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The Effectiveness of Problem Solving-Based Student Worksheet to Improve Students' Critical Thinking Skills

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Abstract: The Effectiveness of Problem Solving-Based Student Worksheet to Improve Students' Critical Thinking Skills. Objectives: This research aimed to find out the effectiveness of student worksheets based on problem solving in science learning to improve students' critical thinking skills. **Methods:** The research population were all tenth-grade science students in one of the Senior High Schools in South Lampung in the even semester of 2017/2018 academic year with the sample was selected using cluster random sampling. This research used d a quasi-experimental method with Pretest-Posttest Control Group Design.The effect of the worksheet was measured based on the mean value of n-Gain of the students' critical thinking skills. The effect size effect size calculation was also applied. **Findings:** The result showed that the n-Gain value mean of the students' critical thinking skills in the experimental was 0.71 and the effect size was 0.89. **Conclusion:** students' worksheet based on problem solving in science learning is very effective to improve students' critical thinking skills

Keywords: students' worksheet, problem solving, critical thinking skill.

Abstrak: Efektifitas Lembar Kerja Siswa Berbasis Pemecahan Masalah untuk Meningkatkan Kemampuan Berfikir Kritis. Tujuan: *Penelitian ini bertujuan untuk mengetahui efektivitas lembar kerja siswa berdasarkan pemecahan masalah dalam pembelajaran sains untuk meningkatkan keterampilan berpikir kritis siswa.* ***Metode:*** *Populasi penelitian adalah semua siswa sains kelas sepuluh di salah satu SMA di Lampung Selatan pada semester genap tahun akademik 2017/2018 dan sampel dipilih menggunakan cluster random sampling. Penelitian ini menggunakan metode eksperimen semu dengan Desain Kelompok Kontrol Pretest-Posttest. Pengaruh penggunaan lembar kerja siswa berbasis pemecahan masalah diukur berdasarkan nilai rata-rata n-Gain keterampilan berpikir kritis siswa.* ***Temuan:*** *Hasil penelitian menunjukkan bahwa nilai rata-rata n-Gain dari keterampilan berpikir kritis siswa dalam eksperimen adalah 0,71 dan ukuran efeknya adalah 0,89.* ***Kesimpulan:*** *lembar kerja siswa berdasarkan pemecahan masalah dalam pembelajaran IPA sangat efektif untuk meningkatkan keterampilan berpikir kritis siswa.*

Kata kunci: *Lembar kerja siswa, pemecahan masalah, kemampuan berfikir kritis.*

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INTRODUCTION

Learning activities are the main activities carried out at school. Every learning activity carried out has a goal to achieve. Learning is not a goal, but is a process to achieve goals (Gao & Wang, 2014; Kawalkar & Vijapurkar, 2015; Shirazi, 2017). So, learning is the steps or procedures taken (Lee & Choi, 2017; Stender et al., 2017; Pongsophon & Herman, 2017).

The ultimate learning goal is to create students who have the knowledge and skills in solving a problem confronted later in the community (Abdullah et al., 2017;Ghadirian et al., 2018). Students' ability to solve problems (problem solving) is very important for their future (Smith, 2015;Major & Mulvihill, 2018). Various efforts have been done by teachers to help students solve problems easily, including creating learning media in the form of audio, printed and visual media. One of the printed media is teaching material. Teaching materials are essential to train students in finding concepts. One of the teaching materials learned in this research is the student worksheet (Gani, et al., 2017; Ramdiah et al., 2018;Tiruneh et al., 2018).

Chemistry subject at school cannot be separated from experimental activities. Electrolysis concept is one of the chemistry materials in the twelfth class of senior high schools. Electrolysis material competence is designing and conducting experiments that include problem formulation, submitting hypotheses, determining variables, selecting instruments, collecting, processing and analysing data, drawing conclusions, and communicating experimental results verbally and in writing (Team Drafting, 2014). Efforts to achieve these competencies require a student worksheet based on problem solving (Gani et al., 2017; Maulida et al., 2017). Problem solving process can provide an opportunity for active students to observe, study, search and find information by themselves to be processed into concepts, principles, theories, or conclusions. The process is arranged in stages in the student worksheet which has a basis according to problem solving stages (Rahayu, 2015; Kashani-vahid et al., 2017;Sutarto et al., 2018).

