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Science Literacy-based Scientific Method: A Study to Improve Science Process Skill of the Middle School Students

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Abstract The main problem in this research was how to apply a scientific literacy-based scientific approach to improve the physics science process skills of students in the XI class of MA Muallimin Muhammadiyah Makassar, Indonesia in the 2018/2019 academic year. This study aimed to determine the magnitude of the improvement in the physics science process skills of students before and after the scientific literacy-based method is applied. This research used pre-experiment and One Group Pretest-Posttest Design consisting of three stages, which were pretest, treatment, and posttest for six meetings. The procedure in this study was divided into, namely the preparation stage, the implementation phase, and the final phase. Two variables, the independent and the dependent were used, while the sample of this research was 28 XI grade students of MA Muallimin Muhammadiyah Makassar, Indonesia in the 2018/2019 academic year assuming the whole class was homogeneous. The research instrument used was a test of physical science process skills that met valid criteria in 23 questions with material temperature and heat. The results showed that the average pretest score of students was 8.29 and the posttest was 14.50 with a normalized N-gain test score of 0.43 (medium category). To conclude, students' science process skills of class students experienced an increase after the experimental method was applied. The researchers recommended that the results of this study provide benefits for practitioners to improve the science process skills of the middle school students through the application of Science Literacy-based Scientific Method.

Keywords Science Process Skills, Scientific Approach, Scientific Literacy

1. Introduction

A good education is a strategic step to improve the quality of human resources to create a great nation. Education must be able to offer solutions to advance and win a strict global competition if it is to survive and exist productively in international competition. The important role of education is explicitly reflected in the National Education System Law Number 12 of 2012 concerning the National Education System. Article 1 number 1 states that "Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to obtain religious, spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation, and country. "

In the context of the nature of learning, science covers four aspects, which are content or products, processes or methods, attitudes, and technology [1]. Science as content or product means that in science, there are facts, laws, principles, and theories that have been accepted for its truth. Science as a process or method means that science is a process of gaining knowledge. Besides being a product and process, science is also an attitude, meaning that science is inseparable from attitudes, such as diligence, openness, honesty, and objectivity. Science as a technology implies that science is related and used in everyday life.

Physics, as one part of science, is one of the disciplines that are closely related to natural phenomena that can be understood through concepts, laws, and theories that are formulated simply with the assistance of mathematics. Learning physics helps humans to understand the symptoms of the environment. However, the paradigm that is built in the middle of society makes physics less desirable. Physics is considered difficult, boring, and creepy and can only be done by smart students. This is coupled with the habit of teachers who are busy choking students with various kinds of formulas that are difficult to understand without trying to explore physics with the daily lives of students so that physics is further away from the word "fun".

In general, the knowledge received by students is only as information, not as an initiative to find knowledge or information. As a result, knowledge is not meaningful in daily life and is quickly forgotten. Lecture methods are often used by teachers without seeing many possibilities of applying other methods in accordance with the types of materials and materials and tools available. Students are seen only as blank paper that can be written by the teacher. Physics is a process that can be shown by science process skills, but it is based on the results of observational surveys, so science process skills of MA Muallimin Muhammadiyah Makassar students were still very low. The learning process was merely shown in "to learn to know" while the "learn how to learn" aspects had not been adequately touched. Students often got science experience in everyday life but did not realize that the experience gained is related to science.

Starting from these problems, the author tried to find a solution to overcome them. Although this solution was not immediately possible to overcome the deterioration of education in Indonesia, the authors wish to play a role in overcoming educational problems, at least within reach of the population studied. The solution offered was in the form of the application of methods that involved more active students, and focused on students through a scientific approach.

The scientific approach as mentioned [2] was a learning process which was designed so that students actively construct concepts, laws or principles through the stages of observing, formulating problems, submitting or formulating hypotheses, collecting data, analyzing data, drawing conclusions and communicating concepts, laws or principles found. In the scientific approach, competencies of attitudes, skills, and knowledge can be accommodated with scientific activities that include scientific processes, scientific attitudes, and scientific products. This opinion is in line with the research conducted [3].

In addition to the scientific approach, learning through scientific literacy can also be used. This is because scientific literacy will guide students to have the ability in terms of knowledge and understanding of scientific concepts and processes needed [4]. Based on the background that covers the education problems and the methods used by the teacher in the learning process.

2. Materials and Methods

2.1. Theoretical Framework

2.1.1. Scientific Method Teaching

Generally, scientific methods involve observational activities needed for the formulation of hypotheses or collecting data [5]. The scientific method is based on the presentation of data obtained through observation or experiment so that the experimental activities can be replaced with activities to obtain information from various sources [6]. The syntax of the scientific method includes observing, questioning, reasoning, trying and communicating.

