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Analysis of Scientific Literacy of Senior High School Students in Relation to Global Warming as a Socio-Scientific Issue

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Abstract

The low scientific literacy skills of Indonesian students should be a serious concern for all science educators. Scientific literacy skills can be improved in contextual learning related to nature and social contexts that occur in the environment around students. This study aims to develop the science literacy of high school students through the application of Problem Based Learning model on the topic of global warming. This study used a quantitative approach with descriptive methods, with participants of 24 students in one of the high schools in Bandung City. The research instrument used is a science literacy test question in the form of descriptions, which consists of 3 domains, namely context, content, and science competence, in addition, student handouts is also used to provide an overview of the PBL learning process containing the applied science literacy. The result shows students performed Moderately in three PISA-based competencies including (i) explaining scientific phenomena, (ii) evaluating and designing scientific investigations, and (iii) analyzing evidence and data scientifically for decision-making and action.

Keywords: global warming; problem based learning; scientific literacy

Abstrak

Rendahnya kemampuan literasi sains siswa Indonesia patut menjadi perhatian serius bagi seluruh pendidik sains. Keterampilan literasi sains dapat ditingkatkan dalam pembelajaran kontekstual terkait alam dan konteks sosial yang terjadi di lingkungan sekitar siswa. Penelitian ini bertujuan untuk mengembangkan literasi sains siswa SMA melalui penerapan model Problem Based Learning pada topik pemanasan global. Penelitian ini menggunakan pendekatan kuantitatif dengan metode deskriptif, dengan partisipan sebanyak 24 siswa di salah satu SMA di Kota Bandung. Instrumen penelitian yang digunakan adalah soal tes literasi sains berbentuk uraian yang terdiri dari 3 ranah yaitu konteks, isi, dan kompetensi sains, selain itu handout siswa juga digunakan untuk memberikan gambaran proses pembelajaran PBL yang berisi tentang literasi sains terapan. Hasilnya menunjukkan siswa berprestasi Sedang dalam tiga kompetensi berbasis PISA termasuk (i) menjelaskan fenomena ilmiah, (ii) mengevaluasi dan merancang penyelidikan ilmiah, dan (iii) menganalisis bukti dan data secara ilmiah untuk pengambilan keputusan dan tindakan.

Keywords: literasi sains; pemanasan global; problem based learning

Introduction

Science and technology have developed rapidly in recent decades. These developments not only have a positive impact but also a negative impact on human life. This needs to be balanced with adequate intellectual abilities and skills to be able to overcome the various impacts caused. The role of education today must be focused on developing learners' skills to be able to adapt and overcome various problems that will arise in the future using science (Dragoş & Mih, 2015). One of the skills needed by learners is literacy skills.

Science literacy according to PISA in Tuttle, et al. (2023) is the ability to (i) explain scientific phenomena, (ii) evaluate and design scientific investigations, and (iii) analyze evidence and data scientifically for decision making and action. Learners' science literacy skills can be improved in contextual learning related to the natural and social context that occurs in the environment around learners. Educators need to present real situations that students will face so that students can apply knowledge to solve global threats (Solikhah & Pertiwi, 2021; Lestari & Setyarsih, 2020).

In relation to science literacy, creating lessons that incorporate discussion of Socio-scientific issues (SSIs) relating to science and real and potential industrial applications of science and technology can be one way to increase learner motivation in science education, which is increasingly seen as an important component of science education (Eilks, Nielsen, & Hofstein, 2014). SSI covers a large number of real-world problems involving debated environmental issues such as global warming, climate change, greenhouse effect, ozone depletion, environmental pollution, waste disposal, nuclear or hydroelectric power generation, alternative energy fuels. Mamlok-Naaman et al. (2015) stated that many chemistry-related issues of sustainable development such as traditional or alternative fuels, bioplastics, climate change and others meet the SSI criteria. These criteria are authenticity, relevance, evaluation, allowing open discussion, answering questions based on science and technology (Stolz, Witteck, Marks, & Eilks, 2013).

The selection of daily life contexts such as chemistry and technology should be authentic and relevant to learners' lives. It is assumed that a context-based curriculum, i.e., environmental context, can increase learners' interest and attitude towards science lessons in general and chemistry in particular (Lee & Erdogan, 2007; Osborne et al., 1998).

