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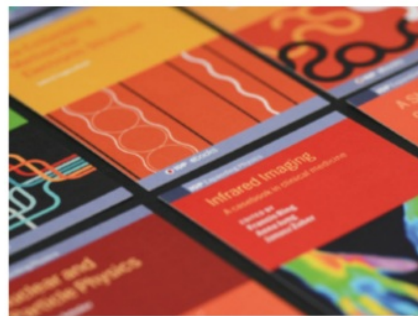
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Scientific Approach and The Effect on Students Scientific Literacy

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Abstract – The development of scientific literacy skills were the main purpose of science education. The curriculum 2013 has suggested scientific approach as the alternative instruction to foster students' scientific literacy. This goal of this study was to examine the effect of scientific approach on scientific literacy of students. The data was collected through pre-test and post-test arranged based on three indicators of scientific literacy, namely scientific reasoning, scientific investigation, and problem solving. The tests were administered to 34 students and the results were analyzed using the normalized gain score (N-gain). The findings informed that scientific approach has a medium effect on scientific literacy. In addition, the dominant indicator of scientific literacy was scientific reasoning. This valuable information could be used by the teacher as a reference to develop the students' scientific literacy through scientific approach.

Keywords – scientific approach; scientific literacy; scientific reasoning

1. INTRODUCTION

The main goal of natural science education is scientific literacy [1]. Thus, the Indonesian national curriculum 2013 has directed students to develop scientific literacy through inquiry activities and scientific approaches in the science learning [2]. Enhancing scientific literacy helps students to solve daily problems scientifically. Students who have scientific literacy skills can foster the ability to think critically, recognize evidence, make informed decisions about the world, master technology, and adaptive to the changes and the developments [3]. Therefore, in order to become a literate person, students need to be equipped with scientific literacy skills.

There are many definitions of scientific literacy. Currently, scientific literacy has been interpreted not only as the ability to read and comprehend science-related articles but also the capability to understand and apply scientific principles to everyday life [4]. Fives et al defined scientific literacy is as a form of critical thinking necessary for evaluating and making informed decisions in our daily lives [5]. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed [6]. Students who became literate are they have ability to identify questions, explain scientific phenomena and draw conclusion of science issues by using their scientific knowledge [7]. Council of Minister of Education Canada (CMEC) reveal that scientific literacy is a student's competence in understanding the nature of science including attitudes, skills, and knowledge to conduct inquiries, to solve problems, and to reason scientifically [8].



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In this study, scientific literacy refers to three competences. The first one is scientific investigation that focused on student's skill to address or develop questions about the nature of things that involves extensive exploration as well as focused investigations [9]. The second one is problem solving which means that students are required to find answers to practical problems requiring the application of their science knowledge in new way [9]. The last skill is scientific reasoning. This competence required students are being able to reason scientifically and make connections by applying scientific knowledge and skills to make decisions and address issues involving science, technology, society, and the environment [9].

Several junior high schools in Sidoarjo Regency have implemented the Curriculum 2013 and Literacy Culture. One of them is SMP Negeri 2 Wonoayu. Based on the results of the interview, the teacher explained that the scientific approach was chosen as one method to improve learning outcomes including aspects of knowledge, attitudes and skills. In addition, schools also implemented literacy activities, such as carrying out a reading culture. However, the applied method and culture did not make students have scientific literacy skills. The result of preliminary tests of scientific literacy informed that student's scientific literacy in each indicator was low. There were 36% of students can explain scientific phenomena, 18 % of students can solve problems, and 35% of students can use scientific evidence for inference, charting, and drawing conclusions based on data.

The lack of students' scientific literacy are of concern. Therefore, there is a need to improve science teaching in order to increase scientific literacy. Through applying scientific literacy-based scientific approaches, not only students' learning outcomes are increasing, but also their scientific literacy. Asyhari and Hartati explained that scientific approach can improve the students' scientific literacy skill on competency and knowledge aspect of environmental pollution topic [10]. Safitri revealed that students gave positive responses to the learning based scientific approach and had the improvement of scientific literacy score [11]. The scientific approach is not a simple approach, but is an activity of inquiry where students make observations, ask questions, use evidence to explain questions, use tools to collect, process and interpret data, and communicate findings [12]. The curriculum 2013 defined scientific approach as learning involving observing, questioning, reasoning, investigating, and communicating activities or networking for all subjects [2]. Some authors described the scientific approach as the inquiry learning and many studies suggested that learning involving inquiry activities in could improve students' ability to solve problems, critical thinking, and scientific literacy [13][14][15]. Thus, the purpose of this study is to investigate the students' scientific literacy after the implementation of learning based scientific approach.

