Cooperative Learning Uses E-Learning Materials to Improve Students' Math Problem-Solving Ability

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Abstract. The research objective was to obtain the effectiveness of cooperative learning using e-learning materials to improve students' math problem-solving ability. This research was a quantitative experimental research method. The subject study of linear and matrix algebra is class 1A with a total number of students 27. Collecting data used observation and test questions. The data analysis technique used the average completeness test, the N-gain test, the comparative test, and the proportion test. The results obtained a) meet individual mastery (KKM = 66), b) classical completeness was 75%, meaning that the proportion of students who have reached 66 is 75%, c) students' math problem-solving ability with cooperative learning using e-teaching materials were 81,2. This was higher than using the expository method of 72.4, d) there was an increase in student problem-solving abilities of 0.42 medium category.

Keywords: Cooperative learning · E-learning materials · Math problem-solving ability

1 Introduction

The emergence of covid 19 became a pandemic that attacked globally, exceeding cases of viruses such as SARS, etc. [1]. The government urges the public not to congregate, maintain physical stamina and carry out social restrictions during the COVID-19 pandemic as a precautionary measure [2]. The coronavirus pandemic has not only hit the health sector but also in various sectors such as the education sector so that learning cannot be done face-to-face as before [3]. The government takes policies regarding the learning system in the field of education. The policy is to apply to learn online. The need for an internet network is a tool in an online learning system that replaces face-to-face learning. Educators must monitor learning activities outside the campus, so it is necessary to make online learning media without reducing the meaning of the learning process. Online learning requires a laptop or personal computer (PC) that connects with an internet network. Educators can carry out activities together in online learning.

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Educators can ensure that students take part in learning even though they are hindered by different places. Online learning is closely related to the internet network, while the internet network is not always stable when used. Educators need efforts to overcome this by learning technology, both hardware, and software, for example by creating learning material content [4]. Educators can use groups on social media such as telegram, WhatsApp (WA), Skype, Google meet applications, Webex, Zoom, or other media as learning media. Educators as human resources in mathematics education can choose to teach mathematics online [5].

Information technology is developing so rapidly every day. Higher education institutions should be able to improve services on aspects of the tri dharma of higher education, especially in the field of education (teaching). The library as a learning provider is enough to give students a role in the learning process and the dissemination of information. Generally, the teaching materials are textbooks containing learning text materials for a particular field of science. The textbook contains learning materials that are equipped with summaries and practice questions to hone the problem-solving ability. The existence of learning texts is important, it is prioritized and used as a guide for students to improve their thinking skills. Without textbooks, students will find it difficult to learn, either in class or independent study. So, the book can be said to be the main guide for students, from elementary to university levels.

Based on the observations, the lecturer provides conventional learning, causing boring learning and reducing student interest. Students are not allowed to develop mathematical problem-solving abilities and construct the material provided. The construction process in explaining mathematical problems is still low, so it has an impact on the continuation of students in receiving material [6]. There are students in completing their assignments who cannot show their abilities to the fullest because students are too sure they will be able to complete them so excessive trust makes it difficult for them to think in a focused manner [7]. Then, students are given materials in the form of conventional teaching materials which the material of reading text is other people's work. If the teaching material is text, students are less motivated to learn the material. Learning activity in university needs interaction between lecturer and students, students and other students. This interaction can be applied to discussion groups. Discussion group plays important roles because students and lecturer can discuss exchanging information to technology development [8].

The development of the era requires educators to use technology in making e-teaching materials. The teaching materials are made in the form of e-teaching materials to attract the enthusiasm of students in reading the material. Making e-teaching materials electronically is one form of effort in overcoming the problems of students in choosing companion resources or learning media to optimize student understanding [9]. In e-teaching materials, besides containing text material, there are also learning videos in each subdiscussion of the material, providing learning evaluations, and digital explanations. The purpose of learning mathematics was for students able to develop optimally in problem-solving. Problem-solving ability is closely related to learning mathematics because the context of mathematics is related to the context of real-life, knowledge, and technology. This is the importance of effective problem-solving ability in their profession and later careers [10]. Four steps can solve problems according is namely (1) understanding the

problem, (2) planning problem-solving, (3) carrying out problem-solving plans, and (4) seeing back to complete troubleshooting [11]. In this research, indicators of mathematical problem-solving ability are (1) students can explain mathematical problems and write what they know, (2) students plan about mathematical problem solving by being able to write what is asked, (3) students can carry out the plan of mathematical problem solving by being able to provide the solution, (4) students review the completeness of problem-solving by being able to write the solution's conclusion that has been learned. Solving mathematical problems can be solved by students if students already understand mathematical schemes [12]. The success of students in understanding mathematics is the result of the learning design applied by educators. Mathematics has the capacity as a tool in solving problems in line with vocational education [13].

