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|  |  | **ABSTRACT** | |
| **Article History:**  Received : D-M-20XX  Revised : D-M-20XX  Accepted : D-M-20XX  Online : D-M-20XX |  | 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. Conceptual understanding data was obtained through a test instrument. The conceptual understanding indicators are 1) restating a concept and providing examples, 2) using, utilizing, and selecting certain procedures or operations, 3) applying the concept or problem-solving algorithm. The results of the study is that students’ conceptual understanding is improving of the circle concept through STEM-based mathematics learning. The increase in conceptual 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 is applied and the posttest is carried out the average value has increased to 83.73. Then, it can be concluded 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 | |
| **Keyword*:***  Conceptual understanding;  STEM;  Pre-experimental design; |
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1. **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 less active in the learning process and how teach teachers who only seek convenience and are always pursued by the target time to complete each subject regardless of student competence ( Sahat 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 choose and use approaches, methods, strategies, and techniques that can involve students actively in learning, both mentally, physically, and socially (Sudjana, 2011). In the process of learning mathematics, understanding concepts is a very important foundation for thinking in solving mathematical problems and everyday problems. Zulkardi (Sari, 2017) states that "mathematical learning emphasizes understanding concepts", meaning that in studying mathematics, students must understand mathematical concepts first to be able to solve problems and be able to apply the learning in the real world. Conceptual understanding is very important because, in addition to being one of the goals of learning mathematics, understanding concepts can also help students not only memorize formulas, but can understand correctly the meaning of learning mathematics (Karunia, E. P., & Mulyono, 2017).

Mathematics learning in Indonesia so far is still dominated only teacher-centered, many teachers in teaching and learning activities in the classroom do not emphasize the aspects of students' ability to rediscover mathematical concepts and structures based on students' own experiences and according to their understanding. This is also in line with what I observed in one school in Ternate City. The teacher dominates learning and students lack active learning. This activity will lead to a lack of conceptual understanding. 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)

Indicators of understanding concepts according to the 2006 curriculum the indicators of mathematical concepts understanding listed in the Ministry of Education's Director General of Primary and Secondary Education Regulation No.506 / C / Kep / PP / 2004 consisting of seven (7) abilities (Asfar et al., 2019); (Tonra & Yuliyanti L, 2021), namely

1) Restate a concept.

2) Classify objects according to certain properties (according to the concept).

3) Provide examples and non-examples of the concept.

4) Presenting concepts in various forms of mathematical representation.

5) Developing the necessary or sufficient conditions for a concept.

6) Using, utilizing, and selecting certain procedures or operations.

7) Apply the concept or problem-solving algorithm.

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 learning approach that can make students actively participate in learning and can construct their knowledge. To achieve students' conceptual understanding, an appropriate learning approach is needed. 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 expected to be able to overcome the challenges and learning needs 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 mathematical problems 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.

1. 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)

1. 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.

1. 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 exists a lot of research on the use of the STEM approach, the difference between this research and the previous research is in the dependent variable, namely 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 research is a pre-experimental design with no control class as a comparison with the experimental class so that the pre-experimental design used in this study is a one-group pretest-posttest design, where before the treatment is given, the pre-test is given first and after the treatment is given then final test (posttest).

1. Population and Sample

The population is all grade VIII students of one of the Junior High schools in Ternate for the 2022/2023 academic year. The sample in this study were students of class VIII-2 with random selection because the ability of students in each class was on average the same based on the results of observations at school.

1. Research variable

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

1. 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.

1. 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 oriented based on success standards or certain passing grades. By applying CRG, lecturers can find out the number of students who have a high, moderate, and low level 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)

(There is no increase in student's conceptual understanding after STEM)

(There is an increase in student's conceptual understanding after STEM)

: Postest average scores)

: Pretest average scores

To facilitate the researchers, in this study the researchers calculated the value of the t-test with the help of the SPSS 23 for the windows program.

**C. Results and Discussion**

1. Conceptual understanding qualification through STEM-based mathematics learning

Data on the results of students' mathematical conceptual understanding ability tests can be presented in the table 1 below.

**Tabel 1.**Pre-test dan Post-test result

|  |  |  |
| --- | --- | --- |
| Description | Conceptual Understanding | |
| *Pretest* | *Posttest* |
| Average | 40,41 | 83,73 |
| Minimum Score | 25 | 66,67 |
| Maximum Score | 75 | 100 |
| Total | 21 | |

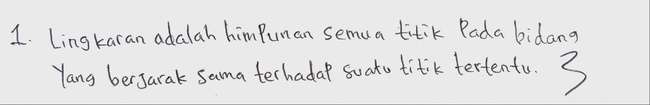
Conceptual understanding qualification through STEM-based mathematics learningaccording to Criterion-Referenced Grading (CRG) can be presented in the table 2 below.