2. METHOD

This study was a pre-experimental research using one group pretest-post test design which can be described as follows:

$$O_1 \text{ X } O_2 \text{ (1)}$$

O₁ was a pretest of scientific literacy given before the learning. Meanwhile O₂ was a scientific literacy posttest given to students after the learning. X was the implementation of scientific approach by the teacher.

The subjects of this study were 34 of eighth grade students of SMP Negeri 2 Wonoayu. The data was collected by giving a test. The test was used to determine students' scientific literacy abilities. The questions in the test were in the form of essay arranged based on learning indicators and based on scientific literacy competencies adapted from the Pan-Canadian Assessment Program (PCAP).

The gained data then was analyzed using descriptive statistics. To find out that the application of the scientific approach influences scientific literacy, the normalized gain formula was used as a below:

$$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{100 - \langle S_{pre} \rangle} \dots\dots\dots(2)$$

$\langle S_{post} \rangle$ dan $\langle S_{pre} \rangle$ respectively shows the average pretest and posttest scores. The value of g is described as: High if $g > 0.7$, medium if $0.3 \leq g \leq 0.7$ and low if $g < 0.3$ [16].

3. RESEARCH FINDING AND DISCUSSION

The obtained data of this study was the results from the pretest and posttest after the implementation of learning science based scientific approach. The test that was used to measure the students' scientific literacy skills, was in the form of essay test consisting of 15 questions. The following data was the calculation of the pretest and posttest of scientific literacy given to students.

Table 1. The Results of Pretest and Posttest of scientific Literacy Test

Data	Pretest	Posttest
N	34	34
Min	35	55
Max	57	77
Mean	44,03	64,03

As can be seen in the table 1, there were improvement minimum, maximum, and average score of post-test. This means that the learning of scientific approach applied by the teacher influences students' scientific literacy skills. In addition to the statistical data above, table 2 informed the level of gain score of scientific literacy of each student.

Table 2. The N-Gain Score of Student

Student	Pre	Post	N-gain	Category	Student	Pre	Post	N-gain	Category
1	43	58	0,26	low	18	43	62	0,32	medium
2	47	62	0,28	low	19	35	63	0,44	medium
3	35	62	0,41	medium	20	40	68	0,47	medium
4	52	68	0,34	medium	21	43	62	0,32	medium
5	43	58	0,26	low	22	40	62	0,36	medium
6	48	62	0,26	low	23	40	63	0,39	medium
7	48	68	0,39	medium	24	52	57	0,10	low
8	43	60	0,29	low	25	40	72	0,53	medium
9	53	75	0,46	medium	26	47	57	0,19	low
10	37	67	0,47	medium	27	40	60	0,33	medium
11	42	62	0,34	medium	28	52	63	0,24	low
12	47	62	0,28	low	29	47	63	0,31	medium
13	35	63	0,44	medium	30	47	70	0,44	medium
14	37	55	0,29	low	31	52	63	0,24	low
15	52	63	0,24	low	32	40	63	0,39	medium
16	52	68	0,34	medium	33	57	77	0,46	medium
17	35	72	0,56	medium	34	48	62	0,26	low

N-gain analysis is used to determine how much influence the learning of the scientific approach to students' scientific literacy skills. Thus, table 2 provides information that the scientific approach

applied by the teacher had a medium effect on students' scientific literacy skills. The scientific approach encourages students to be actively involved in the learning process through a series of scientific methods to independently develop their conceptualization of knowledge through familiar phenomena of students' daily lives (17). Scientific approach was the learning that requires students to do activities as a scientist. In the scientific approach, student learning activities include observing, asking questions, investigating, associating (reasoning), and communicating (18). Abidin (2014) stated that scientific approach was a learning process that guided students to solve problems through careful planning activities, data collection, and data analysis to draw a conclusion. In order to carry out such activities, students must be nurtured their sensitivity to phenomena, improved their ability to ask questions, trained their accuracy in collecting data, developed their accuracy in processing data to answer questions, and guided in making conclusions in response to the questions posed. Therefore, scientific approaches can build students' scientific literacy in learning through conducting investigations by formulating problems, making hypotheses, designing experiments, solving problems from the problems given by the teacher, and reasoning the results of the experiments.