The main competence of humans in dealing with situations of uncertain dynamics of change full of surprises is the ability to solve problems. In solving problems, intelligence and creative strategies are needed to process knowledge [14]. Improving mathematical problem-solving ability needs a learning model approach. One of the learning models which can be used is cooperative learning. Cooperative learning is a learning model in which students are guided for sharing: knowledge, experiences, carrying out duties, taking responsibilities [15]. In line with previous research [16] mathematical problem-solving ability through cooperative learning, jigsaw-type shows enhancement, the same as through student learning activities. In line with previous research dge, there is an enhancement in the mathematical problem-solving ability of junior high school students with cooperative learning jigsaw which shows significantly than conventional learning [17]. Previous research shows enhancement in mathematical problem-solving ability with cooperative learning STAD-type than conventional learning which is not effective [18]. It shows enhancement in mathematical problem-solving ability with cooperative learning Mind Mapping-type through inquiry strategy, and positive attitude is shown by students through mathematical learning using cooperative learning's model Mind Mapping-type through inquiry strategy [19].

This research is expected to obtain the research objective was to obtain the effectiveness of cooperative learning using e-learning materials to improve students' math problem-solving ability. The impact of providing the benefits of fully structured learning tools for teachers, alternative learning models can be used by other teachers in teaching, and this research can improve students' mathematical problem-solving abilities. Then student skills can be formed when they can follow mathematics learning [20]. The research objective was to obtain the effectiveness of cooperative learning using e-learning materials to improve students' math problem-solving ability. Indicators for achieving effectiveness include a) meet individual mastery (KKM = 66), b) classical completeness was 75%, meaning that the proportion of students who have reached 66 is 75%, c) students' math problem-solving ability with cooperative learning using e-teaching materials higher than using the expository method d) there was an increase in student problem-solving abilities.

2 Research Methods

The research method used a quantitative experiment. The subject of this research included students from the D4 Electronics Engineering Study Program of Malang State Polytechnic, 1st-semester academic year 2021/2022 that consists of 6 classes totaling about 150 students then used random sampling. The sample was taken from class 1A with 27 students as experiment class which was given cooperative learning treatment with e-teaching materials, and class 1D with 28 students as control class which was given expository learning treatment with minimum criteria for completeness (KKM) was 66. Research planning activities were preparing learning tools such as Semester Learning Plans, Learning Implementation Plans, e-teaching materials, Student Worksheets (LKM), and test questions. E-teaching materials consisted of material including text, PowerPoint, educational video, and evaluation in each topic. Learning tools were consulted to colleagues (senior lecturers) for giving feedback and suggestion about learning tools that had been made, then did the repairment before using the research's instrument. The research design is as follows.

Information of O is taking class with random sampling, X is class which was given cooperative learning treatment with e-teaching materials, Z is class was given expository method treatment, and Y is the mathematical problem-solving ability of students (Fig. 1).

Method of collection data used observations, document activity photos, and question test sheet was obtained validity, reliability, the difficulty of the question and distinguishing power. The analysis technique used normality test where is the hypothesis results are obtained if the significant value in the Kolmogorov-Smirnov column >5% then H0 is accepted, homogeneity test where is A significant value is greater than 5% H_0 is accepted, proportion test (classically), an average of completeness test (individually), comparative test (T-test), N-Gain test, or improvement using SPSS [21].

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}} \tag{1}$$

Testing individual completeness test by comparing $t_{\text{-value}}$ $at_{\text{-table}}$ which using t-value formula as follows:

$$Z = \frac{\frac{x}{n} - \pi_0}{\sqrt{\frac{\pi_0(1-\pi_0)}{n}}} \tag{2}$$

n is sample total, $\bar{x}$ is the sample mean, μ_0 is the score of minimum criteria for completeness (KKM) that had been set, and is the standard deviation of the sample

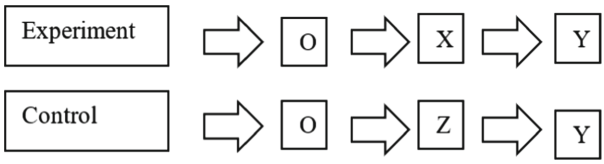

Fig. 1. Research design.

value. Then, testing students whether each of them manages to succeed in learning so proportion test must be done. The proportion test was used to know if the TKPMM minimum score from students as same as the score of minimum criteria for completeness (KKM) reaches a minimum of 75%. To find out the result, Z-test was carried out using the formula:

x is the number of students who reach the minimum criteria for completeness (KKM), π_0 is proportion score which is 75% hypothesized, and n is the total sample. N-Gain test has an important role to see an increase or decreasing movement that can be occurred to each aspect or component in the research. This test is based on the TKPMM score, the test was done twice which is in pretest and posttest. TKPMM after treatment was given, then pretest and posttest score was calculated by N-Gain [22] with the following equation.