The observation and interview results with one of the chemistry teachers in one of the high schools in South Lampung showed that the worksheet used by the students in the form of material summaries and practice exercises was not a guideline for students to get their own concepts and reasoning. This is in accordance with the opinion of Akilli & Murat (2017) that chemistry learning delivered using teaching materials that contain material summaries and practice exercises with the lecture method followed by problem training at the end of learning is considered causing students to get bored easily and feel that the chemistry materials are difficult that the students get low outcomes. Classroom learning was teacher-centred and only one-way communication.

The disadvantage of the one-way learning process is that students can master the material only to the extent conveyed by the teacher. The mastered skills are limited to Lower Order Thinking. This causes students to be unable to solve C4 questions and above because their understanding is still low and they tend to memorize. This situation causes the students' inability to answer questions with application, synthesis, analysis, and evaluation levels (Kusuma et al.,, 2017; Hassan el al., 2017;Lee & Choi, 2017; Sulaiman et al., 2017; Wahyuni, 2018).

Based on the fact, teachers need to improve the student worksheet to improve the students' learning outcomes. Critical thinking skills have a positive relationship to students' cognitive learning outcomes. In other words, if students' critical thinking skills are high, the cognitive learning outcomes are also high (Fung, 2017; Cargas et al., 2017). Students' low critical thinking skills can be overcome by using learning models that

can train higher-order thinking skills, one of which is the use of student worksheet based on problem solving (Gelerstein et al., 2016; Khasanah et al., 2017;Elisanti et al., 2018; Sutarto et al., 2018).

Problem-solving based learning is learning that can develop students' thinking processes by providing problems to be analysed individually or in groups to find solutions to the problems. Problem-solving based learning can improve learning activities and achievements which include students' competencies, knowledge, attitudes, and skills (Carolin et al., 2015; Widowati et al., 2017). The learning model based on problem solving has steps with a clear problem to solve. The steps consist of finding data or information that can be used to solve problems, making hypotheses to the problem, testing the hypotheses, and drawing conclusions (Scherer & Gustafsson, 2015; Orzechowski et al., 2017).

The advantages of learning with problem solving models are that it can develop fundamental concepts in students, familiarize students with facing and solving problems skilfully, stimulate the development of students' thinking skills actively, creatively and thoroughly because in the learning process, students do a lot of mental activities by highlighting problems in various aspects in order to find solutions.

The success of the learning model implementation based on problem solving is evidenced by the research result of Lambertus et al. (2014) that there is an increase in students' learning skills by using the learning model based on problem solving compared to conventional model and an increase in students' activeness of 82.32% averagely. In addition, Andriani et al. (2013) concluded that problem solving model is effective in improving grouping skills and concept mastery in colloidal material. In addition, Safitri et al. (2013) concluded that problem solving model is effective in improving students' classification skills and concept mastery on salt hydrolysis material. Based on the problem above, the effectiveness of student worksheet based on problem solving in science learning is necessary in improving students' critical thinking skills.

■ METHODS

Procedure

The research method used was quasi-experimental with non-equivalent pretest-posttest control group design (Fraenkel, 2012). The step in the research were giving a pre-test to both the experimental class and the control class. Then giving treatment by applying a worksheet based-on problem solving in learning science with the method of experiment on the experiment class and the method of applying workseet usually to using in school on the control class. The giving a post-test to both classes.

Research Popuation and Participant

The population in this research were all tenth-grade science students of one senior high school in South Lampung in 2017/2018 academic year consisting of eight classes. The sampling technique used was cluster random sampling, which obtained class X Science 5 as the experimental class and X Science 7 as the control class.

Instrumens, Analysis of Data Collection

The research instruments used were the pretest and posttest questions which consisted of 8 essay questions representing students' critical thinking skills and the student worksheet based on problem solving. In addition, there was an assessment sheet used, namely the observation sheet for the implementation of the student worksheet based on problem solving in learning process.

The instrument validity and reliability were analysed using SPSS software version 17 for Windows. Question validity was determined by comparing rtable and r values. The criterion is if rtable< r, then the question is valid. Reliability was

determined using Cronbach'sAlpha. The criteria for degree of reliability (r11) according to Guilford are shown in table 1.

