

# The Effectiveness of Student Worksheet Based on Problem Solving to Enhance Scientific Literacy

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**Abstract.** Scientific literacy is important for students to be able to apply science knowledge to solve problems in everyday life. Improvement of scientific literacy can be done by applying problem solving approach in science learning through student worksheet. This research aimed to analyse the effectiveness of student worksheet based on problem solving to enhance students' scientific literacy skills at grade 7<sup>th</sup> of Junior High School in learning science. It was a quasi-experiment research employing pre-test and post-test control group design. The subject of this research was two classes from grade seven of SMPN 12 Padang which were selected based on cluster random sampling. The experimental group was grade at VII A and the control group was class grade at VII C. Each of whom consists of 31 students. Data collection technique used test. The effectiveness of implementation of student worksheet based on problem solving was analyzed using normalized gains score technique and independent sample t-test. The result of data analysis shows the implementation of student worksheet based on problem solving were effective to increase the scientific literacy skills of students at grade 7<sup>th</sup>.

## INTRODUCTION

Science learning in schools always encounters challenges especially in preparing students to apply knowledge in solving daily problems. It can be seen from the results of students' scientific literacy skill which is still low. Based on the results of the PISA (Programme for International Student Assessment) study by the OECD in 2015, scientific literacy skills of Indonesian students are in the position of 62 out of 70 participating countries with a score of 403 compared with the highest score of 556 [1].

PISA defines scientific literacy as the ability to apply knowledge and to draw conclusions based on scientific evidence [2]. Reference [3] reveals the five principles of scientific literacy, namely: (1) everyone is able to obtain literacy, (2) literacy is a basic part of human experience, (3) literacy is not a trait residing only in individual, but requires and creates connections with others, (4) literacy includes communication, contact, and expectation that interaction is possible for all individuals, (5) literacy is the shared responsibility of every individual in society. Scientific literacy can be concluded is the ability to understand science, communicate science and apply science knowledge to solve problems and make decisions based on scientific considerations [4].

Based on the PISA assessment framework in 2015, scientific literacy is divided into four aspects: 1) Context, the scientific literacy context in PISA is addressed in everyday life that involves important issues in life covering the private, regional, national, and global demands of understanding the application of science and technology; 2) Aspects of knowledge in scientific literacy refers to the understanding of facts, concepts and keys of science; 3) Competencies, Literacy competence is the ability to explain phenomenon scientifically, evaluate and design scientific inquiry, and interpret data based on scientific evidence; 4) Attitudes, An attitude expressed with an interest in science and technology, valuating of scientific approach to investigation, where appropriate, and a perception of enviromental issues [5].

The development of the times and technological advances make scientific literacy becoming important to be owned by students to apply the science concepts in understanding the environment and other problems encountered [6]. Students actually have the average scientific literacy level from grade 6 upwards [7]. The application of problem solving in science teaching is an effort to improve students' literacy skill of science. Science is a knowledge that was born and developed through several steps: observation, formulation of problems, hypothesis preparation, hypothesis testing through experiments, conclusions, and the discovery of theory and concept [8]. It means that science has a close relationship with scientific methods, so it is relevant if problem solving approach is applied in the learning process. The use of problem-solving module by Wenno's research is effective to improve students' understanding of science concept [9]. The same results obtained in the implementation of learning using problem solving approach can improve student learning outcomes [10, 11].

Problem solving is an activity that directs students to build scientific knowledge and helps students in finding relationships between variables and generates scientific ideas related to concepts and a number of solutions of a particular problem [12]. Reference [13] suggests that "problem solving is the means by which an individual uses the demands of an unfamiliar situation", this statement means that problem solving is a process for an individual in using his/her knowledge and skills in overcoming unusual circumstances.

Problem solving can be done through five steps: (1) identifying problems, (2) formulating problems, (3) compiling questions, (4) collecting data, (5) analysis of a number of problems so that it can formulate answers for questions and draw conclusions [14]. Reference [15] suggests problem solving steps consist of (1) Understanding (focus on the problem, (2) Planning (plan the solution), (3) Solving (execute the plan), (4) Checking (evaluate the answer). Reference [16] states that the problem solving step consists of (1) description, a step of identifying unknown things, data, and conditions, (2) planning, a step looking for relationship between unknown data, (3) implementation, a step doing arranged plan, (4) checking, a step examining the solution and argument. Reference [17] shows the problem-solving steps consist of (1) the learner is given the problem, (2) formulates the problem, (3) formulates the hypothesis, and (4) tests the hypothesis. The steps of problem solving can be trained to the students through teaching materials in the form of student worksheets.