**Tabel 2.** Conceptual understanding qualification based on CRG

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| cam | Level | Qualification | Frecuency | 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 | | | |

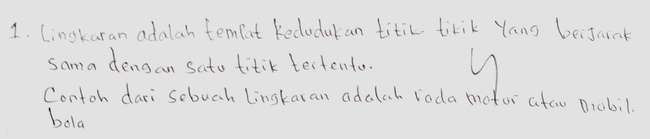
Based on table 1 and 2 above, shows that the student results after applying the STEM learning who obtained very good qualifications were 7 students with a percentage of 33%, good qualifications were 9 students with a percentage of 43%, and satisfactory were 2 students with a percentage of 10%, and those who obtained sufficient qualifications were 3 students with a percentage of 14%, while none of those who obtained insufficient qualifications. With an average of 83.73 good qualifications. 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.

1. Presented the results of the pretest and posttest R-20 for indicators restating a concept and providing examples.



**Figure 1.** Pre-test R-20

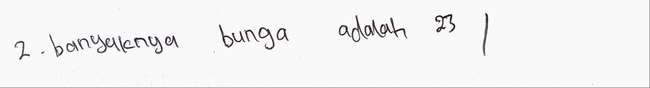
Based on the results of the pretest, students R-20 can used his language in restating the meaning of circle according to students' understanding but could not provide examples in everyday life.



**Figure 2**. Post-test R-20

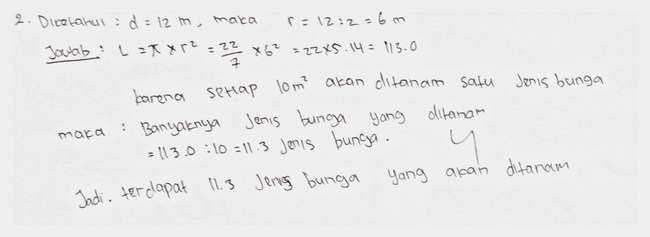
Based on the results of the post-test, R-20 can used his language in restating the meaning of circle according to students' understanding and provide examples in everyday life.

1. The results of the pretest and posttest R-11 are presented for indicators of applying the concept or problem-solving algorithm.



**Figure 3.** Pre-test R-11

Based on the results of the pretes, R-11 cannot applying the concept or problem-solving algorithm because he cannot solve the problem given



**Figure 4**. Post-test R-11

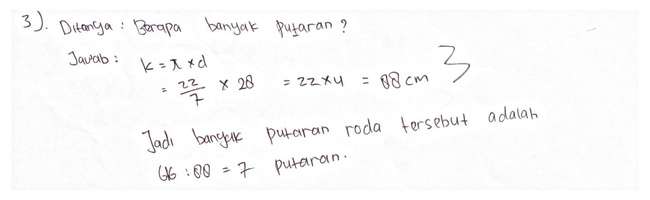
Based on Figure 13, students R-11 were able to make the correct solution. From the results of the pretest and posttest of students R-11 above, it can be seen that there is an increase in mathematical understanding related to the concept of a circle. R-11 apply the concept or problem-solving algorithm.

1. Presented the results of the pretest and posttest R-5 for indicators using, utilizing, and selecting certain procedures or operations.



**Figure 5**. 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 using, utilizing, and selecting certain procedures or operations in order to solve the problem.



**Figure 6**. Post-test R-5

Based on the results of the post-test, students 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.

2. 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 less than 0.05 (sig. < 0.05) so reject H0 and accept H1. Therefore, it can be concluded that 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, using, utilizing, and selecting certain procedures or operations, applying the concept or problem-solving algorithm Applying the concept or problem-solving algorithm. 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 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.

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

The process of applying to STEM) learning is carried out to improve students' thinking skills which can be described as follows:

1. Sciences: Students are formed into small groups, and they are invited to discuss and exchange opinions to complete group assignments about finding the formula for the circumference of a circle
2. Technology: Students are invited to open a website that has been shared in class groups about finding the formula for the area of ​​a circle
3. Engineering:

Teacher promote hands-on activity through work steps below by Find the formula of the area of Circle

1. Mathematics: Find the formula of the area of Circle

|  |
| --- |
| Work steps   1. Prepare a circle with a radius of 10 cm made of cardboard.      1. Divide the circle into 16 congruent squares. And number each line. 2. Use scissors or a cutter to separate the circles. 3. 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 7 below:

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**Figure 7**. Find the formula of circle by student group

**D. Conclusion and Suggestion**

Based on the results and discussion above, the conclusion is that there is an increase in understanding of the circle concept after STEM-based mathematics learning is applied. Increased understanding based on the results of hypothesis testing where it is concluded that there is an understanding of the concept. Based on the average conceptual understanding test scores at the pretest and posttest, there was also an increase in the conceptual understanding test scores. In addition, the comparison of students' answers during the pretest and post-test was also different, seen from the work of the subjects. 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 groups about finding the formula for the area of ​​a circle. 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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**REFERENCES**

Sahat Saragih, S. R. H. (2012). Peningkatan Kemampuan Pemecahan Masalah dan Komunikasi Matematik Melalui Pendekatan Matematika Realistik pada Siswa SMP Kelas VII Langsa. *Jurnal Pendidikan Matematika Paradikma*, *5*(1), 175–186.

