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EFFECTIVENESS OF PBL-BASED MOBILE LEARNING TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS

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Abstract

The purpose of this research is to evaluate whether or not students in the eighth grade at SMP Negeri 2 Betara in the Tanjung Jabung Barat Regency can improve their mathematical critical thinking skills by using mobile learning that is based on problem-based learning (PBL). The participants in this research were all eighth-graders from one junior high school in the Tanjung Jabung Barat Regency. There were a total of 128 students included in this study, and they were distributed across four classes. The sample was selected from as many as two classes, specifically VIIIA with a total of 28 students serving as the experimental group and VIIIB with a total of 28 students serving as the control group. The analysis of the data reveals that the Zcount value is 10,099, and the significance value is 0.000< 0.005; these values were determined to be significant. Therefore, the working hypothesis or alternative hypothesis that was proposed in this study is accepted. It states that there is a difference in the average critical thinking of students who use PBL-based mobile learning compared to students who use standard teaching materials. While the null or nil hypothesis, which states that "there is no difference in the average critical thinking of students who use PBL-based mobile learning and students who use conventional teaching materials," is rejected.

Keywords: critical thinking, mobile learning, math education, problem based learning

1. Introduction

The growth of information and communication technology has led to significant shifts that have contributed to the overall improvement of educational opportunities available to people all over the world. In tandem with these developments, there has also been a substantial growth in the production of a wide variety of learning approaches, including learning methods, learning material, and learning processes. (Chinnappan & Lawson, 2005).

This is something that people who monitor education, such as teachers, education consultants, officials who are in charge of education policy, and even the ministry of education, which is the most influential decision and policy maker in the sector, need to think about. Students in the 21st century will confront a great deal of competition in responding to the various problems that will be presented to them in their lives in the years to come. One of the measures that is being adopted by the Ministry of Education and Culture in order for pupils to be able to respond effectively to these difficulties is to equip them with a variety of skills. (Asmar et al., 2020; Bariyyah, 2021; Kim & Md-ali, 2017; Mariani & Marzal, 2021; Setyarto et al., 2020; Suh et al., 2021; Sunismi et al., 2019).

One of the thinking abilities that has to be cultivated is critical thinking skills. This is because students frequently respond incorrectly to exercises that cover the same content but use different examples of questions (Arisoy & Aybek, 2021; Sachdeva & Eggen, 2021). Because this is one of the thinking skills that need to be developed, you should work on developing it. This is one of the thinking skills that need to be developed. Learning activities such as lectures and group discussions are typically led by instructors under the traditional form of education, which can be described by the phrase "conventional learning model." In this paradigm, the instructor is more involved in the learning process than the students are, and the students participate in the learning process only by receiving information and knowledge from the lectures that the teacher delivers. Because providing opportunities for students to carry out their learning is one way to train thinking skills, including determining alternative problem-solving strategies presented by the teacher, this then results in students' thinking skills not having been trained, which is a problem because students' thinking skills have not been trained. Students are not required to merely sit by, take notes, and memorize information in order to improve their thinking skills; rather, the program involves active participation from the students.

In addition to the requirement that they present students with models that are more varied and simple to remember, teachers have the additional responsibility of cultivating students' mentalities through the use of engaging educational materials. As a direct result of the rapid advancement of science and technology in today's society, students are strongly urged to react swiftly to all of these changes and follow them in an unavoidable manner. The development of mobile technology is progressing at a breakneck pace right now, and as a result, the smartphone has become one of the mobile device types that is utilized the most. (Chinnappan & Thomas, 2015; Khambari et al., 2010; Thurm & Barzel, 2022). The number of students who possess and make use of mobile devices is directly proportional to the variety of educational contexts that lend themselves well to the implementation of mobile technology.

It is envisaged that the availability of this mobile learning media will make the learning process more hospitable, as well as boost critical thinking skills. (Astuti et al., 2018; Cavus & Uzunboylu, 2009; Opticia & Khabibah, 2022; Supandi et al., 2019). For this reason, it is vital to introduce innovative ways to make educational content more appealing to students, so that they have the confidence to continue the learning process. This can be accomplished by making educational content more visually appealing to students. An intriguing learning model that is able to enhance students' analytical and deductive reasoning skills is one of the things that can be done to help improve the situation. This is only one of the things that can be done. The one that can fulfill these needs is the problem-based learning that is integrated into mobile learning (Herdianto et al., 2021; Ismail et al., 2018; Santoso & Soedjoko, 2019).

According to the previous explanation, the The purpose of this research is to evaluate whether or not students in the eighth grade at SMP Negeri 2 Betara in the Tanjung Jabung Barat Regency can improve their mathematical critical thinking skills by using mobile learning that is based on problem-based learning (PBL).

2. Method

The development of mobile learning has already been done, and this research is an implementation of that development. This study makes use of quantitative research, the purpose of which is to test hypotheses utilizing data that has been collected in a manner that is consistent with pre-existing theories and ideas, using *the*

independent sample t test. The data used in this study was collected in a manner that was consistent with pre-existing theories and ideas. The method of investigation is referred to as experimental research.