The figure 1 was the graph of students' scientific literacy in terms of scientific inquiry, scientific reasoning, and problem solving.

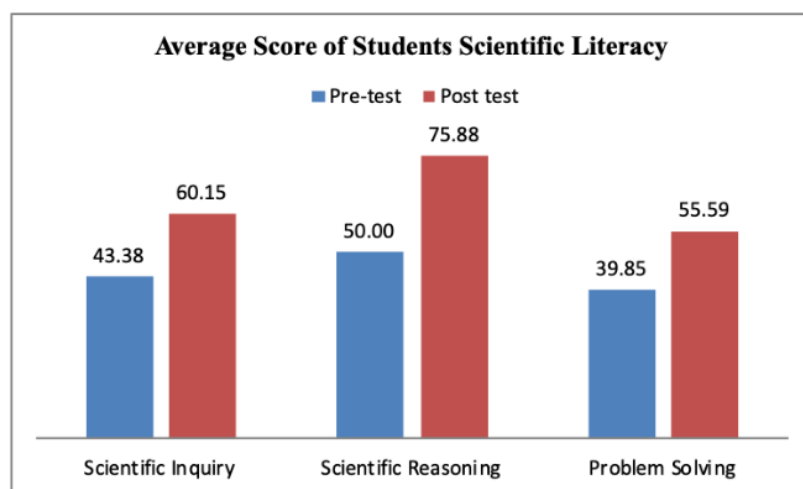


Figure 1. The Scientific Literacy Skill of Students

The graph showed that the dominant indicators of scientific literacy was scientific reasoning, the second one was scientific inquiry, and the last one was problem solving. Scientific reasoning is a skill that involves developing reasonable arguments and using reasoning to make the right decisions for a particular problem in connection with scientific evidence. The explanation of this result was that scientific approach through the activities of observing, associating, and presenting the results of investigation, facilitated students to use their knowledge to explain the phenomena and decide the right scientific statement of light.

The second dominant indicators was scientific inquiry. The competences of scientific inquiry referred to the ability of students of formulating a hypothesis; designing and conduct investigations; regulating and communicating information; analyzing and interpreting data (for example, using charts and tables); and choosing alternative conclusions regarding the evidence presented. The scientific approach promote students to do inquiry activities, such as determining what tools are needed in a regular and diffuse reflection experiment, writing experimental steps about the nature of light, and determining experimental variables. These skills should always be trained by the teacher to students so that students are accustomed to doing science process skills.

The last scientific literacy competence was problem solving. This skill explore students' ability to solve problems by defining problems; formulating questions; communicating goals related to the problem; solving problems by recognizing scientific ideas; and choosing the right solution regarding the identified problem. The application of a scientific approach can make students learn through efforts to solve real world problems in a structured manner. The problems studied are problems found by students in their daily lives. Through this problem, students can develop their scientific literacy competencies in the form of the ability to identify scientific issues. Mastery of this competence can be seen through the activities of students in groups in conveying ideas that allow them to help the problem solving process. The problem studied is then solved through a series of information searches that are useful to obtain problem solving from the phenomena presented.

Overall, the impact of the scientific approach activities was evidenced by the increasing scientific literacy skills of students. Therefore, teacher should considere the use of scientific approach in teaching science. As consequent, the learning objective that will be achieved not only cognitive abilities in the basic level, but skills in higher order thinking such as critical thinking and scientific literacy.

4. CONCLUSION

To conclude, the implementation of the scientific approach in the teaching of lighth topic had the medium effect on students' scientific literacy. This learning can be applied to stimulate students' interest in scientific issues (problem solving), increase scientific inquiry, and encourage students' reasoning skills.

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