Table 1. Criteria for degree of reliability

Criteria for Degree of (r11)	Reliability
$0,80 < r11 \leq 1,00$	Very high
$0,60 < r11 \leq 0,80$	High
$0,40 < r11 \leq 0,60$	Medium
$0,20 < r11 \leq 0,40$	Low
$0,00 < r11 \leq 0,20$	Unreliable

The effectiveness of student worksheet based on problem solving in science learning is determined from the achievement in improving students' critical thinking skills obtained through the pretest and posttest scores. Based on the research results, the students' scores obtained were subsequently converted into student grades. There were then analysed by calculating n-Gain with the n-Gain criteria referred to Hake (2002).

The effect size using the student worksheet based on problem solving to improve students' critical thinking skills is determined based on t-test scores. Before the t-test was carried out, normality and homogeneity tests were conducted on the pretest, posttest, and n-Gain scores using SPSS software version 17 for windows. The normality test was determined based on the sig. valuein the Kolmogorov-Smirnov column, while the homogeneity test was seen from the sig. value in the Test of Homogeneity of Variance column.

The sample is considered being normally distributed and having a homogeneous variance if the sig. value is > 0.05. If the sample is normally distributed and homogeneous, then the parametric statistical test using SPSS version 17 for windows is carried out, which is the independent sample t-test on the n-Gain of both classes. H0 is accepted if the score is significant or sig.(2-Tailed) > 0.05, which means the average n-Gain of critical thinking skills using the student worksheet based on problem solving, is lower than or equal to the average n-Gain of critical thinking skills that use conventional student worksheet. H0 is rejected if the score is not significant. H0 of the independent sample t-test on the pretest and posttest scores of the two classes is accepted if the score is significant or sig.(2-tailed)> 0.05, which means the pretest score is equal to the posttest score (no change) and it is rejected if the opposite is true.

The *t*-value obtained from the independent sample t-test on the pretest and posttest scores is calculated to determine the effect size. The effect size calculation formula according to Jahjouh (2014) with the effect size criteria according to the Dincer (2015). To prove the implementation of the student worksheet based on problem solving, it is necessary to assess the student worksheet implementation through the observation sheet. The data obtained from the analysis of the student worksheet implementation based on problem solving were then interpreted based on the level of implementation criteria as in table 1 as follows:

Table 1. Criteria for implementation level

Percentages	Criteria
80.1% - 100.0%	Very high
60.1% - 80.0%	High
40.1% - 60.0%	Moderate
20.1% - 40.0%	Low
0.0% - 20.0%	Very low

■ RESULTS AND DISCUSSION

Validity and Reliability

Validity test result of the questions is shown in table 5.

Table 2. Test item validity test result

Items Questions	Coefficient Correlation	r table	Comment
1a	0.598	0.4409	Valid
1b	0.589	0.4409	Valid
2a	0.642	0.4409	Valid
2b	0.560	0.4409	Valid
3a	0.461	0.4409	Valid
3b	0.748	0.4409	Valid
4	0.838	0.4409	Valid
5	0.770	0.4409	Valid

Based on table 2, the eight items were declared valid. The overall calculation of the reliability of the test instrument is shown by the Cronbach's Alpha value of 0.804, which means the overall test instrument has a high degree of reliability criteria. Based on the validity and reliability test results, the test questions were declared valid and reliable, so that the test instruments could be used to measure students' critical thinking skills.

The average pretest and posttest score is presented in figure 1, while the average n-Gain difference is shown in figure 2.

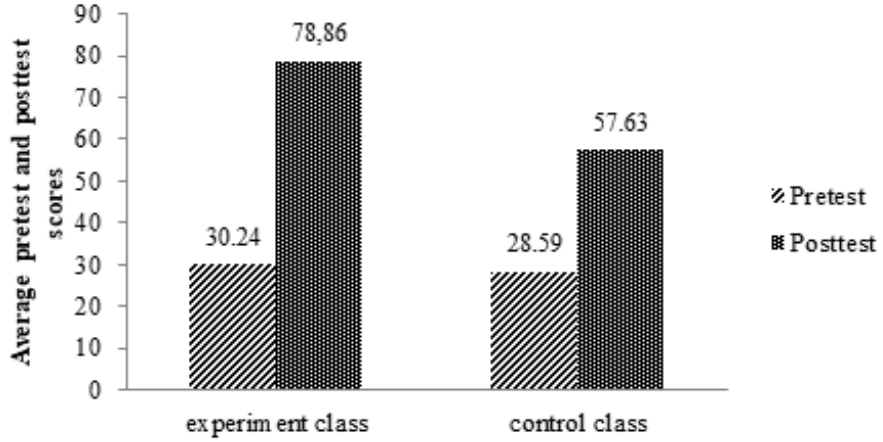

Figure 1. Average posttest and pretest scores

Based on figure 1, it can be seen that the students' average pretest and posttest scores in the experimental class and the control class have increased. The students' critical thinking skills of students in the experimental class increased after learning using the student worksheet based on problem solving compared to those in the control class.

