Improving Student Science Literacy Ability Using the Frayer Model Diagram in Class X Global Warming Materials

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Abstract
This research aimed to describe the application of Frayer Diagrams to students' literacy ability in understanding global warming issues. This research applied a pre-experimental design with one group pretest-posttest concept involving 33 students of class X-4 in SMA Negeri 5 Jember. The data of this research were collected from the objective written test which was analyzed by descriptive - quantitative method. The result of this research showed that the average score of science literacy ability of students on the pretest was 30.00, while on the post test was 68.18, with the increasing number of students, literacy ability showed by N-gain value 0.56 which was categorized as medium level. Based on this research, it can be concluded that the application of frayer diagrams can enhance student's literacy ability to understanding global warming issues.

Keywords: Frayer Diagram, Science Literacy, Global Warming.

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INTRODUCTION

21st century education aims to develop students' abilities to deal with changes that occur along with the times [1]. The 21st century is an era of globalization full of challenges. The development of science and technology in various sectors is progressing very rapidly, including in the field of education. Some important skills to be possessed by 21st century students include critical, innovative, creative thinking skills, problem solving skills, collaboration, leadership, communication, and technology literacy. To produce quality human resources and be able to compete, learning is needed that is able to develop these skills [2].

On the other hand, in the 2018 International Assessment Program for students (PISA), conducted by the Organization of Economic Co-operation and Development (OECD), Indonesia showed low results in science. From 2000 to 2018, the highest score for science was 403 points in 2015, which is always below the average score (500). The most recent PISA results were in 2018, where Indonesia earned 396 points which is significantly lower than the average score of the participating countries [2]. PISA is used as global data that can be compared to measure school performance, where countries with better average PISA scores have better school performance. This condition indicates low achievement in science education.

One aspect that is measured in science achievement in PISA is students' scientific literacy. Scientific literacy is a citizen who thinks critically and has the ability to deal with issues related to science and scientific concepts (OECD, 2018). Therefore, people who have good scientific literacy can understand the main conceptualizations and theories that form the basis of scientific and technical thinking, the process of deriving knowledge, and the extent to which theoretical evidence or explanations can justify that knowledge [2].

According to Shwartz et al. scientific literacy is the ability to understand and apply scientific information in practical everyday life [3]. This includes understanding science concepts, the ability to apply scientific knowledge in real-world situations, and the ability to communicate using scientific language and symbols. OECD explains that scientific literacy skills include the ability to use scientific knowledge, identify questions, and make conclusions based on scientific evidence to understand and make decisions about nature and changes caused by human activities [2].

The low score obtained by Indonesia in the 2018 PISA can be an indicator that there are problems in learning science in Indonesia. Afandi et al. states that science teaching needs to invite students to have critical, creative and innovative thinking skills, problem solving skills, communication, leadership, collaboration, and technological literacy [4]. According to Haryani et al. scientific literacy and understanding of scientific concepts are needed to face the digital era [5].

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Science learning, especially physics, is learning that needs to understand concepts and connect them to explain phenomena in real life. So that physics learning must be adapted to the current needs of the 21st century. However, there is an assumption that there is less importance of studying physics by students, so they are not active in the learning process [6]. Another assumption is that students still find it difficult to study physics on global warming due to difficulties in answering questions in the form of problems [7].

Learning strategies are needed to overcome difficulties and inactivity in learning physics. One way that can be done to improve students' scientific literacy skills is to use the Frayer model diagram. The Frayer model diagram is a form of literacy strategy in learning which involves students to be active in the learning process and helps students gain a better understanding of certain concepts or topics. Frayer model diagrams can combine text, images, and consist of definitions, characteristics, examples and non-examples so that students understand the concept more deeply and thoroughly.

Several studies have been conducted to test the effectiveness of using the Frayer model diagram in increasing literacy skills. Alashry et al. found in his research that the application of the Frayer model diagram can increase student motivation [8]. According to Wati and Alimin the use of the Frayer model diagram helps students understand important concepts, extract meaning, solve problems [9]. Rick Wormeli argues that the use of the Frayer model diagram can improve learning outcomes [10]. Meanwhile, Armstrong et al. and Waljinah et al. show that the Frayer model diagram is useful in helping students understand mathematical vocabulary [11-12].

