Indonesian Journal of Mathematics Education
Vol. 2, No. 1, April 2019, pp: 1~8
p-ISSN: 2654-3907, e-ISSN: 2654-346X
e-mail: ijome@untidar.ac.id, website: jurnal.untidar.ac.id/index.php/ijome

Application of Problem Based Learning Assisted By QR Code to Improve Mathematical Problem-Solving Ability of Elementary Teacher Education Students

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Received: 27 February 2019 *Revised: 3 April 2019* *Accepted:8 April 2019*

Abstract

This study aims to examine the effectiveness of Problem Based Learning (PBL) assisted by QR code on students' mathematical problem solving ability. This experimental research was carried out on students of the Elementary School Teacher Education Study ProgramUniversitas Muria Kudus in the mathematical concept course in the academic year of 2016/2017. The ability to solve mathematical problems is measured by tests. Data analysis techniques used include t-test and proportion test. The results of this study are: 1) the mathematical problem solving ability of students who learn through PBL assisted by QR code is better than the mathematical problem solving ability of students who learn through Direct Instruction learning; 2) the mathematical problem solving ability of students who are taught with PBL assisted by QR code have reached the minimum completeness criteria (MCC) and 3) the proportion of students taught with PBL assisted by QR code that has reached the MCC is better than the proportion of students studying through Direct Instruction learning that have met the minimum completeness criteria (MCC). Thus, the lecturer can develop PBL assisted by QR code to create interesting learning so that students are enthusiastic about the learning, which will have a positive effect on their mathematical problem solving ability.

Keywords: mathematical problem solving ability, problem based learning, QR code

INTRODUCTION

The Elementary School Teacher Education Study Program of the Teacher Training and Education Faculty of Universitas Muria Kudus (PGSD FKIP UMK), as a superior department, must always improve the quality of its graduates in terms of not only the graduates' Grade-Point Average (GPA), but also their soft skills and qualified skills as prospective elementary school lecturers.

Achievement of learning objectives is one of the indicators of educational success. In the Regulation of the Indonesian Minister of Research, Technology and Higher Education No. 44 of 2015 concerning the national standards of higher education, learning outcomes are defined as abilities obtained through the internalization of attitudes, knowledge, and skills (Menristekdikti, 2015). This is because Indonesia requires qualified human resources, who have not only competent knowledge but also strong characters in order to be able to compete in facing the era of globalization and the Asean Economic Community (MEA).

Noting the needs of intellectual human resources, the ability to solve mathematical problems is an ability that students must possess to be able to overcome the problems that they are going to face in the future. Mathematical Concept is one of the courses that can shape the mathematical problem solving abilities of PGSD UMK students. This is because mathematical problem solving ability is the heart of mathematics (Branca, 1980). Therefore, mathematics learning should be able to develop higher-order mathematical thinking skills including understanding, reasoning, connection, communication, representation, critical thinking, creative thinking, analytical thinking, evaluative thinking, reflective thinking, synthesis thinking, and problem solving in mathematics (Sumarmo, 2013).

Mathematical problem solving is a tool that can be used to help to develop not only students' thinking skills but also their basic abilities in solving problems in everyday life (Pimta, Tayruakham, & Nuangchalerm, 2009).

Mathematical Concept as one of the courses in PGSD department with a weight of four (4) credits requires the right method in order to be able to achieve the learning outcomes. This is because the teaching materials of this course are so theoretical that it can make students become bored and feel uninvolved because it is teacher-centered learning. If this condition occurs continuously, it results in the failure of achieving the learning outcomes. The average problem solving ability of PGSD UMK students is only 59.5. This value is far from the minimum completeness criteria (MCC) of 67.

Problems that occur can be overcome through contextual learning patterns that emphasize mathematical problem solving to explore aspects of students' know-how. The application of the Problem Based Learning (PBL) model is one of the forms of student-centered lecture process and is considered relevant to support students' needs and competencies that must be achieved. Problem-based teaching models require the development of skills, collaboration between students and cooperation to investigate problems together (Trianto, 2007). The purpose of problem-based learning is the mastery of learning content from heuristic disciplines and the development of problem solving skills (Rusman, 2012).

