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Problem based learning e-handout: Improving students' mathematical representation and self efficacy

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ABSTRACT

This research aimed to improve students' ability in mastering mathematical representation and self-efficacy in an optical material. The pre-experimental design was implemented as the research method by one group pre-test and post-test. The samples were selected by implementing a cluster random sampling technique. The sample consisted of the eleventh-grade Science students with a total number of 54 in SMAN 1 Sleman. The students' ability in mathematical representation was measured by using pre-test and post-test in the form of an essay test. Students' self-efficacy was measured by using a questionnaire as the research instrument. The data were analyzed using the Wilcoxon test and descriptive analysis to determine the N-Gain score and self-efficacy was calculated by using percentages. The results revealed that the PBL E-Handout supported by PhET simulation using Schoology could improve students' mathematical representation abilities and self-efficacy. This is indicated by the value of Asymp Sig. (2-tailed) smaller than 0.05 where 0.000<0.05 and the N-Gain score is 0.3 in the intermediate category.

INTRODUCTION

Problem-based learning model can help students to solve their problems to improve critical thinking, creativity, and learning outcomes (Abdurrozak, 2016; Nafiah & Suyanto, 2014; Rerung et al., 2017). The success in completing assignments will affect students' psychological aspects (Masri, & Suyono, 2018), since the students will try and give their whole efforts in completing the given task (Husain, 2015). Also, self-efficacy can improve students learning achievement and strategies in solving the problem given (Çaliskan, 2011; Yusuf, 2011).

Students tend to have difficulty in learning optical material (Azizah & Yuliati, Lia, 2015; Wahyuni & Arief, 2015), such as solving a problem in learning physics, which requires a strategy (Ince, 2018; Prain & Tytler, 2013; Toksoy & Akdeniz, 2015). One strategy that can be implemented is by using various representations (Yuanita & Ibrahim, 2015). Besides, in the physics learning process, students should have mathematical, visual, and graphic representations abilities to facilitate their understanding concepts (Korpershoek et al., 2015).

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The problems will be understood and solved easily by the students if the teacher can present the question in the right way (Hubber & Tytler, 2017). Difficulties in mathematical representation among students still happen (Minarni et al., 2016; Samudra et al., 2014).

The learning process in the 21st century requires students to have 4C abilities, such as communication skills, collaboration abilities, critical abilities and creativity abilities (Khoiri & Haryanto, 2018; Siti Zubaidah, 2016). The learning process in the classroom must point at students to be able to participate actively and interact with each other to achieve the intended goals (Gok, 2014). The implementation of the Problem-based Learning model or PBL is effectsive in improving students' mathematical representation ability (Farhan & Retnawati, 2014; Siregar & Djamas, 2013). Mathematical representation capabilities include writing equations, entering values into equations and completing calculation operations correctly (Asmara, 2014; Sari et al., 2018). Learning through PBL makes students more confident and capable to solve problems to have better process skills (Aziz et al., 2014; Pratama et al., 2017).

The implementation of ICT in the learning process can provide experience to students (Setiyadi et al., 2019). The use of handouts can provide interaction between a learning source with students so that it can encourage students to become independent learners and can access these learning resources online in good conditions (Erdogan, 2017; Erlinda, 2016; Syahrowardi & Permana, 2016). The handout contains a summary of the learning material and practice questions that can be accessed by students anytime and anywhere.

E-handouts are online teaching materials made by using the Schoology web. Meanwhile, students can create an account to join in the Schoology class created by the teacher. Schoology website that presents pages like learning in class and easy to use like Facebook (Aminoto & Pathoni, 2014; Krouska et al., 2018; Wijayanti et al., 2017). The use of web Schoology by teachers can provide broad opportunities for students to discuss with each other and provide opportunities for students who have less confidence to be able to give opinions by using an online discussion system (Biswas, 2018; Irawan et al., 2017; Yuhdi & Amalia, 2018).

Web Schoology has several features that can make students interested and motivated in the learning process such as being able to insert videos, pictures, learning materials and even simulations such as PhET (Tigowati et al., 2017; Rosy, 2018). Besides, the implementation of PhET simulations can improve students' psychomotor outcomes (Prihatiningtyas et al., 2013) and Schoology can improve cognitive, affective and psychomotor aspects in students (Hasanah et al., 2016).

Based on the results of the description above, it is in line with the research by Siregar (2013) which found that E-Handout can improve cognitive and affective aspects. Meanwhile, in this research E-Handout can improve students' mathematical representation and self-efficacy.

Besides, research by Prihatiningtyas et al. (2013) found that learning using PhET simulations can improve psychomotor skills. Besides, in this research students can use PhET simulations on handouts without even click on another link, because the link will appear in the handout. Hence, the student can access or click on the link in the handout. Therefore, this research aimed to improve students' mathematical representation ability and self-efficacy.