Based on the description above, researchers conducted research with the aim of increasing students' scientific literacy skills using the frayer model diagram. The focus of this research is on global warming material for class X SMA Merdeka curriculum. This study uses indicators of scientific literacy skills such as identification of scientific issues, elaboration of scientific phenomena, and use of scientific evidence, with the aim of describing the scientific literacy skills of class X-5 SMA Negeri 5 Jember in learning global warming material.

**METHOD**

This study used a pre-experimental design with a one group pre-test post-test design. In this design, one experimental group was given a pretest, then given a treatment, and ended with a posttest. In research, the treatment applied is the use of frayer model diagrams in learning on global warming material. This study focuses on the population of class X-5 students at SMA Negeri 5 Jember for the 2022/2023 academic year. In this population 13 male students and 20 female students. Because the research design used was one-group pretest and posttest, this study only used one class as the research subject.

In this study, the instrument used was an objective written test in the format of multiple choice and true-false questions. There are 10 questions covering three indicators of scientific literacy, namely identifying scientific issues, explaining scientific phenomena and using scientific evidence. The test is used to measure students' scientific literacy skills in understanding global warming material. The indicators of scientific literacy questions are presented in **Table 1**.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Question Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify scientific issues</td>
<td>1,2,6,7</td>
</tr>
<tr>
<td>Describe scientific phenomena</td>
<td>8,9,10</td>
</tr>
<tr>
<td>Using scientific evidence</td>
<td>3,4,5</td>
</tr>
</tbody>
</table>

To analyze the scientific literacy test data, a quantitative descriptive approach was used. The analysis process begins by calculating the initial test scores (pretest) and final technical scores (posttest). Then the data were interpreted using N-gain analysis to measure the increase in students' scientific literacy skills. The category of increasing students' scientific literacy skills is determined based on the average gain score normalized by Hake's criteria.

$$ N - Gain = \frac{\text{Score posttest} - \text{Score pretest}}{\text{Score ideal} - \text{Score pretest}} $$

The results of calculating the N-gain values obtained are then interpreted into three Hake categories which are presented in **Table 2**.

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RESULT AND DISCUSSION

The data obtained from the research is data regarding students' scientific literacy abilities as measured through objective written tests. The data includes the results of the pretest, posttest, and N-gain from the class that is the object of research. The pretest results obtained are shown in Table 3.

Table 3 The size of the distribution of pretest score data

<table>
<thead>
<tr>
<th>Data dissemination</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest value</td>
<td>0,00</td>
</tr>
<tr>
<td>The highest score</td>
<td>60,00</td>
</tr>
<tr>
<td>Means</td>
<td>30,00</td>
</tr>
<tr>
<td>Median</td>
<td>30,00</td>
</tr>
<tr>
<td>Mode</td>
<td>30,00</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>13,69</td>
</tr>
</tbody>
</table>

Table 3 illustrates the concentration and distribution of data based on the number of correct answers students got in the pretest. From the results of the pretest, it can be seen that the mean, median, mode scores of students get 30.00, the highest and lowest scores in the pretest are 60.00 and 0.00. Table 3 also illustrates if the standard deviation value is smaller than the mean, which means that the mean value represents the entire data.

From the results of the posttest after being given the treatment, then statistical calculations are carried out, to find out some of the values for the spread of the data in the posttest values which are presented in Table 4.

Table 4 The size of the posttest score data distribution

<table>
<thead>
<tr>
<th>Data dissemination</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest value</td>
<td>40,00</td>
</tr>
<tr>
<td>The highest score</td>
<td>90,00</td>
</tr>
<tr>
<td>Means</td>
<td>68,18</td>
</tr>
<tr>
<td>Median</td>
<td>70,00</td>
</tr>
<tr>
<td>mode</td>
<td>70,00</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>13,10</td>
</tr>
</tbody>
</table>

Table 4 illustrates the value of the center and distribution of the data on the posttest results, namely the mean value of 68.18, the median and mode values of 70.00. While the highest value is 90.00 and the lowest value is 40.00. By paying attention to the standard deviation value, it can be concluded that the mean value represents the entire data.

To increase students' scientific literacy skills on global warming material, the N-gain formula is used, the results of which are presented in Table 5.