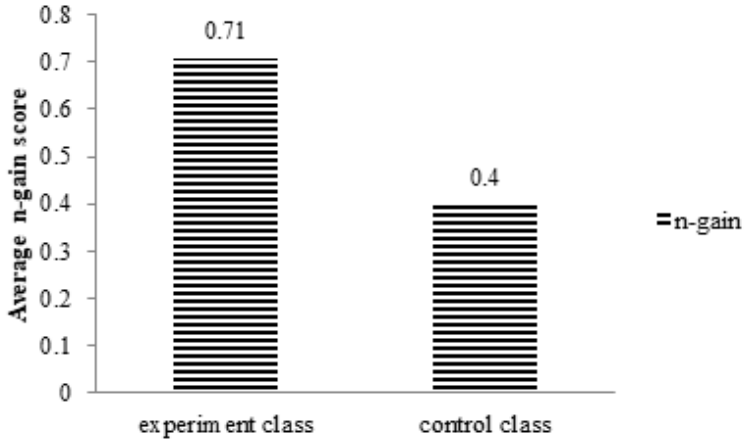

Figure 2. Average n-gain score

Figure 2 shows that the average n-Gain score of the students in the experimental class and control class is different. This shows that the students' thinking skills in the experimental class are influenced by learning using the student worksheet based on problem solving because the average n-Gain score is 0.71 with the criteria of "high". This is in contrast to the control class which gets n-Gain score of 0.40 categorized as "medium".

Normality Test and Homogeneity Test Result

The normality and homogeneity test results of students' critical thinking skills in the experimental and control classes can be seen in the following table.

Table 3. Normality test result

Classes	N	n-Gain	
		Sig. Value	Criteria
Experimental	34	0.110	sig. > 0.05
Control	34	0.158	sig. > 0.05

Based on table 3, it can be seen that the normality test result for the n-Gain score in the control and experiment classes has a sig. value from Shapiro-wilk in the experimental class and control class of > 0.05. Therefore, the research data obtained comes from the normally distributed population.

Table 4. Homogeneity-Test results

Classes	N	n-Gain	
		Sig. Value	Criteria
Experimental	34	0.77	sig. > 0.05
Control	34		

Based on table 4, it is known that the homogeneity test result on the n-Gain score in the control and experimental classes has a sig. value of > 0.05, so H0 is accepted and H1 is rejected, which means that both samples have a homogeneous variance value.

Two Average n-Gain Difference Test

The difference test result in the two average n-Gain of the students' critical thinking skills in the experimental and control classes indicates the sig. value of(2-tailed) < 0.05, so H1 is accepted, which means that the average n-Gain of the students' critical thinking skills using the student worksheet based on problem solving is higher than that using the conventional student worksheet.

Effect Size

After testing the two average n-Gain difference, the difference test on the two average scores was carried out. t value obtained from the difference test on the two average pretest-posttest scores with independent-sample t-test was then used to calculate the effect size of students' critical thinking skills in the experimental and control classes shown in table 5.

Table 5. Pretest-posttest results in improving students' critical thinking skills

Classes	Treat-ment	N	Mean	Std. Deviation	Sig (2-tailed	df	t	μ	Effect Size
Experimental	Pretest	34	30.2415	13.60463	0.000	66	-15.521	0.89	Large
	Posttest	34	78.8629	12.18868					
Control	Pretest	34	28.5865	14.20913	0.000	66	-8.747	0.73	Moderate
	Posttest	34	57.6288	13.15014					

Table 5 above shows that the sig. value(2-tailed) in both classes is smaller than 0.05, so H1 is accepted, meaning that the average learning outcome has a significant difference. The effect size in the experimental class is 0.89 or has a "large effect" according to the Dincer criteria (2015), while that of the control class is 0.73 or has a "moderate effect". This shows that students' critical thinking skills in the experimental class are higher than those of the control class.