METHODS

This research implemented an experimental method, by using pre-experimental design consisted of one group pre-test and post-test. It was conducted at SMAN 1 Sleman. The data of this research was collected from April – May 2019 which consists of 54 students in eleventh-grade

Science classes. The sample of this research was selected by implementing cluster random sampling, with 54 total students there are 16 males and 38 females.

This research was implemented to find out the improvisation or N-Gain of students' mathematical representation ability and level of self-efficacy which was described descriptively. Student's self-efficacy was measured by using questionnaires, consisted of 20 statements. Students' mathematical representation ability was measured by using essay questions, consisted of 5 questions.

The research was used to implement the PBL E-Handout supported with a PhET simulation by using Schoology in the learning process. The learning process was conducted in groups consisting of a random system to form a group in accessing E-Handout using a laptop that had been provided. To access the E-Handout, students first create their account to be able to join in the learning class. By using the FH9QF-6J37S Schoology code, students would automatically be able to join the class that had been created. In this learning process, the students were divided into 4 to 5 groups with each group consisted of 5 to 6 students.

The students can access the school web which contained E-Handout materials, PhET Simulation, and student worksheets that were used as a guide in doing simulations in groups, from observing the demonstration, formulating questions, taking data, answering questions and present the results of group discussions in front of the class. The research process is presented in Figure 1,

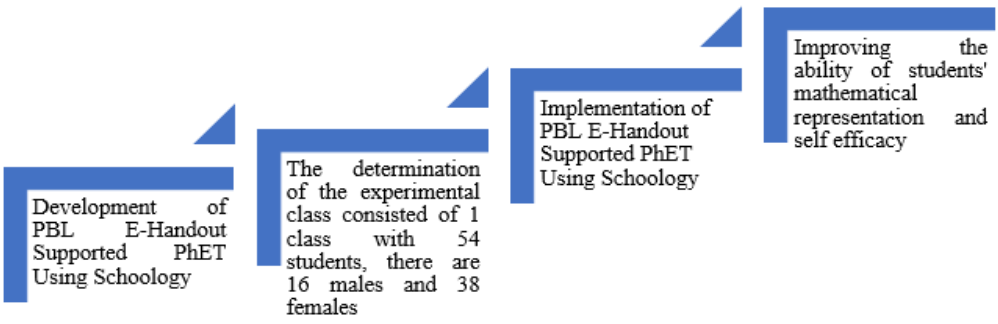

Figure 1. Research flow

The data collections of students' mathematical representations were done through pre-test and post-test. The sanalysis was performed using the SPSS 21 program. The data were analyzed using the Wilcoxon test and descriptive analysis to determine the N-Gain score. The first analysis conducted was to the result data using the SPSS program with the Wilcoxon test. This test was an alternative to the paired sample t-test if the data are not normally distributed. Then the test result data is carried out on an N-Gain test. As for obtaining the gain based on the average scores of the pre-test and post-test used the formula, as follows;

$$<G> = \frac{<S_{post}> - <S_{pre}>}{100 - <S_{pre}>} \quad (1)$$

Information:

G (gain) = attainment of attitudes toward science

S_{post} = average percentage of attitude final science (post-test)

S_{pre} = average percentage of attitude early science (pre-test).

RESULTS AND DISCUSSION

The results of this research found the level of student self-efficacy and mathematical representation.

a. Analysis Result of Self-efficacy

The questionnaire to measure students' self-efficacy was filled by around 54 students. The questionnaire contained 20 items; 10 positive statements and 10 negative statements. The statements 1 to 6 were statements of the magnitude dimension related to the level of difficulty of the task obtained by students. Statements 7 to 14 were statements of strength dimensions which were the strength of students' self-efficacy related to their abilities. After that, statements 15 to 20 were statements of generality dimensions which were feelings of ability shown by students in different task contexts. The self-efficacy questionnaire uses a Likert scale compiled by providing four answer choices, namely: SA (strongly agree), A (agree), D (disagree) and SD (strongly disagree). Each option has a different score. In positive statements SA = 4, A = 3, D = 2, SD = 1. Conversely for negative statements SA = 1, A = 2, D = 3, SD = 4. The criteria in the level of self-efficacy consist of very high to very low, which are presented in Table 1,

Table 1. Short criteria self-efficacy

No	Interval	Criteria
1	91 – 100	Very High
2	78 – 90	High
3	65 – 77	Quite High
4	52 – 64	Moderate
5	39 – 51	Quite Low
6	26 – 38	Low
7	14 – 25	Poor

The questionnaire was distributed to be filled in by the students in the class. Based on the results of the questionnaire analysis for each dimension of self-efficacy, the following calculations were obtained in Table 2,

Tabel 2. Results analysis of self-efficacy questionnaire

Dimension	Number of Question	Mean
Magnitude	1 - 6	18.05
Strength	7 - 14	24.12
Generality	15 - 20	18.83
Average		**20.33**

