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Analysis of Students' Science Literacy Ability Profiles Viewed on Competency Aspect Indicators in Science Learning Environmental Pollution Material

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Abstract: The twenty-first century is marked by rapid transformations driven by advances in science and technology, which significantly influence human competition and global development. In this era, science literacy has become one of the 16 essential skills identified by the World Economic Forum as crucial competencies for students. Science literacy is defined as the ability to apply scientific knowledge, identify questions, and draw conclusions based on evidence to understand natural phenomena and make informed decisions about the impact of human activities on the environment. This study employed a quantitative descriptive research method aimed at analyzing the profile of students' science literacy skills based on competency indicators in learning environmental pollution material. The research subjects consisted of 64 students from two classes. Data collection was conducted using a test instrument based on OECD science literacy competencies, which included five indicators with a total of ten questions. The findings revealed that the highest average achievement was in identifying questions within scientific investigations, reaching 73.96%. In contrast, the lowest achievement was in transforming data between representations, with 50.45%. Overall, the average score across all indicators was 60.91%, categorized as moderate level.

Keywords: twenty-first century, science literacy, environmental pollution

Introduction

Education is now in the 21st century phase, known as the era of the industrial revolution 4.0, characterized by the rapid development of science and technology. Education in the 21st century aims to encourage learners to have skills that support them to be responsive to technological changes along with the times. The twenty-first century is a time of transformation, where rapid advances in science and technology affect competition in human life (Muliastrini, 2020; Pratiwi et al, 2019). A good education system can influence the future progress of a country, and the success of the system depends on the learning process implemented by each country (Egan et al. 2017). With this paradigm shift, teachers face the challenge of creating a learning process that matches the characteristics of 21st century education (Rahayu et al, 2022; Yuliati 2017).

A good education system can influence the future progress of a country, and the success of the system depends on the learning process implemented by each country (Egan et al, 2017). Science is a subject that can consider students' roles in society and daily life activities (Mason, 2017). Science literacy is defined as the ability of students to understand scientific facts that exist in their environment, use technology, and apply the knowledge they have learned to solve problems related to their environment. (Kristyowati & Purwanto, 2019; Yuliati, 2017). Science literacy is one of 16 additional skills identified by the World Economic Forum as competencies required by students in the 21st century (Council, 2012). According to PISA (Programme for International Student Assessment), science literacy is defined as the ability to understand science concepts and processes and utilize them to solve problems in everyday life. Science literacy is also defined as the

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ability to use science knowledge, identify questions, and make inferences based on scientific evidence in order to understand and make decisions about how nature and its changes are affected by human activities (OECD, 2016).

Science literacy consists of four dimensions: science competence/process, science knowledge/content, science application context, and science attitude. Science competence consists of three dimensions: explaining scientific phenomena, evaluating and designing scientific research, and interpreting scientific data and evidence. Content, procedural and epistemic knowledge are components of science knowledge. Health and disease, natural resources, environmental quality, hazards, and advances in science and technology are all examples of science application contexts. However, science attitudes refer to using scientific concepts and methods in life, pursuing a career in science, and expanding science knowledge (OECD, 2017).

The PISA study conducted every three years by the Organisation for Economic Cooperation and Development (OECD) assesses the science literacy of 15-year-old students. The study evaluates students' skills and knowledge in math, reading, and science. Since 2000, Indonesia has participated in the PISA study. However, the results from 2000 to 2018 show that the science literacy skills of Indonesian students are still below the OECD average, which is around 489–500 points. Indonesia's average score in 2018 was approximately 396, indicating a significant gap of nearly 100 points compared to the OECD average. This gap reflects that many Indonesian students still struggle to apply scientific concepts, interpret data, and solve real-world problems based on scientific evidence. In 2015, Indonesia ranked 62 out of 70 participating countries; then, in 2018, Indonesia ranked 70 out of 78 participating countries (OECD, 2019). When compared to several ASEAN countries such as Singapore and Vietnam, Indonesia's performance is also relatively lower, indicating the need for improvement in science learning quality.