To date, no studies have investigated which contexts are most effective in teaching specific chemistry concepts. According to a study that investigated most of the content for developmental chemistry courses in environmental contexts (Robelia et al., 2010), environmental topics will spur learners to learn more chemistry and will change their attitudes to be more pro-environment.

SSI-based education is one of the ideal ways to teach controversial environmental issues because these issues are challenging and cannot be solved by a simple understanding of science. With SSI-based education, individuals have the opportunity to discover complex problems, discuss various solutions, and improve and justify their own perspectives on environmental issues (Koculu & Topcu, 2021).

In the environmental context, global scientific studies on climate change have increased, and many academics are interested in this social science topic. In addition to being a social issue and a hot topic for research, climate change is an important subject for the curriculum in schools. The concept of "climate change" exists in many disciplines, especially chemistry. Three important topics in chemistry are greenhouse gases, acid precipitation and the ozone layer. Learners will be better able to understand climate change if they have a thorough understanding of the nature of matter as particles and the processes that occur within specific elemental compounds. Chemistry is a basic science that is needed by mankind, and is crucial in solving problems related to climate change (Wan, Ding, & Yu, 2023).

Global Warming is the impact of climate change (Wunderling et al., 2021).

Global warming is one of the major threats to humanity today. Global warming and climate change can be used as socio-scientific issues that can bridge students to improve their science literacy skills (Widiyawati, 2020). Socio-scientific issues can stimulate students' awareness of real problems so as to raise awareness and a sense of responsibility to solve these problems. (Permanasari et al., 2020). Even so, researchers found that knowledge, awareness, and desire to make changes still varied quite a lot, even the 'activist' group was not very knowledgeable about this global warming issue (climate change in general) (Oliver & Adkins, 2020). Therefore, this issue still needs to be addressed to provide students with science literacy skills that will make them not only knowledgeable but aware and want to change the fate of the problem.

Sutrisna (2021) stated that Indonesia has always ranked in the lowest 10 since participating in PISA in 2000 until 2018. The latest results of the PISA study in 2022 show that Indonesia's average science literacy score decreased to 383 points despite an increase in rank by 5-6 positions. This shows that efforts still need to be made to improve students' science literacy skills (Widi, 2023).

There are several factors that cause the low science literacy of students in Indonesia. Internal factors such as students' lack of interest in reading and inability to understand science literacy questions that require analytical understanding can be the cause. In addition, there are also external factors such as the lack of teacher understanding of science literacy so that the learning process and assessments given to students are not in accordance with the principles stated in the science literacy framework (Sutrisna, 2021). Utama (2019) added another factor, namely the family environment, where communication between students and parents on environmental and social issues, parental education, and parental support in developing students' achievements will also affect the level of students' science literacy.

As previously described, learners' science literacy skills are also related to learning activities and assessments designed by teachers. Teachers need to design and design appropriate learning processes to develop science literacy. In this case, the selection of learning models as the main thing in determining the framework of students' activities during learning activities is an important thing to note. One of the models that is considered appropriate for science literacy learning is the Problem Based Learning (PBL) model. Utami (2022) explains that PBL focuses on the problem-solving ability of students through scientific data collection and analysis skills. The problem chosen must certainly be relevant and real in the daily lives of students. If we relate the definition of the PBL model to how science literacy was defined at the beginning, there is correspondence between the science literacy framework and the PBL model.

Several studies have been conducted to assess and analyze the science literacy skills of students in Indonesia. Wardi et al. (2023) analyzed the science literacy competency profile of high school students on atomic nucleus and radioactivity material. Utami, et al. (2022) examined the science literacy skills of students using PBL learning on excretory system material. Usman et al. (2018) also conducted a similar study using an inquiry learning model on electrolyte and non-electrolyte solution material for class X SMA. Haruna et al. (2023) also conducted a similar study, namely examining the science literacy skills of students on covid-19 pandemic virus material. The results of these studies still show that students' scientific literacy is still low and efforts need to be made to improve it.

Based on the above explanation, the purpose of this study is to develop the science literacy of high school students through the application of the PBL model on the topic of global warming. Learning and assessment are designed in accordance with the PBL model and aligned with aspects of science literacy. After the learning activities are carried out and then the assessment is

carried out, the assessment results are used to describe the profile of students' science literacy skills.