The results of the analysis in Table 2 above obtained an average of self-efficacy questionnaire analysis of 20,33 which was converted to a scale of 100 to 76,27. This revealed that the attitude of the self-efficacy of students belongs to a quite high category. Calculations were also conducted out on each dimension. The magnitude related to the level of the difficulty level of the tasks faced by students with an average of 18.05 converted into a scale of 100 to 75,23, including in the quite high category. The strength dimension of 24.12 which was converted on a scale of 100 to 75.40 belonged to the very high category, and the generality dimension of 18.83 which is converted into a scale of 100 to 78,47 belonged to high category. Hence, it can be seen from the frequency distribution of students in the categorization of self-efficacy in Figure 1.

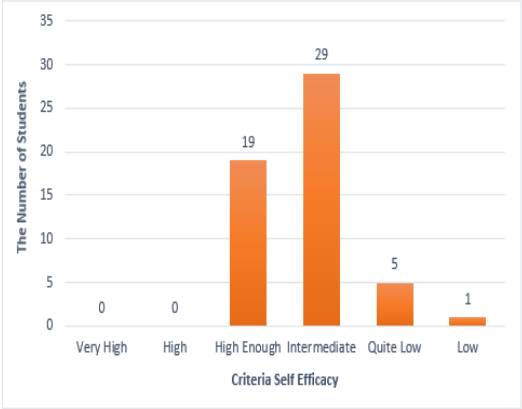

Figure 1. Analysis of self-efficacy categories

The results obtained for the distribution of level of self-efficacy students with the most frequency stated that 29 students were in the intermediate category, 19 students were in high

enough category, 5 students were in quite low, and 1 student in the low category.

The means score of self-efficacy for the class was 76,27 (categorized as high enough). These results are in line with the other research stating that self-efficacy students were improved after implementing Problem-based Learning E-Handout (Chao, Tzeng, & Po, 2017; Masri & Suyono, 2018).

b. Results of Analysis of Students' Mathematical Representation Ability

The students' mathematical representation ability in this study was measured using by essay questions, consisted of 5 questions. This ability was measured at the time before the learning process and after the learning process to determine the improvements. The students' mathematical representation ability refers to several indicators which are presented in Table 3,

Table 3. Indicator of mathematical representation

Indicator of Mathematical Representation	Steps
Determine the right equation by the problem	1. Writing down the known and the asked 2. Linking problems and concept 3. Answering problems through mathematical equations
Carry out mathematical operations into the equation	1. Writing down the known and the asked 2. Linking the problem and the concept 3. Writing the mathematical equation used 4. Filling the known value in the equation 5. Doing Mathematical Operation 6. Getting results from the mathematical equation.

The results of mathematical representation ability of students are presented in table 4,

Tabel 4. Result of Pre-test and Post-test

Pre-test	
Lowest score	0
Highest score	65
Post-test	
Lowest score	0
Highest score	85

The mathematical representation ability of students can be seen by using the N-Gain value which has a level category presented in Table 5,

Table 5. Normalization criteria

Value	Interpretation
$\mathbf{0.70 \leq g \leq 1.00}$	High
$\mathbf{0.30 \leq g \leq 0.70}$	Intermediate
$\mathbf{0.00 < g \leq 0.30}$	Low
$\mathbf{g = 0.00}$	No Improvement
$\mathbf{-1.00 \leq g < 0.00}$	Decreasing

Based on the analysis of the students' mathematical representation ability, the average N-Gain value of 0.3 is included in the intermediate category and for the number of frequencies in each category is presented in Table 6,

Table 6. N-gain frequency of each category

Category *N-Gain*	Frequency
High	9 Students
Intermediate	21 Students
Low	15 Students
No Improvement	4 Students
Decreasing	5 Students

Therefore, the results obtained for the distribution of the level of mathematical representation ability of students with the highest frequency are in the intermediate category of 21 students, the low category of 15 students, the high category of 9 students, the category of no improvement of 4 students and decreasing of 5 students.

These results were in line with the other research stating that mathematical representation ability was increasing after applying E-Handout assisted PhET simulation using Schoology (Fitri et al., 2017; Jenita et al., 2016; Widarti et al., 2014)

Descriptive Analysis

The information of descriptive analysis from data pre-test and post-test can be seen in Table 7,

Table 7. Results of descriptive analysis of Pre-Test and Post-Test

Test	N	Min	Max	Mean	Std. Deviation
Pre-test	54	0	65	13,70	17,177
Post-test	54	0	85	43,52	26,451

The results of the average pre-test and post-test score in the students' mathematical representation abilities are presented in Figure 3,

