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The Impact of Problem-Based Student Worksheets on Improving Problem-Solving Skills in terms of Learning Outcomes

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Abstract

The purpose of the study was to determine the impact of using a problem-based Student Worksheet (SWS) on improving problem-solving skills (PSS) in terms of student Learning Outcomes (LO). The research used a quantitative approach, quasi-experimental method, and the One Group Pretest-Posttest design research. The research sample also involved 31 high school students for the experimental class and 31 for the control class. The research has three variables: problem-based SWS, problem-solving skills (PSS), and Student Learning Outcomes (LO). The problem-solving skill instrument uses five essay questions, and the LO uses 20 multiple choice questions, both of which were developed by the researcher. Data analysis used the N-Gain formula to obtain information on the increase in PSS and LO. Based on the results of data analysis, it was found that the effect of implementing SWS was very significant on students' PSS and LO. In addition, the application of SWS also affects students' LO, and some students with high or low LO scores also have high PSS scores or vice versa. Inference from this study, it is hoped that teachers as educators will try to direct students to get used to solving physics problems using a five-stage problem-solving model.

Keywords: problem-based SWS, problem solving skills, learning outcomes

INTRODUCTION

The Student Worksheet (SWS) is one of the learning tools used to make it easier for students to complete tasks assigned by local teachers. Another expert's opinion says that the SWS is a learning tool that can be used by teachers to increase the involvement or activity of students in the teaching and learning process. In general, worksheets contain practical instructions, experiments that can be done at home, material for discussion, and practice questions, as well as all forms of instructions that can invite students to be active in the learning process. Worksheets are one type of learning aid (Nisa et al. 2018). Research on the development of SWS has been carried out in various ways, including using a guided inquiry model (Afrida et al. 2015), problem-based (Khairunnisa 2016; Zulfa 2018; Mahayoni 2019), using a scientific approach (Hasja et al. 2020), and by using the help of PhET simulation (Halim et al. 2020).

The second variable in this study is PSS in learning physics. Referring to several views of science education research experts, PSS are defined in various versions. Among them, it is said that PSS includes the process used to get the best answer for something that is not yet known and is based on several constraints (Mourtos 2004). The PSS can be improved in various ways that have been carried out by educational research experts, including using problem-based learning models (Simamora et al. 2017; Eviyanti et al. 2017), and ELSII learning models based on local wisdom (Dewi et al. 2017), using visual media (Widodo & Ikhwanudin 2018), and using virtual lab (Gunawan et al. 2017). In most research conducted by researchers in the field of science education, PSS is used as a variable to improve several other dependent variables, including improving LO and critical thinking skills (Marisa et al. 2020), mastery of concepts and generic science skills (Mayasari et al. 2013), motivation and LO (Fajria et al. 2017), and preparing a generation capable of overcoming globalization problems (Halim et al. 2016).

LO has been defined or stated in various versions by education experts, including LO are the abilities of students in the cognitive, psychomotor, and affective domains (Huitt 2011). Other experts say that LO is a change in behavior in a person that can be observed and measured in the form of knowledge, attitudes, and skills. These changes can be interpreted as an increase and development that is better than before, and those who do not know become aware (Hamalik 2017). Based on these findings, it can be said that LO can be interpreted as the maximum results that have been achieved by a student after experiencing the teaching and learning process of studying a certain subject matter. LO is not absolute in the form of values but can be in the form of changes, reasoning, discipline, skills, and so on that lead to positive changes. Several research results have shown that LO can be improved by using a generative learning model using a virtual laboratory (Pratama et al. 2016), a virtual laboratory-assisted NHT model (Sartika et al. 2016), a TSTS cooperative learning model (Ariyani et al. 2017), and through the use of discovery learning-based SWS (Junina et al. 2020).

Based on the findings from the results of previous studies, as explained, it is still very rare for research to use SWS to improve PSS in terms of aspects of student LO. Information from research results is essential because LO is the final benchmark of all forms of learning models implemented in the classroom. Not only that, the research results will provide answers to the question of whether students who have high LO (scores) will also have high PSS scores. The purpose of this research is formulated in detail in the form of Q1: How is the impact of using SWS on students' PSS, Q2: How is the impact of using SWS on student LO, and Q3: How are PSS in terms of student LO.

