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IMPLEMENTATION WORKED EXAMPLE-BASED LEARNING TO IMPROVE JUNIOR HIGH SCHOOL STUDENTS' MATHEMATICAL REPRESENTATION ABILITY

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Abstract

The purpose of this study was to apply worked example-based learning as an effort to improve the representation ability of junior high school students. This research is a quasi-experiment study with a non-equivalent control group design. The population in this study were all students of class VIII SMP Negeri 1 Talang Kelapa, Banyuasin, South of Sumatera, with a purposive sampling technique taken two classes as the sample. Samples on select from is student in class VIII.3 were used as experiment class, and class VIII.4 used as a control class. The instrument that used in this research is a mathematical representation test. The validation of this instrument was carried out by an expert review. Analysis the data using t-test with independent samples test. From the results of data analysis show the average final ability of students' mathematical representations in the experimental class was the same as the average final ability of students in the control class with Asymp.Sig (1-tailed) = 0.086. But, the average value of the post-test in the experimental class was 60, and the average value of the post-test in the control class was 53.13. Its meaning that the average test score of students' mathematical representation abilities in the experimental class was higher than the average ability test score mathematical representation of students in the control class.

Keywords: worked example-based learning, mathematics representation

1. Introduction

Mathematics is an important subject to be taught in schools because it can shape the character of a student and train students to have abilities that can support their lives (Sweller et al., 2012). According to Chambers (2008), mathematics is an important tool in finding patterns, and solving problems so that students can learn the abilities they need to solve problems (Chambers, 2008).

Mathematical representation ability is the most important part among other mathematical abilities. Since, mathematical representation ability can make a person able to communicate ideas, mathematical ideas so that they can be used to solve a problem (Agustina & Sumartini, 2021). With their mathematical representation abilities, students can solve problems in their lives and in society (Nurhamidah & Nuraeni, 2018).

According to NCTM, representation is one of the keys to mathematical communication abilities (Armadan et al., 2017). The ability of mathematical representation is the skills to restate notations, symbols and equations, tables, graphics/diagrams, or other mathematical expressions into other forms. (Mahpudin et al., 2020). Visual representations, images, text, mathematical equations, or expressions are components of mathematical representations.

The ability of mathematical representation in question is the ability to restate notations, symbols, tables, pictures, graphs, diagrams, equations, or other mathematical expressions into other forms (Nuraeni et al., 2020). However, there are still many students in Indonesia who have not been able to represent mathematics properly, one of which is in representing geometric material (Nuraeni et al., 2021).

Meanwhile, the current conditions, learning mathematics in schools still tend to force students to maximize memorization and working memory. This hinders the development of students' abilities. Furthermore, learning mathematics requires working memory which is more complex and involves many elements in constructing knowledge (Handayani & Nuraeni, 2020). Working memory that is too heavy will hinder students' representation abilities.

In an effort to be able to improve students' mathematical representation in accordance with the cognitive development of junior high school students, one of the appropriate learning alternatives is using worked example-based learning. Working example is a learning approach based on Cognitive load theory. Cognitive load theory is an instructional design theory that has been used to produce learning procedures using our knowledge of human cognitive architecture (Retnowati, 2012). When viewed from a cognitive load perspective, the worked example strategy is more effective when students study individually, but is ineffective when students learn collaboratively (Irwansyah & Retnowati, 2019).

The working example presents the steps in getting a solution to a problem that is described step-by-step (Sweller et al., 2012). Working examples contain problem-solving steps so that students more easily learn and understand how to obtain a solution to a problem (Atkinson et al., 2018). Working examples include problems, solutions, and explanations (Mayer, 2002). Working examples do not just present examples and solutions, and then give questions of the same complexity, but the worked example strategy juxtaposes examples and problem-solving questions in a one-page display, making it easier for students to observe examples and associate different problems. This of course will reduce the burden on students' working memory because the main purpose of worked examples is to introduce students to a procedure and the correct final answer (Al-Baqie, 2018).

Previous research by Santosa, Rafianti, & Yulistiany (2022) stated that there were different abilities in solving mathematical problems between students who received worked-example and expository learning methods; (2) There are differences in the ability to solve mathematical problems between students who have high and low initial abilities (Santosa et al., 2022). Meanwhile, Noorfotriani & Rosyid (2020) stated that the increase in students' mathematical understanding abilities using worked examples was in the high category (Noorfitriani & Rosyid, 2020).

So that the purpose of this study was to apply worked example-based learning as an effort to improve the representation ability of junior high school students. The novelty of this research is the implementation of worked example-based learning in the geometry material of the coordinate system chapter using worked example-based learning instruments and models, and comparing the mathematical representation abilities of students using worked example learning with conventional classes.