From some scientific method understanding, physics is very suitable to be taught using this method. The scientific method has a close relationship with the learning of physical science which emphasizes the activity of students in learning and provides opportunities for students to build concepts in their knowledge independently, familiarize students in formulating, dealing with, and solving problems found.

2.1.2. Science Literacy

Many countries are trying to make science literacy the main goal of education [7]. For example, the policy-making process and determine how policy writers understood scientific literacy ideas in the 2005 curriculum in South Africa [8]. Although there were different definitions for scientific literacy, they all generally incorporated talent to use scientific knowledge and think for personal and social purposes. According to the National Science Education Standards, scientific literacy includes understanding scientific concepts and supporting cultural and economic production and decision-making processes.

The stages of science-based science learning are based on the stages, which are the contact stage (contact phase), curiosity stage, concept formation stage, decision-making stage, concept development stage, and the evaluation phase [9].

2.1.3. The Correlation of Scientific Approach and Science Literacy

The scientific approach is closely related to scientific literacy. The scientific approach, as its characteristics, adopts the workings of scientists in finding the knowledge that is done through stages such as observing, asking, classifying, conducting experiments, and drawing conclusions [10]. These stages become an approach that is very likely to be applied in learning science such as physics at school because the character of science is closely related to such stages.

2.1.4. Science Process Skills

Knowledge is something broad. Science continues to improvise and increases so rapidly as a result of new ideas throughout the world [11]. Therefore, people need to be taught about how they can achieve the necessary and accurate knowledge rather than being taught all the knowledge in the education system. Therefore, process science skills (SPS) are important in teaching methods to achieve good knowledge that is important for scientific inquiry as part of cognitive skills and investigation.

Science process skills (SPS) are "intellectual skills along with related learning abilities that scientists use as

self-management management procedures in carrying out their activities" [12]. SPS is very important for each because each uses SPS in several stages from them in everyday life, in science education literacy, SPS can be divided into two groups, "Basic" and "Integrated." Science process skills refer to the following six actions, and there is no specific sequence: observation, communication, classification, measurement, inference, and predictions.

2.2. Methodology

This research is a Pre-Experimental Design (Pre-Experimental) study with One-group pretest-posttest design research design located at MA Muallimin Muhammadiyah Makassar, Muhammadiyah No. 51 B, Indonesia.

This study consists of two variables, which are independent variables (scientific literacy-based scientific methods) and dependent variables (science process skills). The population in this study were all students of the XI IPA class of MA Muallimin Muhammadiyah Makassar Academic Year 2018/2019 and the sample in this study was class XI IPA with sampling techniques based on the assumption that the whole class was homogeneous.

This research was carried out through three stages: preparation, implementation, and final stages. The stage was carried out in a consultation with the principal and physics teachers in MA Muallimin Muhammadiyah Makassar to ask permission to carry out research, to confirm the material to be used as research material, and to compile learning devices consisting of 4 devices, they are: (1) The lesson plan used was adapted to the 2013 curriculum using the scientific method syntax based on scientific literacy. (2) Compiled the test instrument sheet results of science skills. (3) Teaching materials in this study were teaching materials that were created by the researcher which are arranged based on the syntax of the learning model in the study. (4) LKPD (Student Worksheets) used in the research were prepared by the researcher according to the syntax and are prepared based on the 2013 curriculum so that student activities will be directed.

Implementation was the main activity in the research. This stage was conducted by applying science literacy-based scientific method after applying pre-test on the students.

After the learning process was carried out by using a literacy-based scientific method, the results of the students' scientific skills are tested as a result of observation. To process data collected in research, the statistical technique was used. Instrument analysis was carried out to determine the validity and reliability of the instruments used, and the descriptive analysis used was the presentation of data in the form of average values and standard deviation. This analysis was intended to present or express/score the results of scientific skills obtained from the results of student evaluations by grouping them in completeness criteria used at MA Muallimin Muhammadiyah Makassar. The formula for the average value is as follows:

$$\bar{X} = \frac{\sum f_i x_i}{\sum f_i} \quad (1)$$

Standard deviation formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \quad (2)$$

After all the data was collected, the significance of improving the science process skills of students (pretest and posttest) was found out, and the N-Gain formula was used. G was the normalized gain (N-gain) of both models, while Smaks was the maximum (ideal) score of the initial test and the final test. Spost was the final test score, and Spre was the initial test score. The high and low normalized gain (N-gain) were classified as follows: (1) if g 0.7 then the resulting N-gain is high; (2) if 0.3 g 0.7, then the resulting N-gain is included in the medium category, and (3) if g 0.3 then the resulting N-gain is included in the low category.