Table 5 Average N-gain results

<table>
<thead>
<tr>
<th>Average value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>30,00</td>
</tr>
<tr>
<td>Postest</td>
<td>70,00</td>
</tr>
<tr>
<td>N-gain</td>
<td>0,56</td>
</tr>
</tbody>
</table>

Table 5 shows that there is an increase in the average score on the pretest and posttest. From the average N-gain value of 0.56 obtained, it can be concluded that there is an increase in students' scientific literacy abilities in understanding global warming material in the moderate category. The results of this study also show that it is
suspected that the use of the frayer model diagram can improve students’ scientific literacy skills, as can be seen from the increase in scores on the posttest after the treatment.

Based on the analysis of scientific literacy ability data obtained, there is an increase in the percentage of scientific literacy scores of class X-5 students which are presented in Figure 1.

![Figure 1 Percentage graph of increasing scientific literacy](image1)

**Figure 1 Percentage graph of increasing scientific literacy**

Based Figure 1 it can be seen that after students completed the pre-test and post-test, their scientific literacy skills in terms of N-gain increased. Increasing students’ scientific literacy skills as many as 32 students experienced an increase in scientific literacy skills in the moderate category, with a percentage of 97%. While 1 student experienced an increase in the high category scientific literacy score with a percentage of 3%. Based on the data obtained, it shows that before applying the use of the frayer model diagram, the mean score of the pretest results in class X-5 was 30.00. After applying the use of the frayer model diagram, the average scientific literacy score is in the range of 68.18. The following is a diagram of the analysis of scientific literacy indicators obtained from the N-gain score presented in Figure 2.

![Figure 2 Graph of N-Gain scores for Students' Scientific Literacy Indicators (Identifying Scientific Issues (ISI), Describing Scientific Phenomena (DSP), Using Scientific Evidence (USE))](image2)

**Figure 2 Graph of N-Gain scores for Students’ Scientific Literacy Indicators (Identifying Scientific Issues (ISI), Describing Scientific Phenomena (DSP), Using Scientific Evidence (USE))**

Figure 2 shows that the acquisition of the N-Gain score on the scientific literacy indicator related to identifying scientific issues is 0.68. These results provide information that students can identify scientific issues related to global warming material in the moderate category. In the scientific literacy indicator describing scientific phenomena and using scientific evidence each gets an N-gain value of 0.58 and 0.42 which is categorized as moderate. This indicator
means that students have the capability to make decisions regarding issues related to global warming. From these three competencies it can be concluded that even though the increase in scientific literacy scores in students is classified as in the moderate category, they show progress in these competencies.

This research is in line with the research of Davey et al. that the frayer model diagram can increase scientific literacy [13]. Yuricki et al. also explains that the frayer model diagram builds conceptual understanding of the vocabulary learned by students [14]. Meanwhile, Alashry et al. in his research explained that the frayer model diagram can improve the learning process [8].

Based on the N-gain value scale, students' scientific literacy skills in this study have increased, but are still classified as in the medium category and have not yet reached the high category. This is because in learning there are still some obstacles encountered including limited treatment, because learning is carried out in two meetings with two hours of lessons. So that there are limitations for students to discuss further about global warming material. Another obstacle is that researchers are less than optimal in mapping the needs and characteristics of student learning so that they are less than optimal in meeting the needs and characteristics of student learning. Based on this analysis, students' scientific literacy skills in describing scientific phenomena and using scientific evidence are still not optimal. In addition, students are still not used to the new way of learning, namely discussion and tend to be used to the old way of learning, which depends on the information provided by the teacher.

CONCLUSION

The results of this study concluded that the use of the frayer model diagram provides an increase in scientific literacy skills in studying global warming material in the moderate category. Improving students' scientific literacy skills based on the three scientific literacy competencies, namely identifying scientific phenomena and using scientific evidence. The results of the three scientific literacy competencies obtained an average N-gain score of 0.56.

Based on the research that has been conducted in class X-5 SMA Negeri 5 Jember and the research results obtained, the researcher would like to suggest for further research that the use of the frayer model diagram can be tested with an experimental design to ensure an increase in the frayer model diagram on students' scientific literacy abilities in the three competencies described above. In future research, the use of the frayer model diagram can also be applied to other physics materials to improve students' scientific literacy skills in studying physics.

REFERENCES


Author declaration
Author contributions and responsibilities
The authors made major contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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Availability of data and materials
All data is available from the author.

Competing interests
The authors declare no competing interests.