METHODS

Research Approach

This study uses a quantitative approach, quasi-experimental method, and research design using the one group pretest-posttest model with reference to Sugiyono (2010), as shown in TABLE 1.

TABLE 1. Research design one group pre-test – post-test (Sugiyono, 2010)

Group	*Pretest*	Treatment	*Posttest*
A (Experiment)	O_1	X	O_2
B (Control)	O_1		O_2

The research design, as shown in Table 1, was chosen based on several considerations, including (a) based on the primary purpose of the study, namely wanting to know the effect of treatment (X) from the SWS on PSS in the experimental class against the control class. There is no such treatment, (b) want to know the improvement of PSS from the aspect of LO for the control class and also the experimental class, and (c) the effectiveness level of implementing problem-based SWS in the experimental class compared to the control class.

Population and Sample of Research

The study was conducted on high school students in Banda Aceh City in the 2021/2022 academic year. The research population was all students in class XI-MIA, then two classes were randomly taken as research samples with a total of 62 students for both classes. Details for each experimental class (class XI-MIA-1) totaled 31 students, and for the control class (XI-MIA-2) also totaled 31 students. Based on the initial analysis of secondary data, it is known that both classes have the same ability, meaning that both classes meet the homogeneity requirements.

Instruments and Data Collecting

There are two dependent variables that need to be collected data through this research, the first data from the measurement of PSS and the second data from student LO. The problem-solving model used is the Heller and Reif (1984) model consisting of several stages, namely focusing problem, describing the situation of physics, planning the solution, implementing the plan, and evaluating the evaluation of the answer. In other words, the measurement of PSS data is based on these stages, and measurements are carried out two times, before treatment (pre-test) and after treatment (post-test). The PSS instrument (Q1) used is an essay question of 5 physics questions about the concept of force with a reliability level of 0.99 (reliable), a difficulty level of 0.34 (medium), a discrepancy level of 0.85 (very good), and a validity level of 0.98 (very valid). Meanwhile, the assessment of student answers from the essay test used a rubric sheet for assessing problem-solving skills (Halim et al. 2016). The development of the assessment rubric is based on the problem-solving model of Heller and Reif (1984), and its validity has been carried out in previous studies (Halim et al. 2016).

Meanwhile, the instrument to obtain data on student LO (Q2) uses a multiple-choice test of 20 questions with the cognitive levels used are understanding (C2) and applying (C3). All these questions were developed by the researcher with the provisions of 1 question body (stimulus), four answer choices, and only one correct answer. The results of the trial on a limited sample showed that the level of reliability was 0.97 (reliable), the level of difficulty was 0.33 (medium), the level of difference was 0.65 (good), and the level of validity was 0.725 (high).

Data Analysis

The raw data obtained from this research is quantitative data in the form of scores, both data from measuring PSS and also data from measuring LO. Thus, the method of data analysis refers to the type of data and also the research objectives.

Q1: Problem-Solving Skills (PSS) (1)

Data of PSS were measured twice, before treatment (pre-test) and after treatment (post-test), and both had data in the form of scores. Information about improving PSS before and after treatment, both experimental and control classes, can be found after data analysis using the N-Gain formula from pre-test and post-test data (Hake 1998).

$$\text{N-Gain} = \frac{\text{Skor Posttest} - \text{Skor Pretest}}{\text{Skor Ideal-Skor Pretest}} \tag{2}$$

Where g = N-Gain is the comparison between the difference between the highest score (S_f) and the lowest score (S_i) and the difference between the maximum score and the lowest score (S_i).

TABLE 2. N-Gain decision matrix

Percentage	Effectivity
0,00 < g < 0,30	Low
0,30 < g < 0,70	Moderate
0,70 < g > 1,00	High

The highest score (S_f) is the highest score achieved by students in the experimental class or control class. The lowest score (S_i) is the lowest score obtained by students in each class. At the same time, the maximum score is the highest score set by the researcher on a scale of 100 or a scale of 10. The decision on the calculation of the N-Gain value refers in TABLE 2.