The learning in a mathematical concept course is expected to be able to motivate and involve students actively. The role of the lecturer in delivering teaching material is an important factor in achieving learning success. One medium that can be used is the QR code. The purpose of using a QR code is as an effort of using technology and becomes a medium that allows students to enjoy the lectures. The QR code does not only provide information about the materials but can also be used as a tool to evaluate the mastery of the materials. Students will feel up to date with the media used.

This study tries to accommodate QR code learning media in problem-based learning so that students' dependency on lecturers and books can be reduced, while at the same time making information more interactive. QR codes can be integrated with PBL by entering assignments in mathematical concepts in the form of QR code.

The objectives of this study are: 1) to identify whether the average mathematical problem solving ability of students taught by Problem Based Learning (PBL) assisted by QR code is better than the average mathematical problem solving ability of students learning through direct instruction learning; 2) to identify whether the mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted by QR code has reached the minimum completeness criteria (MCC); and 3) to identify whether the proportion of students learning through Problem Based Learning (PBL) assisted by QR code that has achieved the minimum completeness criteria (MCC) is better than the proportion of students studying through direct instruction learning who have achieved the minimum completeness criteria (MCC).

METHOD

The population of this study was the 2nd semester students of PGSD UMK. The sampling technique used in this study was random sampling. The sample in this study was divided into two classes namely the experimental class and the control class. In the experimental class, students were taught with PBL models assisted by QR code while in the control class, students were taught using the direct instruction model normally performed by lecturers.

The design of this study is a true experimental design because the researcher controls all external variables that influence the course of the experiment. The design is a true experimental design in the form of posttest-only control design. Table 1 below is the research design used in this study.

Table 1. Research Design

Group	Treatment	Post-test
Control Group	X	T_1
Experimental Group	Y	T_2

Note:
X: Learning with a direct instruction model
Y: Learning with PBL models assisted by QR code
T_1: Measurement of control group post-test
T_2: Measurement of experimental group post-test

Data collection techniques were carried out through test techniques. Tests of mathematical problem solving ability were carried out to obtain data on students' mathematical problem solving ability. The data obtained from the measurement results were then analyzed as follows.

a. Average Difference Test

Test of the difference of two average of one side: the right side is used to test whether the mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted QR code is better than that of students taught by direct instruction learning.

The hypotheses to be tested were:
$H_o: \mu_1 = \mu_2$;
$H_1: \mu_1 > \mu_2$.
Note:
μ_1 = average test score for mathematical problem solving ability of the experimental group
μ_2 = average test score for mathematical problem solving ability of the control group

To test the hypothesis the formula was used:

$$t = \frac{\overline{X_1} - \overline{X_2}}{s \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \text{ with}$$

$$s^2 = \frac{(n_1 - 1){s_1}^2 + (n_2 - 1){s_2}^2}{n_1 + n_2 - 2}.$$

Note:
$\overline{X_1}$ = average test score of students' mathematical problem solving ability the experimental group class
$\overline{X_2}$ = average test score for students' mathematical problem solving ability in the control group class
n_1 = number of subjects in the experimental group
n_2 = number of subjects in the control group
${s_1}^2$ = variance of the experimental group
${s_2}^2$ = variance of the control group
s^2 = joint variance

With $dk = (n_1 + n_2 - 2)$, the test criterion is that H_o is rejected if $t_{count} \geq t_{table}$ by determining significant level = 5%, chance (1-α) (Sudjana, 2005).

b. Learning Completion Test

The learning completeness test is to test whether the mathematical problem solving ability of students learning through PBL models assisted by QR code has reached the Minimum Completeness Criteria (MCC). A minimum score of 67 is the minimum completeness criteria (MCC) applied in PGSD FKIP UMK.

The hypotheses to be tested were:
$H_o: \mu = 67$
$H_1: \mu > 67$.
with:
μ = average test score for mathematical problem solving ability of the experimental group
67 = the minimum completeness criteria (MCC) for mathematics concept course

The formula used is:

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

Note:
$\bar{x}$ = average test score for mathematical problem solving ability
S = standard deviation
n = number of students

With the right side test, the criterion used is H_o is rejected if $t_{count} > t_{(1-\alpha),(n-1)}$ (Sudjana, 2005).

c. Test of Two Proportion Similarities

Test of two proportion similarities: the right side test is used to determine whether the proportion of students studying through Problem Based Learning (PBL) assisted by QR code that has achieved the minimum completeness criteria (MCC) was better than the proportion of students studying through direct instruction learning who have achieved the minimum completeness criteria (MCC.
For the right-side test, the hypothesis pair is:
$H_o: \pi_1 = \pi_2$;
$H_a: \pi_1 > \pi_2$.