Asfar, A. M. I. T., Asmawaty, A., & Nursyam, A. (2019). Mathematical Concept Understanding: the Impact of Integrated Learning Model. *Al-Jabar : Jurnal Pendidikan Matematika*, *10*(2), 211–222. https://doi.org/10.24042/ajpm.v10i2.3880

Fitzallen, N. (2015). STEM Education : What Does Mathematics Have To Offer ? *Proceedings of the 38th Annual Conference of the Mathematics Education Research Group of Australasia*, *June 2015*, 237–244.

Gravemeijer, K., Stephan, M., Julie, C., Lin, F. L., & Ohtani, M. (2017). What Mathematics Education May Prepare Students for the Society of the Future? *International Journal of Science and Mathematics Education*, *15*(2017), 105–123. https://doi.org/10.1007/s10763-017-9814-6

Handal, B., Campbell, C., Cavanagh, M., Petocz, P., & Kelly, N. (2013). Technological Pedagogical Content Knowledge of Secondary Mathematics Teachers. *Contemporary Issues in Technology and Teacher Education*, *13*(1), 22–40. http://www.citejournal.org/vol13/iss1/mathematics/article1.cfm

Karunia, E. P., & Mulyono, M. (2017). Analisis Kemampuan Pemahaman Konsep Siswa Kelas VII Berdasarkan Gaya Belajar dalam Model Knisley. *Prosiding Seminar Nasional Matematika*, 337–346.

Kertil, M., & Gurel, C. (2016). *Mathematical modeling: A bridge to STEM education*. *January*. https://doi.org/10.18404/ijemst.95761

Magdalena, T., & Surya, E. (2018). PENGARUH MODEL PEMBELAJARAN MEANS-ENDS ANALYSIS TERHADAP KEMAMPUAN PEMECAHAN MASALAH MATEMATIKA SISWA PADA MATERI SPLDV PADA KELAS X SMA. *Prosiding Seminar Nasional Sains Teknologi Humaniora Dan Pendidikan (QSinastekmapan)*.

Masjudin, M. (2017). Pembelajaran Kooperatif Investigatif Untuk Meningkatkan Pemahaman Siswa Materi Barisan Dan Deret. *Jurnal Edukasi Matematika Dan Sains*, *4*(2), 76. https://doi.org/10.25273/jems.v4i2.687

Nurbayani, E. (2012). Penilaian Acuan Patokan (PAP) Di Perguruan Tinggi (Prinsip dan Operasionalnya). *Dinamika Ilmu: Jurnal Pendidikan*, *12*(1), 1–9. https://journal.uinsi.ac.id/index.php/dinamika\_ilmu/article/view/33

Ostler, E. (2012). 21st Century STEM Education: A Tactical Model for Long-Range Success. *International Journal of Applied Science and Technology*, *2*(1), 6. http://www.ijastnet.com/journals/Vol\_2\_No\_1\_January\_2012/3.pdf

Sari, P. (2017). PEMAHAMAN KONSEP MATEMATIKA SISWA PADA MATERI BESAR SUDUT MELALUI PENDEKATAN PMRI. *Jurnal Gantang*, *II*(1), 41–51.

Smith, K. A., & Moore, T. J. (2011). Advancing the state of the art of STEM integration. *BioTechniques*, *51*(5), 311. https://doi.org/10.2144/000113758

Soylu, R. A. Ş. (2016). Stem Education in Early Childhood in Turkey. *Journal of Educational and Instructional Studies in the World*, *1*, 2146–7463.

Sudjana, N. (2011). *Penilaian Proses Hasil Belajar Mengajar*. Remaja Rosdakarya.

Thahir, A., Anwar, C., Saregar, A., Choiriah, L., Susanti, F., & Pricilia, A. (2020). The Effectiveness of STEM Learning: Scientific Attitudes and Students’ Conceptual Understanding. *Journal of Physics: Conference Series*, *1467*(1). https://doi.org/10.1088/1742-6596/1467/1/012008

Tonra, W. S., & Yuliyanti L, R. I. (2021). Analisis kesalahan pemahaman konsep matematis siswa SMP pada materi teorema pythagoras. *Delta-Pi: Jurnal Matematika Dan Pendidikan Matematika*, *10*(2), 192–206.