$$\text{N-Gain} = \frac{S_{postest} - S_{Pretest}}{S_{mak} - S_{Pretest}} \tag{3}$$

Information:
$S_{postest}$ = Posttest TKPMM score
$S_{Pretest}$ = Pretest TKPMM score
S_{mak} = Maximum score from TKPMM

3 Result and Discussion

Learning tools that have been prepared by the researcher, then construct validation by two colleagues (senior lecturers). The validated learning devices are given input and evaluation of improvements until the research instrument that is made is feasible to be tested in research to see the content, clarity, and readability of the instrument. The criteria for preparing the test are based on the results of discussion of learning objectives, task analysis, and study analysis. The test design developed in this study is a mathematical problem-solving ability test (TKPMM) on linear & matrix algebra material to measure the achievement of learning objectives. The test is prepared based on indicators of competency achievement that have been formulated with the stages of compiling the TKPMM question grid, compiling items, and making assessment criteria. Each student's completion is assessed according to the aspects of the indicators of students' mathematical problem-solving ability. The test was carried out in class 1E, which consisted of 27 students who had the same characteristics as the research class. The test results of the mathematical problem-solving ability test were obtained.

The questions tested were 6 questions, then 3 questions were taken which were used as research evaluations by taking into account the duration of the work 50 min (1 JP) (Table 1). After the analysis is done then the selected questions can be used.

The selection of the control class and the experimental class was tested for normality and homogeneity in class 1A totaling 27 students and 1D totaling 28 odd semester students in the 2021/2022 academic year, then a posttest (evaluation) was carried out on students' mathematical problem-solving ability. Normality test using Kolmogorov Smirnov, with the output in Table 2.

Table 1. Recapitulation of test results for TKPMM items

Question Number	Validity	Reliability	Difficulty level	Distinguishing power	Information
1	Invalid	High	easy	Pretty good	Not used
2	Valid		diff	Good	Not used
3	Valid		Medium	Good	Used[a]
4	Valid		Medium	Good	Used[a]
5	Valid		Medium	Good	Used[a]
6	Valid		Medium	Pretty good	Not used

[a]Content validation (senior lecturer)

Table 2. Normality test result

	Kolmogorov-Smirnov[a]		
	Statistic	Df	Sig.
Evaluation	.087	55	.200[b]

[a,b]Lilliefors Significance Correction

Table 3. Homogeneity test results

		Levene's Test for Equality of Variances	
		F	Sig.
Evaluation	Equal variances assumed	1.244	.793[a]
	Equal variances not assumed		

[a]Lilliefors Significance Correction

The hypothesis results are obtained if the significant value in the Kolmogorov-Smirnov column > 5% then H0 is accepted which is 0.200 or 20% > 5% and H1 is rejected. This means that the data of the mathematic problem-solving ability test (TKPMM) is a normal distribution. As for homogeneity tests for classes conducted with independent sample tests.

The results of the homogeneity test obtained that the sig value was 0.793 or 79.3% (Table 3). A significant value is greater than 5% H_0 is accepted. So it can be concluded that students in the classroom using cooperative learning using e-teaching materials and in the classroom using expository learning have the same variant or both classes have homogeneous/same abilities. The results of the selection of researchers obtained that class 1A as the experimental class used cooperative learning using e-teaching materials

Table 4. Summary of linear and matrix algebra learning materials

No	The material	Learning Objectives
1	System of Linear Equations[a]	Students can formulate the general form of linear equations Students can explain the method of solving a system of linear equations
2	System of Linear Equations[a]	Students can distinguish between row echelon and reduced row echelon Students can explain the method of solving a system of linear equations Students can explain the system of homogeneous linear equations
3	Matrix[a]	Students can know the general form of the matrix Students can distinguish the types of matrices Students can operate matrices
4	Matrix[a]	Students can explain the determinants of the Matrix Students can explain inverse matrices Students can apply matrices to electricity networks
5	Vector[a]	Students can explain vector concepts in R2 and R3 Students can explain cross product Students can explain the dot (dot) vector
6	Vector[a]	Students can explain linear combinations Students can explain linear freedom Students can explain vector base
7	Vector[a]	Students can explain the eigenvalues Students can explain eigenvectors

[a]Source Semester Learning Plans

and class 1D as the control class using expository learning. Research activities were carried out for 7 meetings with details in Table 4.

The ability to solve mathematical problems is declared complete if the class average score reaches the KKM (66). The cooperation between students in groups makes it easy to explain problems to gain an understanding of facts or material concepts in simple language [23].