2. Method

This research is included in quasi-experiment research where the research uses classes that already exist. The design used in this study is the non-equivalent control group design. In this experiment design there are two groups of samples, the existence of a pretest, different treatments and the existence of a post-test. The sample in the first group is an experiment class that uses the worked example-based learning. Meanwhile, the second group as the control class who received learning using conventional learning. The existence of this control class is as a comparison, to what extent changes occur due to the treatment of the experiment class. The design diagram of this research is as follows (Ruseffendi, 2005):

O X O
- - - - - - - - - - -
O O

Information:

O : Pretest and Post-test represent ability of student representations.
X : Treatment using the worked example-based learning
- - - : The subject was not selected randomly.

The population in this study were all students of class VIII SMP Negeri 1 Talang Kelapa, Banyuasin, South of Sumatera. The sampling technique was carried out using purposive sampling technique. Samples on select from is student in class VIII.3 were used as experiment class, and class VIII.4 used as a control class.

The instrument that used in this research is a mathematical representation test. The validation of this instrument was carried out by an expert review, then it was tested on upper class students who had received geometry material and had their validity and reliability tested. Analysis the data using t-test with independent samples test.

3. Results and Discussion

3.1 Results

Descriptive statistics of mathematical representation ability in the experiment and control groups are obtained as shown in the following table.

Table 1. Counting the Number of Dancers

Test	Control Class		Experiment Class	
	Pretest	Post-test	Pretest	Post-test
N	32	32	32	32
Xmin	8	16	14	27
Xmax	81	91	86	100
$\bar{x}$	47,07	53,13	49,57	60
Sd	21,26	18,20	16,8	19,71

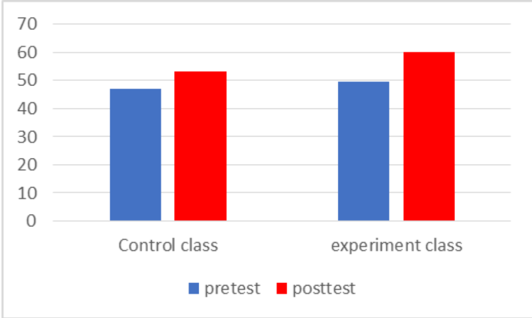

Figure 2. Representation Abilities Test

The average value of the post-test in the experimental class was 60, while the average value of the post-test in the control class was 53.13 meaning that the average test score of students' mathematical representation abilities in the experimental class was higher than the average ability test score mathematical representation of students in the control class. In other words, this worked example-based learning tool is effective for improving students' mathematical representation abilities.

The initial stage analysis carried out in this study was to analyze the pretest value. The pretest value analysis was carried out to determine whether there were differences in the ability, and increase in the mathematical representation ability of students in the experiment group, and the control group calculated by the pretest value similarity test using the Mann-Whitney non-parametric test.

Table 2. Test Results of the Average Difference in Pretest Scores

Test Statistics[a]

	Pretest
Mann-Whitney U	470.500
Wilcoxon W	998.500
Z	-.558
Asymp. Sig. (2-tailed)	.577

a. Grouping Variable: code

The results of the analysis state that the mean initial mathematical representation ability of students in the experiment group is the same as the initial ability of students in the control group with a significance value of 0.577, which means that it is greater than α = 0.05.

While the results of the difference test on the average post-test scores of students' mathematical representation abilities analyzed using SPSS 21.0 are shown in table 3 below.

Table 3. Test Results of the Average Difference in Post-test Scores

Test Statistics[a]

	Post-test
Mann-Whitney U	384.000
Wilcoxon W	912.000
Z	-1.719
Asymp. Sig. (2-tailed)	.086

a. Grouping Variable: code

Based on table 3, the Asymp.Sig (2-tailed) value for the students' mathematical representation post-test data is 0.086. If taken $\alpha = 0.05$ then Asymp.Sig (1-tailed) $> \alpha$ so that H_0 is accepted. The average final ability of students' mathematical representations in the experimental class is the same as the average final ability of students in the control class.

To find out whether the difference in the increase in students' mathematical representations between the experimental class and the control class is significantly different, it is necessary to carry out a t test. To see the increase in students' mathematical representation that has been achieved by students and their qualifications, normalized gain data is used. The average normalized gain is an illustration of an increase in students' mathematical representations both with worked example-Based learning and with conventional learning. The mean and standard deviation of gain from the results of students' mathematical representation tests in the experimental class and control class are presented in table 4 below.

Table 4. Mean and Standard Deviation of Ability Gain mathematical representation

Class	Mean	Gain Qualification	Std. Dev
Experiment	0,243	Low	0,363
Control	0,078	Low	0,320

From table 4, it can be seen that the students in the experimental class whose learning used the worked example-Based Learning had a higher average gain than the control class students whose learning used conventional learning. Gain qualifications for the experimental class and control class are moderate. While the standard deviation for the experimental class is relatively larger than the control class. This shows that the increase in the mathematical representation of students in the experimental class is more widespread than the mathematical representation of students in the control class.

The results showed that students whose learning used the worked example-based learning had a higher average mathematical representation ability than students who did not use the worked example-based learning. This result is possible because students who use worked example-based learning are not too burdened with cognitive content. They also easily work on questions that are in accordance with existing examples. Meanwhile, these activities did not occur in mathematics learning in the control class.