3. Results and Discussion

This part presents the results of the analysis. There were two kinds of results presented, the result of the descriptive analysis and the results of the analysis that applied inferential statistics.

3.1. Descriptive Analysis of Physics Science Process Skill

The results of the descriptive analysis showed a description of the scores of students' physical science process skills in the group under the research. Based on the results of the descriptive analysis, the score of the XI physics science process skills test results of the MA Muallimin Muhammadiyah Makassar in the 2018/2019 academic year is shown in the following summary table.

Table 1. The score of the Science Process Physics Skills of Students Before and after being Taught Using the Scientific Method Based on Science Literacy of Class XI MA Muallimin Muhammadiyah Makassar

Statistics	Statistic Score	
	Pretest	***Posttest***
Sample Size	28	28
Highest Score	14	20
Lowest Score	3	9
Score Range	11,00	11, 00
Average Score	8,29	*14,50*
Standard deviation	3,23	*3,42*

3.1.1 Pretest Data Analysis

Table 1 shows that the XI grade students of MA Muallimin Muhammadiyah Makassar have a total sample of 28 people. Considering from the highest score of Physics science process skills of Pretest students at 14, the lowest score achieved by students was 3 from the ideal score of 23, with a range of 11.00, so that the average score of students was 8.29 and the standard deviation was 3.23. The scores of science process skills of XI MA Muallimin Muhammadiyah Makassar students was analyzed using percentages on frequency distribution. The results are shown in the following table:

Table 2. Frequency Distribution and Percentage of Physics Science Process Skills Score of Class XI Students of MA Muallimin Muhammadiyah Makassar at Pretest.

Scores	Frequency	Percentage
3 – 4	3	10.71
5 -6	8	28.57
7-8	3	10.71
9-10	7	25.00
11-12	3	10.71
13-14	4	14.29
Σ	**28**	**100.00**

The Pretest Frequency distribution data in table 2 is presented in the figure 1 as follows:

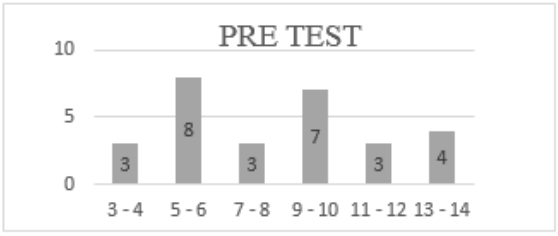

Figure 1. Cumulative Frequency Distribution and Physical Science Skill Process Score Percentage Students in Class XI MA Muallimin Muhammadiyah Makassar at the Pretest.

3.1.2. Posttest Data Analysis

It can be seen that the data was obtained from the physical science process skills of students in class XI MA Muallimin Muhammadiyah Makassar after being taught with scientific methods for 5 meetings with temperature and heat material; according to Table 4.3, the highest score of learning outcomes of Physics students was 20 and the lowest achieved was 9 of the ideal score of 23. The number of samples in the Posttest is the same as the pretest sample, which is 28 people, and the average score of 14.50 with the standard deviation obtained is 3.42. Data obtained from the science process skills of students after being taught by scientific literacy-based scientific methods using the analysis of frequency distribution and the percentage score of physics science process skills are shown in the following table:

Table 3. Frequency Distribution and Percentage of Physics Science Process Skills Score of Class XI Students of MA Muallimin Muhammadiyah Makassar on Posttest

Scores	Frequency	Percentage
9-10	5	17.86
11-12	4	14.29
13-14	4	14.29
15-16	6	21.43
17-19	5	17.86
19-20	4	14.29
Σ	**28**	**100**

Posttest frequency distribution data on Table 3 is shown in the following chart:

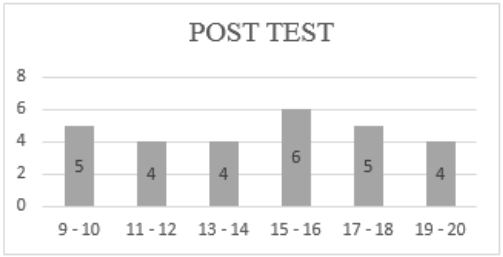

Figure 2. Cumulative Frequency Distribution and Physical Science Process Skills Percentage Score of Class XI MA Muallimin Muhammadiyah Makassar on the Posttest

3.2. Practice Result Data Analysis

Data was obtained from the observation sheet of physics science process skills of students in class XI laboratory activities of MA Muallimin Muhammadiyah Makassar after being taught with scientific methods for 5 meetings with temperature and heat material; according to what is shown in Table 4.4, the highest score from the results of physics laboratory practice students are 30 and the lowest score is 20. The number of samples in practice was 28 students, which were divided into five groups. After being analyzed, the sample obtained an average score of 33.86 with the standard deviation obtained at 2.54. Data obtained from the science process skills of students after being taught by scientific literacy-based scientific methods by using frequency distribution analysis and the percentage score of physics science process skills can be seen in the following Table:

Table 4. Frequency Distribution and Percentage of Physical Science Process Skills Scores of Students for Practice of Class XI Activities MA Muallimin Muhammadiyah Makassar on Posttest

Scores	Frequency	Percentage
19 – 20	1	3.57
21 - 22	1	3.57
23 - 24	3	10.71
25 - 26	3	10.71
27 - 28	13	46.43
29 - 30	7	25.00
∑	**28**	**100.00**

3.2.1. N-Gain test

This test was conducted to determine the increase occurred before and after being given treatment, to find out the increase in science process skills of students in the category of low, medium, or high. This N-Gain test was conducted on Pretest and Posttest data, including tests of students' physical science process skills before and after being treated. The results of the analysis of the data obtained can be seen in the following table.

Table 5. N-Gain Test Category of Students Process Skill Score before and After the Application of the Method

Criteria	Gain Index	Normalized Gain (G)
High	$g > 0.70$	
Moderate	$0.70 \geq g \geq 0.30$	*0.43*
Low	$g < 0.30$	

Table 5 illustrates the results of the calculation of the N-Gain test with criteria of 0.43, then the improvement of students' science process skills that occurred before and after applying scientific literacy-based scientific methods to physics learning in class XI MIA MA Muallimin, Muhammadiyah Makassar is considered in the moderate category.

3.3. Discussion

This research is a pre-experimental study conducted on class XI students of MA Muallimin Muhammadiyah Makassar with a sample of 28 people. This study compared the scores of the science process skills of students before and after being taught by scientific literacy-based scientific methods. This research was carried out by the research procedures that had been made previously. The stages in this study are divided into two parts, which are before and after treatment. The treatment in question is the application of scientific literacy-based scientific methods to students in the process of learning physics.

Before being given treatment, the students were given a pre-test to determine the score of the students' science process skills and are given a post-test after the treatment is applied. This score from the pre-test and post-test of the students was analysed.

This study used two types of analysis. The first analyst was carried out using descriptive analysis. Descriptive analysis results showed that the average score of science process skills obtained by students before the application of scientific literacy-based scientific methods is lower than the scores obtained by students after treatment. It happened because students who are taught using scientific literacy-based scientific approaches could understand physics learning from experimental activities equipped with the given literacy [12]. Also, the activities carried out were shared equally among each group member so that learning activities were completed more quickly. This offered an opportunity to interact each other involving various ideas and opinions and exchanging experiences through a process of mutual argumentation in analyzing the information obtained to conclude.

In addition to the descriptive analysis of the results of the pre and post-test scores of students, the researchers also conducted a descriptive analysis using scores from the observation sheets of students' science process skills. From the results of data analysis, the average score was 33.86, and the standard deviation value was 2.54. If the average score was calculated in the form of a value, the average score obtained by students was in the range of 84. The second analysis was done using the N-Gain test analysis. The data obtained from the pre and posttest results were then analyzed using the N-Gain test, and the improvement of the students' science process skills was 0.43, which means that this was in the medium category. The results of this analysis illustrate that after the application of scientific literacy-based scientific methods to the learning of XI grade physics, the MA Muallimin Muhammadiyah Makassar experienced an increase in science process skills.

As a result, it can be concluded that a series of learning processes using scientific literacy-based scientific methods can improve students' science process skills. This is because the scientific literacy-based method makes students practice to build their concepts and understanding before conducting experiments and then proved by analyzing. Learning that involves students directly creates meaningful learning so that the material is easily accepted by students.

4. Conclusions

Based on the results of the research and discussion, it can be concluded that the results of the descriptive analysis show the science process skills of the XI grade students of MA Muallimin Muhammadiyah Makassar, Indonesia, 2018/2019 academic year before being taught by scientific literacy-based scientific methods with an average score of 8.29. The results of descriptive analysis showed that science process skills of class XI students of MA Muallimin Muhammadiyah Makassar in the academic year 2018/2019 after being taught by scientific literacy-based scientific methods showed an average score of 14.50. The results of inferential analysis (N-Gain) show that physical science process skills of students class XI students of MA Muallimin Muhammadiyah Makassar, Indonesia, in the academic year 2018/2019 on temperature and heat material after learning through science-based scientific method methods increased by 0.43 (medium category). Finally, it can be stated that learning physics with experimental methods can improve students' science process skills. The researchers recommended that the

results of this study provide benefits for practitioners to improve the science process skills of the middle school students through the application of Science Literacy-based Scientific Method.

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