Method

This research was conducted in the odd semester of the 2023/2024 academic year at one of the high schools in Bandung City. The sampling technique used convenient sampling, namely taking 1 class of students from class X-3 as many as 22 people. The research instrument used is a science literacy test question in the form of a description, which consists of 3 domains of science literacy, namely context, content and science competence. Guiding questions in the LKPD include science literacy domains that combine context, content, competence and science identity.

Students' science literacy skills were measured using test instruments that had been validated and tested for reliability. The data analysis technique uses quantitative descriptive analysis with the calculation of science literacy scores. After calculating the science literacy score, then categorizing the test results of students using categories adapted from Djaali (2023).

$$SLS = \frac{S}{S\ Max} x\ 100\%$$

Descriptions:
$SLS = Scientific\ Literacy\ Score$
$S = Score$
$S\ Max = Maximum\ Score$

Assessment and categorization are carried out on the results of LKPD and test results. The test results in the form of individual student science literacy achievements are then translated as mastery for each indicator of learning outcomes.

Table 1
Criteria for Assessing Students' Scientific Literacy Abilities

Interval (%)	Criteria
86-100	Very High
72-85	High
58-71	Medium
43-57	Poor
0-42	Very Poor

Result and Discussion

In the early stages of the research, the assessment was carried out on the LKPD which contained content directed by questions covering a combination of four domains of science literacy namely context, knowledge, competence, and science identity listed in the PISA framework (2023) as follows.

Table 2
Scientific Literacy Grid in Students' Worksheet

Question Number	Competencies
2, 3, 4, 5, 6, 7, 8, 9, 10	Explain phenomena scientifically
11,12	Evaluate and design scientific investigations
	Interpret data and eveidence scientifically decision-making and action

In the science context domain, one context is used, namely environmental impacts and climate change (environmental problems caused by global warming), while for the science identity domain, science identity is used in the form of recognition by oneself and others of one's competence to engage with science-related phenomena. For

the science knowledge domain, three science knowledge are used, namely content, procedural, and epistemic. In the science competency domain, three competencies were used, namely (i) explaining scientific phenomena, (ii) evaluating and designing scientific investigations, and (iii) analyzing evidence and data scientifically.

Table 3
Group Worksheet Score

Group	*Percentage (%)*	*Criteria*
1	90	Very High
2	79	High
3	88	Very High
4	83	High
5	90	Very High
Avg.	*86*	*Very High*

Table 3 shows that in general the acquisition of group scores in working on LKPD is in the value range of 79-90. The criteria for students' science literacy scores can be explained that the scores of groups 1, 3, and 5 are in the 86-100 score range so that they are included in the very high category; while the scores of groups 2 and 4 are in the 72-85 score range so that they are included in the high category. This can be evidence that the LKPD developed has directed students to achieve science literacy learning indicators.

Of the 11 questions tested, the knowledge domain is spread into content knowledge as many as 4 questions, procedural knowledge as many as 5 questions, and epistemic knowledge as many as 2 questions. As for the distribution of the science competency domain, namely (i) the competence to explain phenomena scientifically as many as 4 questions, and (ii) the competence to research, evaluate, and (iii) use scientific information for decision making and action as many as 7 questions. The context domain used for all questions is only 1 context, namely the context of the dangers of climate change due to global warming.

Tabel 4
Scientific literacy grid in Global Warming Sumative Assessment

Question Number	Competencies	Context	Question Number	Knowledge
1, 2, 4a, 4b	Explain phenomena scientifically	Global Warning	1, 2, 4a, 4b,	Content
3, 5, 6a, 6b, 7a, 7b, 8	Evaluate and design scientific investigations		5, 6a, 6b, 7a, 7b,	Procedural
	Interpret data and eveidence scientifically for decision-making and action		3, 8	Epistemic

Before being used to test students' science literacy skills, the test instrument was first tested for validity and reliability. The results of the validity test obtained that question no.1 was invalid, while the other questions were declared valid. Therefore, question number 1 was discarded and not used to measure students' science literacy skills. As for the results of the reliability test, it was found that the reliability value of the test instrument questions was 0.81 and included in the category of very high reliability values in accordance with the reliability value category in Arikunto (2021).

The acquisition of science literacy test scores from students is then analyzed to determine the extent to which students can master science literacy competencies and science content. The test results that have been carried out can be seen in Table 5 below.