Q2: Learning Outcome (LO)

Data of student LO was measured twice, namely before treatment (pre-test) and after treatment (post-test), in both the experimental class and the control class. Information on improving LO, both experimental class and control class, can be known after data analysis using the N-Gain formula, and the decision refers to the value in TABLE 2 (Hake 1998). Meanwhile, the significance level of the effect of the implementation of the Student Worksheet on improving PSS and LO can be determined through data analysis using a t-test between the experimental class and the control class.

Q3: Problem-Solving Skills toward Learning Outcome

Based on the results of the data analysis of student LO in the Q2 section, the category or level of PSS is determined. Presentation of data to obtain information on the level of PSS in terms of LO using graphs.

RESULTS AND DISCUSSION

The raw data obtained from the research is quantitative data in the form of scores, both data from measuring PSS and also data from measuring LO. The validity of the data obtained or the level of bias is very low if the instrument or test used is reliable and valid, as shown in TABLE 3 for essay tests and TABLE 4 for multiple-choice tests.

TABLE 3. The results of the validity and testing of the PSS instrument (N = 20)

Items	Diff. Index		Difference Power			Validity			Noted
	Index P	Category	D value	Category	Noted	r_xy	Category	Noted	
1	0.359	Moderate	0.897	Very good	Accept	0.984	Very high	Valid	Good test
2	0.355	Moderate	0.868	Very good	Accept	0.990	Very high	Valid	Good test
3	0.359	Moderate	0.882	Very good	Accept	0.986	Very high	Valid	Good test
4	0.359	Moderate	0.838	Very good	Accept	0.993	Very high	Valid	Good test
5	0.315	Moderate	0.809	Very good	Accept	0.973	Very high	Valid	Good test

Reliability: 0.992 (very high)

The data in TABLE 3 is the value of validity, reliability, and the results of item analysis for an essay test of 5 questions, and this is an instrument used to measure PSS. Overall, all items in TABLE 3 are good, valid, not too tricky, and can distinguish between brilliant students and students who are not good enough and deserve to be used.

TABLE 4. The results of the validity and testing of LO measurement instruments (N = 20)

Items	Diff. Index		Difference Power			Validity			Noted
	Index P	Category	D value	Category	Noted	r_xy	Category	Noted	
1	0.323	Moderate	0.353	Enough	Revision	0.714	High	Valid	Good test
2	0.323	Moderate	0.588	Good	Accept	0.694	High	Valid	Good test
3	0.323	Moderate	0.529	Good	Accept	0.689	High	Valid	Good test
4	0.339	Moderate	0.647	Good	Accept	0.726	High	Valid	Good test
5	0.339	Moderate	0.647	Good	Accept	0.672	High	Valid	Good test
6	0.323	Moderate	0.529	Good	Accept	0.784	High	Valid	Good test
7	0.355	Moderate	0.706	Very good	Accept	0.791	High	Valid	Good test
8	0.339	Moderate	0.706	Very good	Accept	0.823	Very high	Valid	Good test
9	0.355	Moderate	0.706	Very good	Accept	0.739	High	Valid	Good test
10	0.355	Moderate	0.765	Very good	Accept	0.692	High	Valid	Good test

Items	Diff. Index		Difference Power			Validity			Noted
	Index P	Category	D value	Category	Noted	r_xy	Category	Noted	
11	0.323	Moderate	0.706	Very good	Accept	0.769	High	Valid	Good test
12	0.355	Moderate	0.706	Very good	Accept	0.725	High	Valid	Good test
13	0.339	Moderate	0.647	Good	Accept	0.751	High	Valid	Good test
14	0.339	Moderate	0.765	Very good	Accept	0.741	High	Valid	Good test
15	0.339	Moderate	0.706	Very good	Accept	0.701	High	Valid	Good test
16	0.355	Moderate	0.765	Very good	Accept	0.828	Very high	Valid	Good test
17	0.323	Moderate	0.647	Good	Accept	0.643	High	Valid	Good test
18	0.306	High	0.588	Good	Accept	0.691	High	Valid	Good test
19	0.339	Moderate	0.647	Good	Accept	0.810	Very high	Valid	Good test
20	0.306	High	0.647	Good	Accept	0.636	High	Valid	Good test

Reliability: 0.971 (very high)

Based on the data in TABLE 4, it can be understood that overall, all the tests are categorized as good and suitable to be used to measure student LO. However, for question no. 1, the discrepancy power is low, namely 0.353, while the difficulty and validity indexes are in the medium and valid category.

