypothesis below: Research Hypothesis (t-test) $H_O: \mu \leq \mu_0$ (There is no increase in student's conceptual understanding after STEM) $H_1: \mu > \mu_0$ (There is an increase in student's conceptual understanding after STEM) μ: Postest average scores) μ_0: Pretest average scores. To facilitate the researchers, in this study the researchers calculated the value of t-test was performed using the SPSS 23 for Windows application.
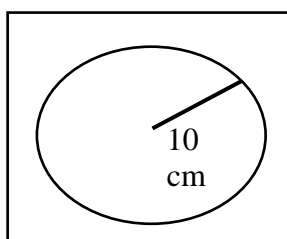
C. RESULTS AND DISCUSSION

1. Description of the process of improving students' conceptual understanding through STEM-Based mathematics learning

The process of applying to STEM-based mathematics learning is carried out to improve students' thinking skills which can be described as follows:
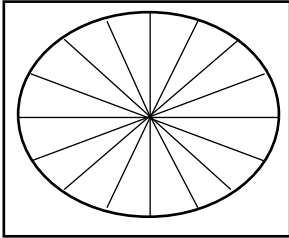
a. Sciences: Students are formed into small groups, and they are invited to discuss and exchange opinions to complete group assignments determining the circumference of a circle's formula
b. Technology: Students are invited to open a website that has been shared in class groups
c. Engineering: Teacher promote hands-on activity through work steps
d. Mathematics: Find the formula of the area of Circle
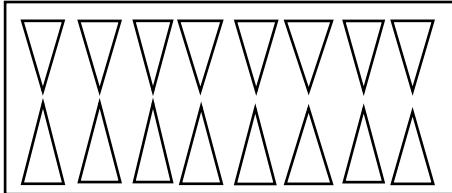
Work steps
1. Prepare a circle with a radius of 10 cm made of cardboard.
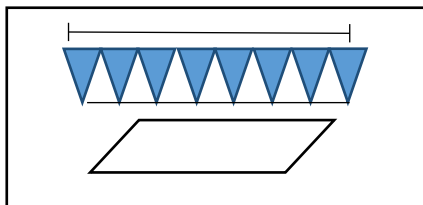

2. Divide the circle into 16 congruent squares. And number each line.

3. Use scissors or a cutter to separate the circles.

4. Arrange the grids so that they form a parallelogram. It would be more interesting if given a different color for the lines number 1 to number.

5. Determine the area of the parallelogram. Remember that the circle is divided into 16 squares, which means that 8 arcs are obtained from the arcs of the semicircles.
6. Write down the steps for forming the formula for the area of a circle.

STEM with hands-on actvities result by student groups can be seen in Figure 1.

Figure 1. Find the formula of circle by student group

2. Conceptual understanding qualification through STEM-based mathematics learning

Table 1 below shows the outcomes of the students' mathematical conceptual understanding aptitude examinations, as shown in Table 1.

Table 1. Pre-test and Post-test result

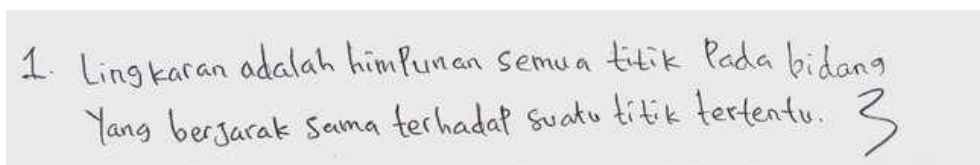| Description	Conceptual Understanding	
	Pre-test	Post-test
Average	40,41	83,73
Minimum Score	25	66,67
Maximum Score	75	100
Total	21	

Conceptual understanding qualification through STEM-based mathematics learning according to Criterion-Referenced Grading (CRG) can be presented as shown in Table 2.

Tabel 2. Conceptual understanding qualification based on CRG

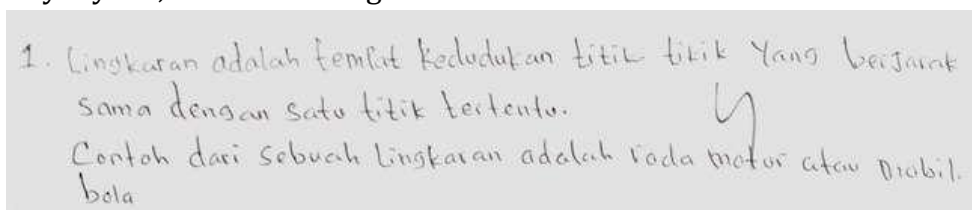| cam	Level	Qualification	Frequency	Presentation
1	91% - 100%	Very good	7	33%
2	81% - 90%	Good	9	43%
3	71% - 80%	**Satisfactory**	2	10%
4	61% - 70%	Sufficient	3	14%
5	0% - 60%	Insufficient	0	0%
Total			21	100%
Average	83,73			

The following is a description of the subject's work at the pretest and posttest, namely R-20, R-5, and R-11, all of which are in the high category.

a. Presented the results of the pretest and posttest R-20 for indicators restating a concept and providing examples, as shown in Figure 2.
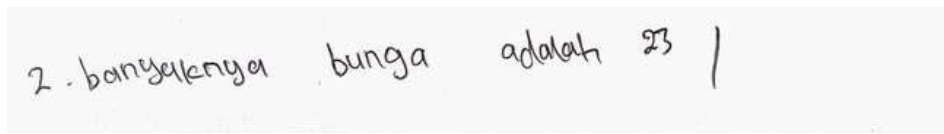

Figure 2. Pre-test R-20

Based on the results of the pretest, students R-20 can used his language in restating the meaning of circle according to students' understanding but could not provide examples in everyday life, as shown in Figure 3.