The Student Worksheet is a sheet of instructions or steps for completing a task using a learning approach, especially a process skill approach [18]. It indicates that the worksheet allows students to participate in the learning process actively and also it can improve student achievement [19]. This study aims to determine the effectiveness of the use of students worksheet based on problem-solving to improve scientific literacy of junior high school students at grade 7<sup>th</sup>.

## **METHODS**

### **Research Design**

This was a quasi-experimental research in which it employs two classes. A class was called as experimental class, while another one was called as control class. Experimental class employed student worksheet based on problem solving, whereas the control class employed worksheet commonly used by teacher at school.

### **Place and Time of Research**

This research was conducted at SMPN 12 Padang in West Sumatera, Indonesia, involving 31 students of class VII A as experimental class and 31 students of class VII C as control class. This study was conducted from 29 January to 12 February 2018.

### **Population and Sampling Technique**

The population of this study was all students of grade 7th at SMPN 12 Padang. Sampling technique employed in this research was cluster random sampling technique which includes two classes in which class VII A as experimental class, while class VII C as control class.

### Data, Instruments, and Data Collection Techniques

Data obtained in this research was quantitative based on the result of scientific literacy test. The instrument used was the test with 11 questions in form of description. In this study, the scientific literacy capability focuses on the competence of scientific literacy competencies adopted from the PISA 2015 framework [5]. The scientific literacy competence aspect which was measured in this research includes (1) explain the phenomena scientifically, (2) evaluate and design scientific inquiry, and (3) interpret data and evidence scientifically. Each aspect was derived from some of the indicators shown in Table 2. Data were collected by taking pre-test of scientific literacy capability before performing treatment and taking post-test after treatment. The question used to measure the scientific literacy at the post-test was the same as the pre-test, but with the random number of questions.

Table 2. Indicators of scientific literacy

No	Aspect of Scientific Literacy Competence	Indicator
1	Explain phenomena scientifically	a. Apply science knowledge in given situations
		b. Identify descriptions, explanations, and make predictions about a problem
		c. Describe or interpret the phenomenon scientifically and predict change
		d. Explain the potential implications of science knowledge for a problem
2	Evaluate and design scientific enquiry	a. Identify or recognize problems or questions that can be scientifically investigated
		b. Identify key words to obtain scientific information
		c. Suggest ways to investigate problems or questions scientifically
		d. Evaluate ways to investigate problems or questions scientifically
3	Interpret data and evidence scientifically	a. Analyze and interpret data and describe conclusions appropriately
		b. Identify assumptions, evidence and reasons in texts related to science
		c. Evaluate scientific arguments and evidence from multiple sources (eg newspapers, internet, journals)

### Procedure

The steps of this research are: 1) The first stage was done pretest in the experimental and control group, 2) implementation of student worksheet based on problem solving at experimental class whereas student worksheet commonly used by teacher at school at control class, 3) performing post test in experiment and control class. The design of this research is presented in Table 1.

Group	Pre-test	Treatment	Post-test
<b>Experiment</b>	Y <sub>1</sub>	X <sub>a</sub>	Y <sub>2</sub>
<b>Control</b>	Y <sub>1</sub>	X <sub>b</sub>	Y <sub>2</sub>

Notes:

Y<sub>1</sub>: pre-test of the students' scientific literacy

X<sub>a</sub>: teaching and learning science by using student worksheet based on problem solving

X<sub>b</sub>: teaching and learning science by using student worksheet based on what teacher commonly used

Y<sub>2</sub>: post-test of the students' scientific literacy

Student worksheet based on problem solving that has been valid, then implemented in science learning in the experimental class. In this worksheet, there are three activities related to Environmental Pollution and its Impact for the Ecosystem. The three activities consist of: (1) water pollution, (2) air pollution, and (3) soil contamination. Each activity in this worksheet is prepared using problem solving steps.

### Data Analysis Technique

After conducting pre-test and post-test, the increase of scientific literacy skills of students treated by using worksheet based on problem solving will be compared with students using worksheet commonly used by teachers in schools. The increase of scientific literacy skills will be calculated using normalized gain or gain score [20]. Normalized gain score is symbolized by *g*. The value of *g* can be calculated using the following formula:

$$g = \frac{\text{posttest score (\%)} - \text{pretest score (\%)}}{100 - \text{pretest score (\%)}}$$

There are three categories from the result of gain score analysis. The categories are as follows:

Table 3. Category of Result Analysis Using Gain Score [20]

Value	Category
$(g) \geq 0.7$	High
$0.7 > (g) \geq 0.3$	Medium
$(g) < 0.3$	Low

In this study the data analyzed was the normalized gain score of the students' scientific literacy the ability. The analysis was conducted to find out the difference of scientific literacy scores of the experimental class and control class. Normality and homogeneity tests should be performed first as a prerequisite test before the independent test of the t-test is performed. Normality test aims to determine whether the data was normally distributed or not. In this study, the normality test was performed using Kolmogorov-Smirnov statistical test, with a significance level of 5%. This test was done by using SPSS version 22. The criterion used was if the significance value was greater than 0.05 then the data was declared to have normal distribution.