Q1: Problem-Solving Skills (PSS)

The impact of the implementation of the SWS on PSS can be seen from the increase in pre-test scores before treatment and post-test after treatment in the experimental class and control class which is expressed by the N-Gain value.

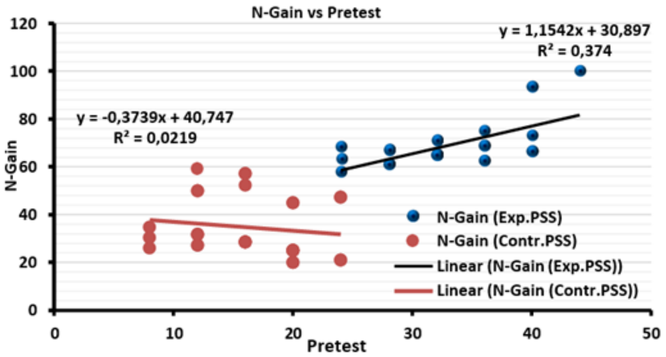

FIGURE 1. The relationship between N-Gain and Pretest scores for PSS

Based on the data in FIGURE 1, it can be understood that overall, the experimental class and control class have different data clusters with different scores. The graph in FIGURE 1 shows the relationship between the initial pre-test score and the improvement score or N-Gain value. In other words, for the experimental class, it can be stated that the increase in PSS is not only caused by the implementation of the SWS. The increase is also caused by the initial ability of students, which is 37.4%. At the same time, the increase in the N-Gain value of PSS of around 62.6% was caused by the implementation of the SWS. On the other hand, for the control class, the increase in the N-Gain value has absolutely no relationship with the initial value, or there is even an inverse relationship from the pre-test (dashed).

Other information that can be obtained from the graph is that the SWS is less able to change students' initial abilities in solving physics problems, so the influence of initial abilities on improving PSS is still visible. Meanwhile, for the control class, the opposite happened, where the treatment given led to an increase in problem-solving ability, which was inversely proportional to the student's initial abilities.

Q2: Learning Outcomes (LO)

The data in FIGURE 2 shows that the increase in LO is almost not affected by students' initial abilities, both for the experimental class (1.1%) and the control class (3.6%). In other words, the increase in LO is influenced mainly by the implementation of the SWS, both for the experimental class (98.9%) and the control class (96.6%).

Other information that can be extracted from FIGURE 2 is that the scores of the experimental class and the control class are in different cluster scores (low and high). The two classes have a negative correlation between the initial ability and the increase in the N-Gain value of LO for both classes.

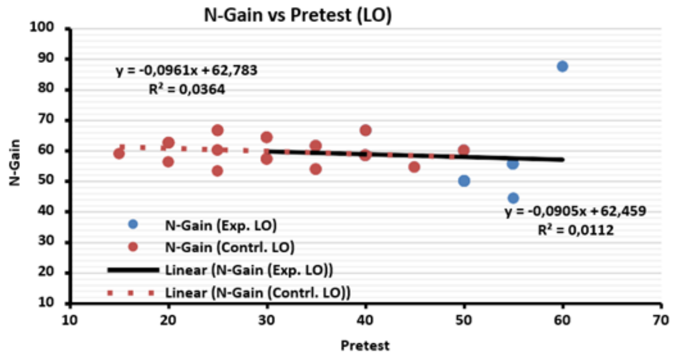

FIGURE 2. The relationship between the initial value (pre-test) and the N-Gain value for LO

Based on the two graphs above, FIGURE 1 and 2, it can be understood that the impact of implementing the SWS has a more dominant influence on LO compared to improving PSS. This is due to several factors, including (a) the syntax in the application of the SWS basically trains students to understand the physics concepts being taught, and (b) the ability to solve problems in physics also reflects the ability to master the physics concepts being taught, and (c) LO are the final output of the learning process, meaning that whatever learning model is applied in the classroom, its success is measured in student LO.