Note:
π_1 = proportion of test score for mathematical problem solving ability of the experimental group which has reached the minimum completeness criteria (MCC)
π_2 = proportion of test score for mathematical problem solving ability of the control group that has reached the minimum completeness criteria (MCC)
The formula used was:

$$z = \frac{(\frac{x_1}{n_1}) - (\frac{x_2}{n_2})}{\sqrt{pq(\frac{1}{n_1} + \frac{1}{n_2})}}$$

with
$p = \frac{x_1+x_2}{n_1+n_2}$ and q = 1- p (Sudjana, 2005).

Note:
x_1 = the number of test scores of mathematical problem solving ability of students in the experimental class that have met the MCC
x_2 = the number of test scores of mathematical problem solving ability of students in the control class that have met the MCC
n_1 = number of students in the experimental class
n_2 = number of students in the control class
In this case, H_o is rejected if z $\geq z_{0,5-\alpha}$ and H_o is accepted if z $< z_{0,5-\alpha}$.

RESULT AND DISCUSSION

Description of Mathematical Problem Solving Ability Data

The results of the mathematical problem solving ability of students were measured using a test instrument with 12 description questions. 45 students in the experimental group and 44 students in the control group joined the test. Descriptive analysis of calculations using SPSS tool in both sample classes can be observed in Table 2 below.

Table 2. Results of Descriptive Analysis of Mathematical Problem Solving Ability Data

	N	Min.	Max.	Mean	Std. Deviation
Experiment	45	37	93	77.42	11.252
Control	44	50	95	69.41	12.337

From Table 2 it can be identified that the minimum and maximum values in the experimental class are lower than the minimum and maximum values in the control class. The average value of mathematical problem solving ability of students in the experimental class, however, is better than the average mathematical problem solving ability of students in the control class.

Normality Test Results

Normality test data was used as one of the prerequisite tests in testing the hypothesis in this study. Normality testing in this study used Kolmogorov-Smirnov with the hypothesis H_0: data came from normally distributed populations and H_1: data came from a non-normally distributed population. This test uses a criterion that H_0 is accepted if the Kolmogorov-Smirnov significance value is more than 0.05. The results of testing data using SPSS are presented in Table 3.

Table 3. Data Normality Test Results of Mathematical Problem Solving Ability

	Eksperimen t	Control
N	45	44
Kolmogorov-Smirnov Z	.682	.631

The results of the normality test for mathematical problem solving ability in Table 3 indicate that Kolmogorov-Smirnov significance value of the experimental group is 0.740 while that of the control class is 0.820. Because 0.740 > 0.05 and 0.820 > 0.05, then H_0 in the normality test of each experimental class and control class data is accepted. This means that the two groups of samples come from a normally distributed population because they have a significance value of more than 0.05.

Homogeneity Test Results

The second prerequisite test is the homogeneity test. The analysis was carried out through the Levene test with the hypothesis of H_0: $\sigma_1^2 = \sigma_2^2$ for the same variance (homogeneous) and H_1: $\sigma_1^2 \neq \sigma_2^2$ for the different variance. The H_0 acceptance criterion is when the Levene Statistic significance value is more than 0.05, then H_0 is accepted. The results of data processing with SPSS are presented in Table 4.

Table 4. Results of the Homogeneity Test of Mathematical Problem Solving Ability Data

Levene Statistic	df1	df2	Sig.
1.344	1	87	.250

Based on Table 4, the results show that the significance value of Levene Statistic is 0.250. This shows that both sample groups have the same variance (homogeneous) because the significance value is more than 0.05. Since the data are normally distributed and homogeneous, hypothesis testing, which includes the test of the average difference, learning completeness test, and proportion test, can be carried out.