Figure 3. Post-test R-20

Based on the results of the post-test, R-20 can used his language in restating the meaning of circle according to students' understanding and provide examples in everyday life.
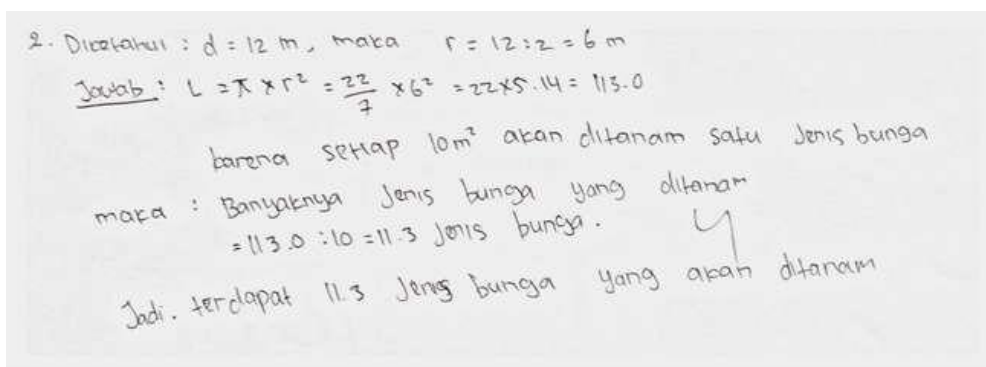
b. The results of the pretest and posttest R-11 are presented for indicators of using algorithm to solve a problem, as shown in Figure 4.

Figure 4. Pre-test R-11

Based on the results of the pre-test, R-11 cannot applying the concept or problem-solving algorithm because he cannot solve the problem given, as shown in Figure 5.
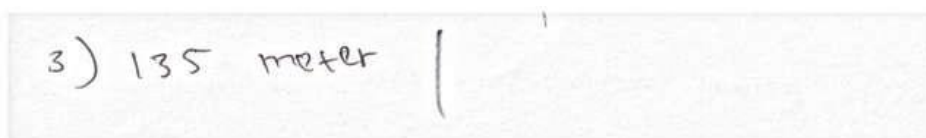

Figure 5. Post-test R-11

Based on Figure 13, students R-11 were able to make the correct solution. From the results of the pretest and posttest of students R-11 above, it can be seen that there has been an improvement in conceptual understanding of the concept of a circle.

c. Presented the results of the pretest and posttest R-5 for indicators implementing specific procedures or operations, as shown in Figure 6.

Figure 6. Pre-test R-5

Based on the results of the pretest of R-5 students, which can be seen in Figure 8, it shows that the student has not been able to implement specific procedures or operations as shown in Figure 7.

Figure 7. Post-test R-5

It can be seen that R-5 showed that the student had answered correctly and was able to make a solution where the student was able to perform multiplication operations to obtain the circumference of a circle and understand the division operation to understand how many turns the wheel has.

3. **Improved conceptual understanding through STEM-Based mathematics learning**

Based on the analysis of the research results using the SPSS 23 for the windows, it was found that the significant value was 0,000 that less than 0.05 (sig. < 0.05) so reject H0 and accept H1. This is the result of SPSS analysis of the data as shown in Table 3.

Table 3. Test Statistics result using SPSS

	Post-test & pre-test
Z	-4,033[b]
Asymp. Sig. (2-tailed)	,000

To sum up, there is an increase in students' conceptual understanding after the application of STEM. We can see this in the increasing indicators of student conceptual understanding, namely restating a concept and providing examples, implementing specific procedures or operations, use algorithm to solve a problem. The increase in understanding of the concept can also be seen in the average value obtained, where for the pretest it is 40.41 then after the STEM approach is applied and the posttest is carried out the average value has increased to 83.73. STEM give students have the opportunity to study individually or to work together with group members. This is in line with Masjudin (Masjudin, 2017) that group learning provides many benefits for students. In group learning, students discuss and exchange ideas in solving the problems given. STEM learning for students is expected to be able to innovate, collaborate and survive everyday problems (Soylu, 2016). In learning, students are led to solving problems in the LKS using their knowledge assisted by researchers as facilitators.

D. **CONCLUSION AND SUGGESTION**

The increase of conceptual understanding can be seen in the average value obtained, where for the pretest it is 40.41 then after the STEM is applied and the posttest is carried out the average value has increased to 83.73. Moreover, it was found that the significant value was 0,000 that less than 0.05 (sig. < 0.05) so reject H0 and accept H1. Therefore, the conclusion is

that conceptual understanding has improved after STEM-based mathematics learning is applied. In addition, the comparison of students' answers during the pretest and post-test was also different, it is seen from the students' answer sheet. From conceptual understanding indicators, after STEM-based mathematics learning, Students fulfill the indicators of restating a concept and providing examples, implementing specific procedures or operations, use algorithm to solve a problem. The description of the process of increasing students' understanding of concepts through STEM learning on circle material can be seen from the learning process with activities to find the formula for the area of a circle and the circumference of a circle. Sciences: Students are formed into small groups, to discuss and exchange opinions to complete group assignments Technology: Students open a website that has been shared in class. Engineering: Teacher promote hands-on activity. Mathematics: finding the formula for the area of a circle to students and using formulas to solve problems. From this activity, it can be seen that STEM-based mathematics learning is one of learning approaches that can improve conceptual understanding, and promotes the use of hands-on activities to solve problems in everyday life.

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