Q3: Problem-Solving Skills toward Learning Outcome

Although the relationship between PSS and LO has been briefly described, it has not been answered whether students who have excellent or high LO will also have high PSS. Referring to Bloom's (1989) view, LO is a combination of cognitive, psychomotor (skills), and affective (attitude) abilities. This means that if students have LO well, according to Bloom's theory, these students should also have good skills. This section will be analyzed empirically how the relationship between PSS with LO. The graph in Figure 3 shows this relationship between the experimental group and the control group.

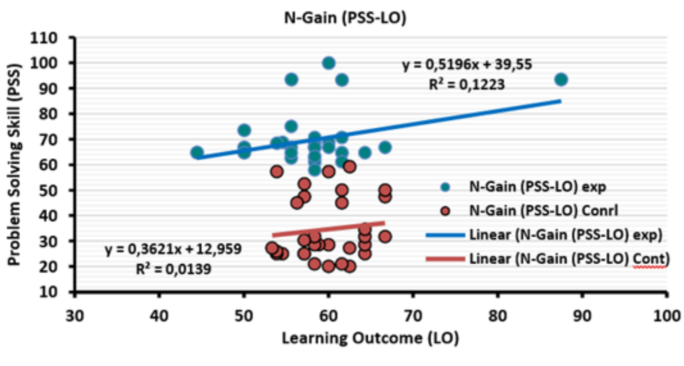

FIGURE 3. Problem-solving skills (PSS) toward Learning Outcomes (LO)

The data in FIGURE 3 includes a control group and an experimental group, both of which have two data clusters with different high and low scores. Based on the linear line from the experimental group data, it can be understood that the increase in LO is also followed by the PSS of students, with the contribution of PSS toward LO of around 12.23% (low positive correlation). However, if we look more closely at the data that forms a straight line, it can be understood that only a few PSS scores are scattered in areas with high LO and in areas with low LO. Most of the PSS scores are spread over the area of the average LO score for the experimental class.

Overall, the slope of the straight-line graph of the experimental group and the control group is relatively the same, but the contribution of PSS scores to LO scores is relatively low, which is around 1.4% (low positive correlation). The distribution of PSS scores is more spread out or distributed in the average LO score, but both have different score clusters. Other information that can be extracted from FIGURE 3 is the impact of the application of the SWS being more dominant on PSS in the experimental class. Based on the graphs in Figures 1, 2, and 3, there is interesting information that should be noted. Namely, the initial abilities of students are different for the control class and the experimental class. This difference causes the N-Gain value data from the two to differ significantly between the control class and the experimental class. This finding forces us to say that the increase in the N-Gain value for the experimental class is more dominantly influenced by the students' initial ability to solve physics problems. PSS can also be improved in various ways that have been carried out by educational research experts, including by using problem-based learning models (Sutiadi & Nurwijayaningsih 2016; Simamora et al. 2017; Eviyanti et al. 2017), 4D models (Hidayat et al. 2017), ELSII learning model based on local wisdom (Dewi et al. 2017), using visual media (Widodo & Ikhwanudin 2018), and using virtual lab (Gunawan et al. 2017). Several research results have shown that LO can be improved by using a generative learning model using a virtual laboratory (Pratama et al. 2016), practicum design methods (Sabirin et al. 2017); project learning model (Serevina & Muliyati 2015); virtual llaboratory assisted NHT model (Sartika et al. 2016), TSTS cooperative learning model (Ariyani et al. 2017), and through the use of SWS (SWS) based on discovery teaching (Junina et al. 2020).

CONCLUSION

Based on data analysis on the independent variable or students' worksheet SWS and the two dependent variables, PSS, and LO, we obtained some information. The impact of the use of SWS on PSS can be seen from the increase in the N-Gain value, which is very dominant, although it is also affected (lowly) by students' initial abilities (Q1). The same thing applies to LO, where the application of the SWS significantly affects the increase in student LO scores which are expressed with the N-Gain score (Q2). The goal of this study is to improve PSS in terms of student LO, and the results of the study show that only some students have high LO scores and high PSS scores and vice versa (Q3).

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