The effectiveness of the student worksheet based on problem solving in improving critical thinking skills is also supported by the implementation of the student worksheet based on problem solving, which was assessed by two observers, namely partner teachers and research partners with the observation aspects covering the student worksheet content, ease of learning, cooperation, and results. The assessment result indicates that the implementation of the student worksheet based on problem solving increases at each meeting with the "very high" implementation criteria. The calculation result of the student worksheet implementation can be seen in table 6. Table 6 shows that the implementation of the student worksheet based on problem solving in improving critical thinking skills gained an average of 82% with very high criteria.

Table 6. Student worksheet implementation result

Observation Aspects	Meet-1	Meet-2	Meet-3
Content	3.000	3.214	3.714
Ease of Learning	3.000	3.100	3.666
Cooperation	3.000	3.000	3.750
Result	3.000	3.000	4.000
Total	12.000	12.314	15.131
Maximum Score	16	16	16
Percentages	75%	77%	95%
Average Percentage		**82%**	
Criteria		**Very High**	

The effectiveness of student worksheet based on problem solving in science learning is necessary in improving students' critical thinking skills. The result students' critical thinking skills in the experimental class are higher than those of the control class. This is in line with the research that states that the experimental class has higher critical thinking skills than the control class (Mundilarto & Helmiyanto Ismoyo, 2017; Elisanti et al., 2018). The improvement of students' critical thinking skills in the experimental class is influenced by the student worksheet based on problem solving while that in the control class is influenced by the conventional student worksheet (Qing et al, 2010; Nurita et al., 2017; Siew & Mapeala, 2016).

The implementation of the student worksheet based on problem solving in improving critical thinking skills gained an average of very high criteria. It is a student worksheet that requires students to be active in learning. This is evidenced by the student worksheet aspects; ease of learning, enthusiasm and activity and very good cooperation among students (Kopzhassarova et al., 2016; Sa'adah et al,. 2017) . The students' activities in the experimental class have increased from the first to the third meeting. At the beginning of the meeting, the students' activities in paying attention to their teacher's or friend's explanation, identifying problems and formulating hypotheses, and involving themselves in working on the student worksheet/discussion with groups are still relatively low.

This happens because the students still make adjustments to the learning process. In the next meeting, the students' activities began to improve. They were more enthusiastic in participating in learning and carrying out activities requested by the teacher in accordance with the lesson plan (Pukdeewut et al., 2013; Kell et al., 2016; Cruz-Guzmán et al., 2017). The teacher could only apply lecture method without discussion to teach the students in the control class using conventional student worksheet which contains a summary of electrolysis materials and exercises. Consequently, during the learning process the students were not actively involved.This made them become bored and lazy to learn. This is in accordance with the research stating that teacher-centred learning and one-way communication make students bored and tend to be passive both in thinking and physically (Yanto, 2013; Martínez et al., 2016).

The results stated above were obtained from the instructional effects and side effects as stated by Carolin et al. (2015) that problem solving learning can improve learning activities and achievements which include students' competencies, knowledge, attitudes, and skills. The side effects include; a) Students can communicate well and politely; b) they can cooperate with their friends in groups by

respecting each other's opinions; c) they have an independent and responsible attitude, especially in completing individual tasks; d) they have a happy attitude and a high interest in science, resilience, and are not easily discouraged in solving problems, especially electrolysis.

The student worksheet that solves problems can condition the students to use information or knowledge that has been learned to understand new concepts (Sala et al., 2015; Widowati et al., 2017;Putra et al., 2018). The implementation of the problem solving method is able to encourage cognitive skills so that students are able to build and construct concept and principal mastery independently, increase generalization and explore their self potential in improving their critical thinking skills (Rahman & Ahmar, 2016; Nurita et al., 2017; Sriyansyah & Azhari, 2017; Hendriana et al., 2018).

■ CONCLUSIONS

Based on the research result and discussion, it can be concluded that the student worksheet based on problem solving in science learning is very effective to improve students' critical thinking skills especially in electrolysis material. The increase in the pretest-posttest scores (n-gain) is categorized as "high". This is supported by the average percentage of the student worksheet implementation, which is very high, and the students' high enthusiasm in learning.

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