Average Difference Test Results

The average difference test is done to test the difference in the average mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted by QR code with the average mathematical problem solving ability of students learning through direct instruction learning. This test uses the independent sample t-test with the assistance of SPSS. The t-test is carried out after fulfilling the requirements for normality and homogeneity.

Testing the average difference uses a hypothesis of H_0: $\mu_1 = \mu_2$, meaning that there is no difference in average mathematical problem solving ability of students learning through learning Problem Based Learning (PBL) assisted by QR code with average mathematical problem solving ability of students learning through direct instruction learning, while H_1: $\mu_1 > \mu_2$, meaning that the average mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted QR code is better than the average mathematical problem solving ability of students with the application of direct instruction learning. The hypothesis testing criterion is that H_0 is rejected if the value of $t_{count} \geq t_{table}$. The results of the analysis with the assistance of SPSS are presented in Table 5.

Table 5. Results of the Average Difference of Mathematical Problem Solving Ability Data

	df	t	Sig. (2-tailed)
Experiment	87	3.203	.002

Based on Table 5, it is obtained that the t_{count} value is 3.203. The t_{table} value obtained with $dk = (n_1 + n_2 - 2) = 45 + 44 - 2 = 87$ and the significant level of 5% shows the number of 1.66. This means that the value of $t_{count} \geq t_{tableg}$so that H_o is rejected. In other words, sig. (2-tailed value) is 0.002. It means that sig. < 0.005, so H_o is rejected. Based on the testing of the average difference, it can be concluded that the average mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted by a QR code is better than the average mathematical problem solving ability of students learning through direct instruction learning.

Learning Completion Test Results

A learning completeness test is used to test the achievement of student learning mastery based on the Minimum Completion Criteria (MCC). The MCC score limit is based on the minimum value of the predicate B, which is 67. Individual learning completeness testing uses the one sample t test. Learning completeness testing was only carried out in the experimental class that received Problem Based Learning (PBL) treatment assisted by QR code.

The hypothesis in the individual learning completeness test is $H_0: \mu = 67$ which means that the mathematical problem solving ability of students have not yet reached the Minimum Completion Criteria (MCC), while $H_1: \mu > 67$ meaning that the problem solving ability of students has reached the Minimum Completion Criteria (MCC). The hypothesis testing criterion is that H_0 is rejected if $t_{count} \geq t_{table}$.

The results of calculations using the formula t obtained the results that t_{count} = 6.46. The value of t_{count} obtained is then compared with the value of $t_{tableg}$with dk = 44 and α = 5%, which is 1.68. This means that the value of $t_{count} \geq t_{tableg}$so that H_0 is rejected. Thus, it was concluded that the mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted by QR code has reached the Minimum Completion Criteria (MCC).

Proportion Test Results

In proportion testing, the proposed hypothesis is $H_0: \pi_1 = \pi_2$ (proportion of test scores on problem solving ability of experimental class students who have successfully met the Minimum Completion Criteria is equal to the proportion of test scores on problem solving ability of control class students who successfully fulfill the Minimum Completion Criteria), while $H_1: \pi_1 > \pi_2$ (proportion of test scores for problem solving ability of experimental class students who are successful in fulfilling the Minimum Completion Criteria/MCC is more than the proportion of test scores for problem solving ability of control class students who have successfully met the Minimum Completion Criteria/MCC). The criterion for this proportion testing is H_0 is rejected if $z_{count} > z_{table}$. The z_{table} value is obtained from the z_{table} list with α = 5%, which is 1.64.

Based on the calculation of the proportion test, z value is obtained at 3.60. This indicates that the value of $z_{countg} > z_{table}$, in this case, H_0 is rejected. From the proportion testing using the z test, it can be concluded that the proportion of the test scores for the problem-solving ability of experimental class students who are successful in fulfilling the Minimum Completion Criteria/MCC is more than the proportion of the test scores for problem-solving ability of control group students who have reached the Minimum Completion Criteria/MCC. Hence, the proportion of students taught by learning Problem Based Learning (PBL) assisted by QR code that is successful in achieving the Minimum Completion Criteria/MCC is better than the proportion of students studying through direct instruction learning who are successful in achieving the Minimum Completion Criteria (MCC).