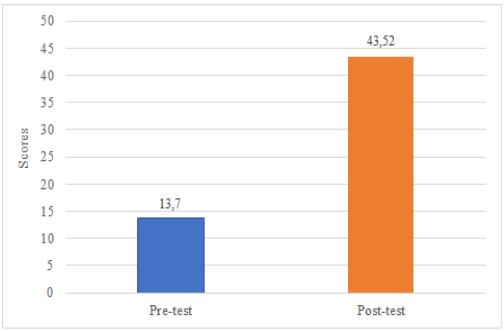

Figure 3. Comparison of average pre-test and post-test score

Figure 3 shows that class has increased Pre-test to Post-test scores. It means based on the increased Pre-Test and Post-Test scores, the students' mathematical representation is improving. It can be concluded that the PBL E-Handout Supported PhET Using Schoology is effective in improving students' mathematical representation of grade XI at SMAN 1 Sleman with optic material.

The normality test and homogeneity test of data were conducted before finding the N-Gain scores. This basic assumption test was carried to determine if the data distributed normally or not and homogeneous or not. The results of normality can be seen in Table 8:

Table 8. Normality test output

	Kolmogorov-Smirnov[a]		
	Statistic	Df	Sig.
Pre-test	0.269	54	0.000
Post-test	0.087	54	0.200*

Therefore, based on the result of the normality test in table 8, sig of pre-test score is 0.000 and post-test score are 0.200. From these results the sig. Which > 0,05 just post-test score. It means the data of the pre-test in the implementation class and the data of the post-test is not distributed normally.

The Wilcoxon Test

The normality test showed post-test data were not normally distributed. Statistical analysis that used was the Wilcoxon test, instead of paired sample t-test. The Wilcoxon test was used to examine the hypothesis. The hypothesis proposed in this study is:

H_0: There is no significant difference between the results of the students' mathematical representation abilities pre-test and post-test.

H_1: There is a significant result of the students' mathematical representation abilities pre-test and post-test.

With the basic decision making as follows:

If the Asymp Sig. (2-tailed) is smaller than <0.05, so H_0 is rejected. Conversely, if Asymp Sig. (2-tailed) is smaller than <0.05, so H_0 is accepted.

Based on the results of the analysis of students' mathematical representation scores using the Wilcoxon test, the output results are shown in Table 9.

Table 9. Wilcoxon test output (a) ranks and (b) test statistics

		N	Mean Rank	Sum of Ranks
Post-Pre	Negative Ranks	7[a]	11.57	81.00
	Positive Ranks	43[b]	27.77	1194.00
	Ties	4[c]		
	Total	54		

[a]Post<Pre
[b]Post>Pre
[c]Post=Pre

Test Statistics

	Post-Pre
Z	-5.373[b]
Asymp, Sig. (2-tailed)	0.000

[a] Wilcoxon Signed Ranks Test
[b] Based on negative ranks

The interpretation of output in table 9 is divided into two parts. First in table 9 (a) and table 9 (b). The negative rank in table 9 (a) shows N = 7. It means that 7 students have a lower post-test score than the pre-test score. The average of the decreased score is 11.57 while the sum of rank is 81.00. The positive rank show N = 43. It means 43 students have higher post-test scores than their pre-test scores. The average of increased scores is 27.77 while the sum of rank is 1194.00. The ties category shows N = 4. It means that 2 students have the same pre-test and post-test scores.

The second interpretation, results of the Wilcoxon test Analysis shown in table 9 (b) can be decided, Asymp Sig. (2-tailed) is smaller than 0.05 where 0.000 < 0.05 so that the decision H_0 is rejected and H_1 is accepted.

This means that there are differences in the results of the students' mathematical representation pre-test and post-test, so it can be concluded that "there is an effect of the implementation PBL E-Handout Supported by PhET Simulation using Schoology in class to students' mathematical representation abilities".

These results are in line with the other studies stating the ability of students' mathematical representation can be increased by using the help of instructional media (Krouska et al., 2018; Oktaria et al., 2016). Meanwhile, this research implementation E-Handout Supported by PhET Simulation and using Schoology can improve students' mathematical representation. Problem-based learning can improve mathematical representation (Artha et al., 2014; Nafiah & Suyanto, 2014). Meanwhile, this research use PBL models to developed E-Handout to help the student understand the material

CONCLUSION

PBL model with E-Handout supported by PhET simulation using Schoology can improve students' mathematical representation abilities and self-efficacy. Based on the results of the analysis obtained, students' self-efficacy belonged to the high enough category and mathematical representation has increased during the learning process. It is indicated by Asymp Sig. (2-tailed) which was smaller than 0.05 where 0.000 < 0.005 and the N-Gain score was 0.3 included in the intermediate category.

AUTHOR CONTRIBUTIONS

DU, HK and NF prepared research design and reviewing literature. IW, JJ and DP collected data and analysed data. HK, IW, JJ and NS writing result and discussion.

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