Homogeneity test was conducted to find out the similarity of variance of experimental class and control class. The test was performed using Levene statistical test with the help of SPSS version 22 program with 5% significance level. Data was said to be homogeneous if the significance was greater than 0.05. Hypothesis test was done by using independent sample t-test. Independent sample t-test was a test of difference to know whether there is a significant mean difference between the 2 free unpaired groups. This test was performed to analyze the data consisting of one independent variable and one dependent variable. The independent sample t-test was conducted to determine the effect of learning significance using student worksheet based on problem solving on students' scientific literacy capability.

## RESULTS AND DISCUSSION

This research was conducted in SMPN 12 Padang, by taking two classes as sample. Class VII A was as an experimental class with 31 students, while class VII C was as control class with 31 students. The learning process in the experimental class used student worksheet based on problem solving, while the control class used student worksheet which was commonly used by the teacher. The learning process consists of 5 meetings with 13 hours of lessons. In the first meeting, pre-test was conducted to find out the initial ability of students regarding scientific literacy. Meanwhile, in the second, third and fourth meetings, students in experimental class were treated by using student worksheet based on problem solving. In the last meeting, post-test was conducted to determine the ability of scientific literacy of students after being treated.

In improving students' scientific ability, student worksheet based on problem solving was seen from three indicators of scientific literacy competence: (1) explain the phenomena scientifically, (2) evaluate and design scientific enquiry, and (3) interpret data and evidence scientifically. Differences in the scientific literacy competence of the students from the experimental class and control class can be determined by comparing the pre-test and post-test scores of the students' scientific literacy competencies, as presented in Table 4.

Table 4. Comparison of pre-test and post-test scores of students scientific literacy

No	Indicator of Scientific Literacy Competence	Experimental class		Control class	
		Pretest	Posttest	Pretest	Posttest
1	Explain the phenomena scientifically	51.76	83.20	54.40	70.16
2	Evaluate and design scientific enquiry	47.93	80.65	46.54	65.67
3	Interpret data and evidence scientifically	38.91	69.76	39.52	61.29
Average		46.20	77.87	46.82	65.71

Based on data from Table 4, it was known that the pre-test values of the experimental class and control class have almost the same mean. This shows the initial ability of both classes was equivalent. The post-test score of the scientific literacy skills of both classes have an improvement, but the experimental class was higher than the control class. This means that there was an effect of using student worksheet based on problem solving in learning science. Based on three indicators of scientific literacy competence, the indicator explain the phenomena scientifically gets the highest value of 83.20. The evaluate and design scientific enquiry aspect in the experimental class obtained an average posttest score of 80.65 while the control class obtained an average score of 65.67. Aspects of the Interpret data and evidence scientifically experimental classes get the final score of 69.76 and the control class 61.29.

The differences of pre-test and post-test scores of scientific literacy skills are presented more clearly in the form of diagrams as shown in Figure 1. Based on the results of the normalized gain score analysis, the scientific literacy skills of the experimental class scores was higher than the control class with the gain score of 0.5887 which was categorized as "medium" (Table 5). This shows that learning that implements student worksheet based on problem solving can improve scientific literacy skills of junior high school students of grade 7<sup>th</sup>.

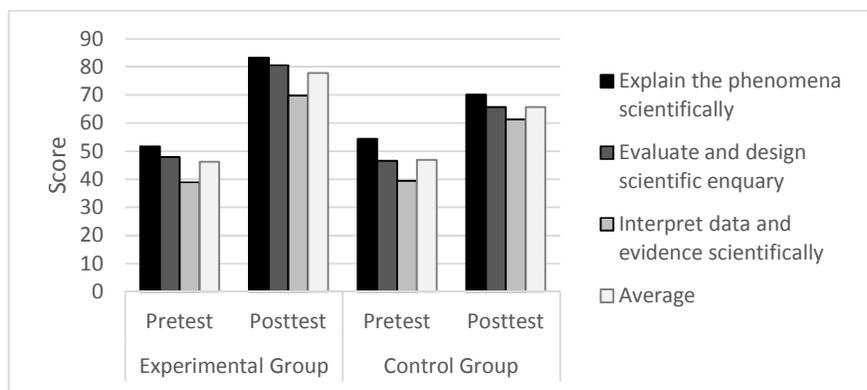


Fig 1. Diagram on the differences of pretest and posttest scores of scientific literacy