Individual completeness testing is carried out by calculating the formula (1) $n = 27$, obtained t_{count} $t_{(1-\alpha)}$ with significance 5%, $DK = (27–1) = 26$ is 1,706 it means $t_{count} > t_{table}$ or 9.575 > 1,707 H_0 is rejected and H_1 is accepted, which means that the average TKPMM in the test class exceeds 66. Classical learning completeness in this study if the average TKPMM uses cooperative learning with e-teaching materials is more than 66 and students who get scores above 66 are 75%. Mastery learning that is meant is mastery of mathematical problem-solving ability. The completeness test is taken from the scores obtained by students from TKPMM in classes that use cooperative learning with e-learning materials at the end of the lesson. To test whether each student is complete in learning, a proportion test is carried out. This test is carried out to determine whether

the student's TKPMM score is at least the same as the KKM reaching at least 75%. Testing the proportions with $n = 27$, $\pi 0 = 0.75$, $x = 26$, obtained by using the formula (2) the value of $Z = 2.555$ is greater than the Z table, namely 1.96 with a 5% confidence degree, then reject H_0 and accept H_1. This means that the proportion of students who have received >66 has exceeded 75%. Comparative testing of the difference in average student scores from TKPMM results between the experimental class using cooperative learning with e-teaching materials and the control class using expository learning was carried out to determine whether the use of the new model would produce better results or not.

Based on Table 5, the value of the table in the distribution of t_{values} is $DK = 27 + 28 - 2 = 53$ with a significance level of 5% is 2.021. In conclusion, the value of $t_{count} > t_{table}$ or $2.659 > 2.021$ then H_0 is rejected and H_1 is accepted. It means that the mathematical problem-solving ability of students who use cooperative learning with e-teaching materials is greater than the mathematical problem-solving ability with expository learning. The test of increasing mathematical problem-solving abilities is carried out by calculating the initial test scores and final test scores in learning activities. The formula used to calculate the increase in mathematical problem-solving ability uses the formula (3) Gain Normality value (Table 6).

Problem-solving is part of knowledge to get a solution that is not yet known how to solve, with various experiences experienced it can be taken to solve the best problem solution [24]. E-teaching materials made by lecturers are proven to provide an effective and strategic role in efforts to manage to learn in the classroom. With books that have been prepared according to the planned learning flow, the implementation of learning runs smoothly and students can follow the learning to the maximum. This is because, in the design and preparation of E-teaching materials, it is always synchronized between

Table 5. The comparative test of experimental class and control class.

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Post-test	Equal variances assumed	.505	.481	2.659[a]	53[a]	.010
	Equal variances not assumed			2.662	52.918	.010

[a]t count of SPSS

Table 6. The calculation of N-Gain

Score	Pretest	Posttest	Gain Score
Average	70,1	80,41	0,345[a]

[a]Count N-Gain

the materials and models used in learning. The elements that are used as the basis for making student books are: 1) completeness of subject matter, 2) student interest in teaching materials, 3) giving challenge questions to develop student knowledge, 4) providing examples of systematic completion, 5) providing training as reinforcement end of learning, 6) providing answer keys as material for controlling answers, 7) providing supporting images that attract students, and 8) using simple language so that it is easy to understand. 9) the group discussion went well. Where is the principle in cooperative learning is the involvement of students in groups where there are two important things including a) if you want to get properly cooperative then each group member must have an awareness of the same goal to get the results of work together, b) group success depends on the sense of responsibility of each individual in contributing to the group [25].

Teachers must understand the implementation of cooperative learning by conducting group discussions has challenges that are not easy [26]. The activeness of students is an inseparable part of cooperative learning because it can create a learning atmosphere that is not boring [27]. Students do not hesitate to ask questions to express their opinions on the learning given. If students have difficulty or confusion, they actively ask their peers and even ask the teacher. The teacher can respond to student responses so that they can straighten out if what students understand is wrong or emphasize important things. The implication is that students will be ready to receive the next material.

4 Conclusions and Suggestions

The effectiveness of cooperative learning using e-teaching materials to improve students' problem-solving ability was carried out experimentally. The results of the study obtained a) fulfilled individual mastery (KKM = 66), b) classical completeness was 75%, meaning that the proportion of students who had reached 66 was 75%, c) students' mathematical problem-solving ability with cooperative learning using e-teaching materials were 81,2 is higher than using the expository method of 72.4, d) there was an increase in student problem-solving abilities of 0.345 in the medium category.

As for suggestions on the completion process related to the process of mathematical problem-solving ability, lecturers are expected to pay attention to how students complete so that lecturers know the flow of thought patterns that are intended for students, from this lecture can provide follow-up to direct students' mindsets if there are errors. Looking at the written answer reflects the original ability of the student.

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