Mathematical Problem Solving Ability of Students

Problem solving ability is classified as cognitive ability in mathematics that students must have. Mathematical problem solving skill needs to be sought so that students are able to solve various problems in the field of mathematics and complex problems in everyday life (Ulya, 2015).

The results of descriptive analysis data of mathematical problem solving ability of students who received Problem Based Learning (PBL) treatment assisted by QR code with the data of mathematical problem solving ability of students who received direct instruction learning treatment revealed that the average value of students who received treatment based on Problem Based Learning (PBL) assisted by QR code is higher than that of students who received direct instruction learning. The average mathematical problem solving ability of students who get the Problem Based Learning (PBL) treatment assisted by QR code is descriptively better because in PBL learning there are several phases that can facilitate students in developing mathematical problem solving skills. The third phase in PBL is assisting independent and group investigations (Sugiyanto, 2009). In this stage, students think about the problems given by the lecturer then try to gather information from various sources to solve the problem. In addition, students can also exchange ideas freely but responsibly.

Based on the average difference test, the value of t_{count} is 3.203. This value exceeds the t_{table} value which shows 1.66. This means that the proposed H_o is rejected; thus, it can be concluded that the average mathematical problem solving ability of students with the application of Problem Based Learning (PBL) assisted by QR code is better than the average mathematical problem solving ability of students with the application of direct instruction learning. Students are given treatment with the use of QR code in learning become more interested because they use their smartphones so that it has an impact on mathematical problem solving skills which are better than students taught using direct instruction learning. This result is in line because in addition to the efforts of using technology, the use of QR code in learning can be used as a medium to make students become enthusiastic in solving problems related to mathematical thinking skills (Rahayu et al., 2018).

PBL learning model assisted by the QR code emphasizes active student involvement in learning. Students can use the smartphone they have during learning but they must also be responsible. Students are initially confronted with the problems then they are divided into groups to conduct investigations, both individually and in groups. Then, students develop and present the results of their discussion to other groups, and analyze as well as evaluate the problem solving process based on the solutions presented. This learning process requires students to be serious in learning. With PBL learning treatment assisted by QR code, students experience individual learning completeness based on MCC which is 67. This is in line with the results of the study that through the application of PBL learning models assisted by learning media, students can achieve learning completeness (Endang, 2017). Furthermore, learning with the Problem Based Learning method in Mathematics Education I course can improve the achievement of the basic competency standards of students (Soleh, 2010).

The proportion test was conducted by comparing the proportion of the test scores on the problem-solving ability of experimental class students who are successful in fulfilling the MCC with the proportion of the test scores on the problem-solving ability of the control class students who have reached the MCC. The results were obtained that the proportion of students taught by Problem Based Learning (PBL) treatment assisted by QR code that is successful in achieving MCC is better than the proportion of students studying through direct instruction learning who are successful in achieving MCC. The reason is that learning in the experimental class is more innovative and can facilitate students to do problem solving. The use of QR code in learning not only works as an effort to use technology but can also function as a medium capable of changing the paradigm that learning mathematics is scary into a fun learning. The QR code does not only provide information about the material but in this research, it is also used as a tool to evaluate the mastery of the materials. Using technology-based media will make the mathematical ability of students' increase (Khoiri et al., 2013).

The use of QR code learning media in problem-based learning can accommodate students' dependence on lecturers and books, and make the information more interactive. The media can also be integrated with PBL by entering assignments in mathematics concept courses into QR codes. The use of technology can assist lecturers and students in courses. In line with the research the results of which showed that the application of mobile learning can increase students' interest significantly because of its attractive appearance and can be an alternative learning media. M-learning that contains QR code makes this application more practical because it can be accessed anytime and anywhere (Hari et al., 2015).

CONCLUSION

Based on the results and discussion of the research that has been carried out, it can be concluded that (1) mathematical problem solving ability of students learning through Problem Based Learning (PBL) treatment assisted by QR code is better than mathematical problem solving ability of students through direct instruction learning; (2) mathematical problem solving ability of students learning through Problem Based Learning (PBL) assisted by QR code that has achieved minimum completeness criteria (MCC); and (3) the proportion of students taught by learning Problem Based Learning (PBL) assisted by QR codes that are successful in achieving MCC is better than the proportion of students studying through direct instruction learning who have successfully achieved MCC.

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