3.2. Discussion

In general, the learning process that occurred in the experimental class was in accordance with the signs and criteria and characteristics of assisted learning. This is reflected in the active process of students in discussing, asking questions, answering problems according to the instructions in the worked example-based instructional video. During the learning process students enthusiastically listen and pay attention to the material presented in the video then students start working on the LKPD if instructions appear in the video to do the work as exemplified in the previous video. Some students who watched the video well, immediately understood the instructions and worked on their worksheets well, but there were also some students who were still confused about understanding the intended instructions. This is understandable because the learning process carried out in this experimental class was somewhat different from the learning that they were used to receiving from their teachers.

The experience of teaching with the Working Example approach and the learning outcomes obtained by students after receiving Mathematics learning media in the form of worked example-based instructional videos has maximized students' self-efficacy to learn more independently and tough in solving problems and assignments given. Another finding, during the process of implementing worked example-based learning, is that students have the enthusiasm to take part in learning using Work Example-based LKPD. Because this LKPD is integrated with learning media in the form of a worked example-based instructional video. Students are enthusiastic about completing all the instructions contained in the video by working on the LKPD in each lesson. Students have an interest in the problems given in learning because the questions and the steps for doing it are in accordance with the examples that have been given.

The application of this worked example-based learning tool begins with giving apperceptions, then students are invited to listen to the material, observe problems and examine examples of working on problems contained in learning media in the form of instructional videos. When the video shows instructions for doing the questions, students are asked to work on a worked example-based LKPD which is structured to optimize students' mathematical representation abilities and self-efficacy. The teacher as a facilitator always accompanies and guides students in completing their assignment.

With a worked example-based learning approach and the use of learning media in the form of worked example-based instructional videos, learning becomes more interesting and increases students' enthusiasm in participating in learning because the videos are in the form of animations. When students work on the practice questions given, the teacher goes around paying attention to how students do the exercises and helps direct students who are having difficulties.

Furthermore, if we look at the results of the research that has been put forward, it shows that learning based on Worked Example is significantly better at improving students' mathematical representations compared to conventional learning. Some of the reasons put forward are that in the implementation of learning in the control class that uses learning using a conventional approach, the teacher provides learning only in a one-way informative manner even though the teacher provides a detailed explanation of the subject matter, and provides examples of how to solve problems, and provides exercises. And students also pay close attention to the teacher's explanation, then record what the teacher explains and do the exercises. Monotonous like that, but there is no interesting impression because there is no use of learning media and the right approach in teaching. After the time for working on the questions is up, all students collect their work to the teacher's desk to be assessed. For the discussion, several students were asked to work on the problem on the blackboard. Student activity during this lesson tends to be passive and does not train students' independence in learning compared to worked example-based Mathematics learning.

When implementing worked example-based learning in the experimental class, the results showed that students whose learning used worked example-based learning had a higher average mathematical representation ability than students who used conventional learning. This is in line with the results of research conducted by Handayani & Nuraeni (2020) which applies learning using worked examples based on mathematical understanding abilities which are valid and quite effective in terms of cognitive content (Handayani & Nuraeni, 2020).This is corroborated by Muryanto's research (2020) regarding the effectiveness of worked example pairs in regional learning solving a system of linear inequalities of two variables. It was concluded that there was no significant difference in the average learning achievement between the integrated worked example pairs strategy and separated worked example pairs. In addition, there was no significant difference in the average learning time between integrated worked example pairs and separated worked example pairs strategies. The integrated worked example pairs strategy provides a higher average learning achievement (Muryanto, 2020).

In general, worked example-based learning is suitable for students who have weak working memory so that it will help them better understand the theory and steps to solving a problem. As for students whose cognitive abilities are already good, this worked example-based learning can minimize the occurrence of excess burden on students' cognition content.

4. Conclusion

Based on the results of the research, it was found that the average final ability of students' mathematical representations in the experimental class was the same as the average final ability of students in the control class with Asymp.Sig (1-tailed) = 0.086. But, the average value of the post-test in the experimental class was 60, and the average value of the post-test in the control class was 53.13. Its meaning that the average test score of students' mathematical representation abilities in the experimental class was higher than the average ability test score mathematical representation of students in the control class.

However, students in the experimental class who learned using Worked example-based learning had a higher average gain than control class students who used conventional learning. It also can be said that the ability of mathematical representation in students whose learning uses mathematics learning using the worked example-based learning is better than students who do not use the worked example-based learning, and there are also differences in improvement the ability of mathematical representation of students who learn using the worked example-based learning, and students who do not use the worked example-based learning.

Suggestions for further research that wants to use worked example-based learning should be the class used is a class with low abilities. Because this learning model is more suitable for using Low

Order Thinking Skill (LOTS) type problems with routine problems. So it is not recommended for problem solving questions and High Order Thinking Skill (HOTS) type questions.

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