This experimental research is being done with the intention of determining whether or not the research topic can be modified as a result of the imposition of "something." There are a total of 128 persons who make up the population for this study. These individuals are all students in the eighth grade at SMP Negeri 2 Betara, located in the Tanjung Jabung Barat Regency of Jambi Province. The method of sampling that was utilized in this research was a random sampling method. The researchers chose to take a sample from two classes out of the total number of classes that were offered at SMP Negeri 2 Betara in Tanjung Jabung Barat Regency, Jambi Province. There were a total of 56 students in these two classes. The random sampling method was utilized.

Documentation and actual tests were employed as methods of data collecting for this particular study. The documentation is used to acquire statistics on the number of students enrolled in class VIII at SMP Negeri 2 Betara for the academic year 2021/2022, whilst the test is used to measure critical thinking skills in mathematics with regard to the topic of flat-sided space. The test that is employed is a written test, and every student, regardless of whether they are in the experimental group or the control group, is required to complete it. An essay test with ten questions is utilized as the evaluation method, and a weight of ten points is assigned to each question that is answered correctly. Therefore, the highest possible score is 100.

Table 1. The indicator for Critical Thingking Skills

Aspect Measured	Indicator	Item Number
Critical Thinking Skills	Checking the truth of arguments, statements and the solution process	1,3
	Formulate questions with reasons	2,4
	Identifying relevant and irrelevant data for a math problem	6,8
	Identify assumptions	5,9
	Compile answers/solve math problems with reasons	7,10
Total		**10**

The grid of instruments and tests of critical thinking skills is that the test instruments are arranged in accordance with the basic competencies that exist at the level of the junior high school education unit according to the level so that the grids and questions that are made can be used to obtain data in the research that will be conducted.

This research is an implementation of a mobile learning product that has been developed with a lengthy series of processes, and it has been well validated by material experts and media experts, and it has been tested limited to mathematics teachers and students. Here is one display of PBL-based mobile learning on the topic of spatial construction flat side, as shown in figure 1.

Figure 1. Mobile learning exhibit focused on PBL with the topic of Build a Flat Side Space

3. Results and Discussion

3.1 Results

To determine whether or not students' critical thinking had improved, a pre- and post-test was administered to the experimental class, which was taught using PBL-based mobile learning; the control class, which was taught using conventional teaching materials, served as a comparison. The results of these two tests were processed, and the N-Gain index formula was used to determine whether or not the experimental class had improved.

To determine whether or not the processed data came from a normally distributed population, a normality test of data gain is first carried out in both the control class and the experimental class. This allows one to determine whether or not the data were obtained from a normally distributed population.

The following is a list of the decision-making criteria that should be used when testing the data:

a. If the significance level is less than 0.05, then the data from the sample do not have a normal distribution.
b. If the significance level is greater than 0.05, then the data from the sample have a normal distribution.

Table 2. Normality Test N-Gain Critical Thinking Ability

Class	N	Shapiro-Wilk			Decision
		Statis	Df	Sig.	
Experiment	28	0.866	28	0.002	Reject Ho
Control	28	0.961	28	0.371	accept Ho

The experimental class Ho was not chosen to continue since it did not meet the criteria for making the selection. This indicates that the population from which the sample taken from the control class comes from is normally distributed, whereas the population from which the sample taken from the experimental class comes from is not normally distributed. The N-Gain homogeneity test is the next step, and it evaluates the analytical capabilities of the students in order to determine whether or not the two classes serving as samples have the same or different variances.

Then the homogeneity test was carried out using Levene's test with the result that the significance value was 0.676. because the significance value is greater than 0.05, based on the decision-making criteria it can be concluded that there is no difference in variance between the experimental class and the control class or in other words the variance between the experimental class and the control class is the same.

The data obtained from the two classes indicates that the experimental class has a non-normal and homogeneous distribution, so the next test is to do the average similarity test with the z-test. Since the results of the normality test and the homogeneity test that have been carried out on the results of the N-Gain critical thinking ability state that the experimental class has a non-normal and homogeneous distribution, the results of the tests that have been carried out on the results of the N-G (equal variance assumed). Taking into consideration the next hypothesis:

Ho : (there is no discernible difference between the students who utilize PBL-based mobile learning and the students who use conventional teaching materials in terms of their overall level of critical thinking)

H_1 : (there is a difference between the average critical thinking of students who participate in PBL-based mobile learning and the critical thinking of students who participate in traditional teaching methods)

The following are the statistical hypotheses that can be derived from these:

Ho : $\mu_1 = \mu_2$

H_1 : $\mu_1 \neq \mu_2$

The following are the criteria that will be used to make a decision:

a. Ho will be disregarded if the significance value is lower than 0.05
b. The Ho hypothesis is considered valid if the significance value is larger than 0.05.

Table 3. Mann Whitney U Test Critical Thinking Ability

Aspect	Z	Variance	Sig.	Deicision
N-Gain	10.099	Homogen	0.000	Ho Rejected

It is known that the Asymp value can be found in table 3 of the Mann-Whitney U test that was just presented. Sig of the probability value with two tails set at 0.000<0.05. As a result, using the information presented in the preceding section regarding the Mann-Whitney test, one might get the conclusion that "H_0 is fail to rejected." It is therefore possible to say that there is a difference between the average increase in critical thinking skills of students who use PBL-based mobile learning and students who use conventional teaching materials.