Table 5. Value of gain score of scientific literacy from experimental and control class

	Pretest	Posttest	<g>	Category
Experimental Group	46.20	77.87	0.5887	Medium
Control Group	46.82	65.71	0.3552	Medium

To analyze the difference of effectiveness between classes using student worksheet based on problem solving with those not using it, was done by using independent sample t-test. However, before conducting the t-test, there should be conducted normality test and homogeneity test. Normality test was conducted by using the help of SPSS version 22 program with Kolmogorov-Smirnov statistical test. The results of this test obtained a value of significance of 0.200 for the experimental class and 0.200 for the control class, it shows in Table 6. This indicates that the data is normally distributed because the result of the significance value is greater than 0.05.

Table 6. The result of kolmogorov-smirnov test

	<b>Test</b>	<b>Sig.</b>
Experimental Group	Kolmogorov-Smirnov	0.200
Control Group	Kolmogorov-Smirnov	0.200

The homogeneity test was also done using SPSS version 22 program employing Levene statistic test. Homogeneity test results are presented in Table 7.

Table 7. The result of levene statistic test

	<b>Test</b>	<b>Sig.</b>
Experimental and Control group	Levene Statistic	0.896

Based on the result of Table 7, from the homogeneity test it was obtained the scientific literacy value of the experimental class and the control class is 0.896. The result of significance value is shown greater than 0.05 so that the variance of both groups can be said to be homogeneous.

Based on the prerequisite test results that have been done on the sample, it has fulfilled the assumption of normality and homogeneity of variance. This indicated that the independent sample t-test can be continued. The result of independent sample t-test on the average score of scientific literacy skills of students is presented in Table 8.

Table 8. The Result of Levene Statistic Test

<b>t</b>	<b>df</b>	<b>Mean Difference</b>	<b>Sig. (2-tailed)</b>
3.601	60	12.09677	0.001

Based on the data in Table 8, the result of the independent sample t-test of the normalized gain score of the scientific literacy skills of the students obtained a significance value of 0.001. This result showed lower than the 0.05 significance level so that  $H_0$  is rejected. This means that student worksheet based on problem solving is effective to improve the scientific literacy of junior high school students at grade 7<sup>th</sup>.

This research focuses on assisting students in improving the ability of scientific literacy competence by using problem solving approach. The results revealed that the attainment of the scientific literacy of the experimental class was significant compared to the results obtained from the control class. This difference was related to the learning approach applied to the experimental class. The steps of problem solving used in learning were addressed to students to provide problem-solving experience to find the right solutions. Experience in solving the problems given to the students led to the development of student success in solving the problem so that their skills increased [21]. This was observed on the basis of the average value of the scientific literacy of the experimental class and the control class obtaining similar results on pretest. Scientific literacy scores on the posttest experimental class students increased while the control class does not show significant improvement. The improvement of scientific literacy is influenced by students' understanding of the increasing science materials. This was relevant to the research findings conducted by Supriyanti Student Skills in solving problems related to problem-solving approaches that encourage students to improve their conceptual material understanding of the problem-solving process [11].

This study examined the ability of student's scientific literacy competence. Aspects explain the phenomenon scientifically obtained the highest score. This was because the ability of students who have been trained to use the stages of problem solving in science learning, especially in terms of identifying the problem and test the hypothesis.

Each step in the problem solving approach stimulates students to be able to solve problems creatively from identifying to evaluating problems [11]. with Application of problem solving in science learning, students were more creative in developing themselves and students have the opportunity to learn independently to understand the concept of science [9].

Evaluate and design aspects of scientific enquiry and interpret the data and evidence scientifically experimental class students scored higher than the control class. Student in completing an experimental class activity students used complex skills ranging from identifying problems, formulating problems, preparing hypotheses, then testing hypotheses and drawing conclusions so that students develop in thinking. The expansion of thinking scope of trained students links knowledge in solving problems [10]. This was relevant to the scientific literacy competence that emphasizes the students' ability to apply science knowledge in everyday life. References [2] revealed that science literacy is an act of understanding science and applying it to the needs of society. Results of research conducted by [22] revealed that learning that applied problem solving can guided students to apply knowledge to find solutions during the problem-solving process. In this research problem solving stages applied through the student worksheets to solve problems with environmental pollution subject matter successfully helped improve scientific literacy competence ability.

## CONCLUSION

Based on the results of research and discussion, it can be concluded that the implementation of student worksheet based on problem-solving in science learning is effective to improve the scientific literacy of students at grade 7th of Junior High School.

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