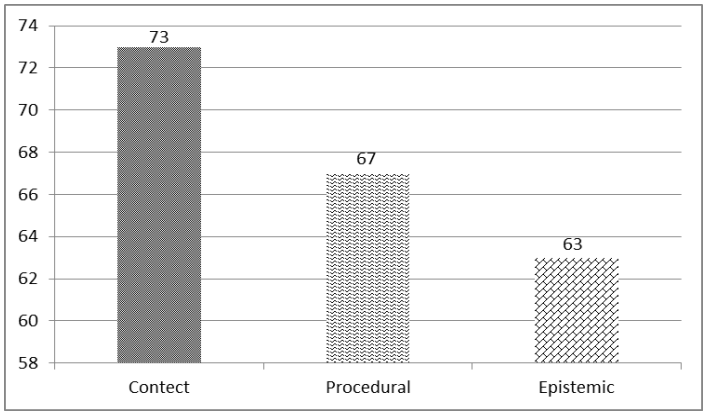
Table 5
Scientific Literacy Competencies Average Score in Global Warming Sumative Assessment

Competencies	Avg. Score (%)	Criteria
Explain phenomena scientifically	74	Medium
Evaluate and design scientific investigations		Medium
Interpret data and evidence scientifically decision-making and action	64	Medium

From Table 5, it is known that the ability of students to master the competency of explaining scientific phenomena is in the score range of 72 - 85 or in the high category. Meanwhile, the value of mastery of the competencies of researching, evaluating, and using scientific information for decision making and action is in the value range of 58 - 71 or in the medium category. This means that the ability of students in the competence of explaining scientific phenomena is better than the competence of researching, evaluating, and using scientific information for decision making and action. According to Wardi, et al. (2023) the low ability of students in the competence of researching, evaluating, and using scientific information for decision making and action can occur because students do not yet have the ability to interpret and draw an appropriate conclusion from data, information presented to be used in decision making or action.

The same thing happened in the research conducted on climate change learning. After learning, students experienced a significant increase in content knowledge. However, not the ability to make decisions or take action. Therefore, learning should focus not only on the scientific explanation of a phenomenon but also on mitigating or solving the problem after understanding it (Tolppanen et al., 2022).

Figure 1
Graph of Learners' Knowledge Domain



From Figure 1, it is known that the ability of students to master content knowledge is in the 72-85 score range or in the high category. Meanwhile, mastery in procedural knowledge is in the value range of 58-71 or in the medium category. The lowest category is in the mastery of epistemic knowledge, which is in the range of scores 43-77 or in the low category. This means that students' abilities in content knowledge are better than mastery in procedural and epistemic knowledge. This

can occur because the questions given only cover the content knowledge domain so that other domains have juxtaposed values.

Research conducted by Utama et al. (2019) in which the average acquisition of students' science literacy scores only reached 50% and was included in the low category. In the study, students were immediately given a science literacy test without being given a stimulus in learning activities or the use of an appropriate model. Different research was conducted by Utami, et al. (2022) who used the PBL learning model in developing students' science literacy skills. The results showed that after experiencing PBL-based learning, the ability of students can increase significantly seen from the increase in post-test scores when compared to the pretest scores tested on students. This shows that the use of PBL models can improve science literacy skills quite effectively. Providing leading questions in LKPD based on PBL models that are aligned with the science literacy domain of students can be an effective stimulus in familiarizing students with understanding science literacy questions.

Although in this study it was started with PBL learning activities integrated with the four domains of science literacy, it was not able to show good results in improving the ability of procedural and epistemic knowledge. This shows that the ability of students at this level needs to be trained continuously. Efforts that can be made are to present learning activities that emphasize procedural knowledge such as the ability of students to interpret scientific data and information, both in the form of tables or graphs and emphasize epistemic knowledge such as the ability of students to use their various knowledge to present solutions to various problems that occur in everyday life and provide an even composition of tasks in each competency and knowledge domain of science literacy.

Conclusion

The science literacy ability of 22 students in one of the high schools in Bandung Regency after carrying out learning and testing using a question instrument on global warming has a Moderate category in three competencies based on PISA including (i) explaining scientific phenomena, (ii) evaluating and designing scientific investigations, and (iii) analyzing evidence and data scientifically for decision making and action.

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