3.2 Discussion

Through the use of PBL-based mobile learning, students were able to successfully acquire mathematics related to the flat-sided space building material. For this reason, it is essential to have an understanding of the efficacy of utilizing mobile learning in the process of acquiring mathematical skills. It is possible to determine whether or not mobile learning is beneficial by seeing whether or not students' critical thinking abilities improve as a result of using mobile learning and also by calculating the effect size value. The usefulness of problem-based learning (PBL), flat-paced mobile learning, and mobile learning overall will be discussed more below.

a. The effectiveness of mobile learning in building a PBL-based flat space can be seen from the improvement of students' critical thinking skills

The findings of the study that analysed the students' critical thinking skills in their entirety revealed that the increase in critical thinking skills in the experimental class was greater than the increase in critical thinking skills in the control class. This is because the experimental class used PBL-based mobile learning to learn how to build data space, whereas the control class did not. This is consistent with the findings of several studies that were conducted in the past, such as the one that

found that learning mathematics through the use of mobile learning media that took a realistic mathematical approach was more effective in improving critical thinking skills in geometry classes (Prasetyowati, 2016); 62% of students are using mobile learning-based LKS, which has resulted in a score higher than the KKM; hence, the LKS is able to optimize the critical thinking skills of the majority of students (Sadiyyah et al., 2019).

According to the findings of Atewell et al. (2009), mobile learning media will be able to be utilized in the not-too-distant future, which is in conformity with the ever-quickening pace of the advancement of science and technology. Additionally, mobile learning media has a favourable effect on pupils, in that it can inspire kids to learn and entice students to comprehend the subject matter (Attewell et al., 2009).

This mobile learning is designed by embedding problem-based learning. The results of students' mathematical critical thinking ability tests-both initial ability tests and critical thinking skills tests-can demonstrate that students' mathematical critical thinking abilities can be improved through learning in mathematics. This can be demonstrated from the results of students' initial ability tests (Nainggolan, 2020).

It can be seen from the results of the analysis of the effectiveness of PBL-based flat-space mobile learning in improving critical thinking skills that there was a significant increase in critical thinking skills in the experimental class after learning to build flat-sided spaces assisted by PBL mobile learning. This is because the use of ICT in mathematics learning helps students provide access to wider information, quickly and precisely, in addition to the use of ICT in the form of mobile learning. The results of the analysis of the effectiveness of PBL-based flat-space mobile (Adolphus et al., 2012).

b. The effect size demonstrates that mobile learning is an excellent method for constructing a PBL-centered flat area

In addition to determining the category based on the effect size of using mobile learning to build PBL-based flat space from strengthening critical thinking abilities, it is also possible to measure the efficacy of using mobile learning to build PBL-based flat space. Based on the findings of the N-Gain study of critical thinking skills, it has been determined that the data does not follow a normal distribution. As a result, the Mann-Whitney U non-parametric statistic will be used for the subsequent analysis of the data; consequently, the following formula will serve as the basis for calculating the effect size:

$$ES = \frac{|z|}{\sqrt{n}},\ n = n_1 + n_2$$ (Rice & Harris, 2005)

Information :
ES : Effect Size
z : z statistic
n : number of samples 1 and 2

The size of the effect can be computed using the following formula:

Table 4. Mann Whitney U Test

	N-gain
Mann-Whitney U	53,500
Wilcoxon W	459,500
Z	-5,550
Asymp. Sig. (2-tailed)	,000

a. Grouping Variable: class

$$ES = \frac{|-5.55|}{\sqrt{56}} = \frac{5.55}{7.48} = 0.74$$

The calculation findings show that the effect size value for students' critical thinking skills after learning to design flat side spaces helped by PBL-based mobile learning is 0.74. This value can be found in the results of the calculation. According to Cohen, an impact size of 0.74 falls into the strong group, which indicates that the efficiency of PBL-based flat-side spatial mobile learning in enhancing critical thinking abilities is quite strong. This is due to the fact that students experience increased motivation to learn mathematics when mobile learning is used as an alternate teaching material in the subject of learning mathematics. This is characterized by an increase in the level of mastery of the critical thinking skills that were outlined earlier.

In addition, the usage of PBL-based mobile learning is something brand new for the kids, and it is an experience that they have never had before. They believe that the only time computers are used for learning is during ICT classes; as a result, when they utilize PBL-based mobile learning software to learn mathematics, they feel really enthused and it becomes a new experience for them.

4. Conclusion

The effectiveness of mobile learning in terms of increasing students' critical thinking skills demonstrates that there is a significant difference between the experimental class and the control class. More specifically, the experimental class that

utilizes PBL-based mobile learning is superior to the control class. The calculation of the effectiveness using the Cohen effect size formula in the strong (high) category indicates that the effectiveness of mobile learning in improving students' critical thinking skills is in the strong (high) category. This is the case because the strong category corresponds to the high category of the Cohen effect size formula.

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