Research shows that learning activities that do not focus on improving science literacy are the main cause of students' low science literacy skills in Indonesia (Kurnia et al., 2014; Ni'mah et al., 2017; Fauziah et al., 2019). Several studies have found that the curriculum and education system, the choice of teaching methods and models by teachers, human resources, minimal use of learning media, monotonous selection of teaching materials, and school management are all factors that contribute to the low science literacy skills of students in Indonesia (Lendeon & Poluakan, 2022; Kimianti & Prasetyo, 2019). The tendency of science learning is now only oriented towards science as a product. This can be seen from the number of students who learn science only by memorizing concepts, principles, laws, and theories of science (Trimawati et al., 2020). As a result, the dimensions of attitude, process, and application cannot be received by students optimally (Depdiknas, 2011). Therefore, many adjustments are needed in the learning process.

The material tested in this study is environmental pollution. In the learning outcomes released by the Ministry of Education and Culture in 2022 in the independent curriculum, environmental pollution is included in a series of learning outcomes stating that "students identify interactions between living things and their environment, and can design efforts to prevent and overcome pollution and climate change". Environmental pollution material covers problems that occur in the surrounding environment, including types of water, air, and soil pollution. It impacts the ecosystem and involves learners in identifying pollution in their environment, making efforts to prevent it, and presenting the results of data analysis from observations. The urgency of choosing environmental pollution material is because it is closely related to science, the environment, and students' daily activities, which are in line with improving students' science literacy skills. Currently, environmental pollution is a real problem that requires scientific problem solving. Therefore, it is very important for students to learn about the importance of maintaining a healthy environment from an early age (Afriana et al., 2016).

The previously mentioned problems were also found in SMPN 9 Gresik, East Java. Based on interviews with students, it was found that this happened because the subject matter was not taught in a way that supported science literacy skills, students were not used to working on problems that involved discourse, and the learning process did not support science literacy skills. In addition, students have a lower level of learning difficulty than other students. The results of interviews with teachers at SMPN 9 Gresik show that teachers face challenges to teach students independently and actively in learning activities because students are accustomed to the material being given directly, which results in students being less active to learn for themselves, students' inability to answer questions that demand analytical skills is shown by their inability to relate one concept to other concepts they have learned. Because the evaluation questions given by teachers are not aimed at measuring students' science literacy skills, but only to measure students' knowledge of the material studied, students' science literacy skills and the factors that influence them are unknown. It is recognized that there is not enough data or information about the science literacy skills of SMPN 9 Gresik students based on the problems mentioned above. Based on the problems that have been explained, the purpose of this research is to

analyze the profile of students' science literacy skills in terms of indicators of competency aspects in learning science on environmental pollution material.

Method

Time and location of the research

This research was conducted using a quantitative descriptive research method which aims to analyze the profile of students' science literacy skills in terms of indicators of competency aspects in learning science material on environmental pollution. The research subjects were students of class VII C and VII D, each of which amounted to 32 students so that the total number of respondents was 64 students.

Research Stages

The data collection technique used a test form with a science literacy instrument based on the OECD (2019) in terms of competency aspects that tested 5 indicators presented in Table 1 below, and each indicator contained 2 questions so that the total number of questions was 10.

Tabel 1. Indicators of Competency Aspects

Competency Aspect	Indicator
Explaining Scientific Phenomena	- Recall and apply appropriate science knowledge
Evaluating and Designing Scientific Inquiry	- Identify questions explored in a given scientific study - Describe and evaluate the various methods used by scientists to ensure data reliability and objectivity along with general explanations.
Interpreting Scientific Data and Evidence	- Transforming data from one representation to another - Analyze, interpret data, and draw appropriate conclusions

(OECD, 2019)

Data Analysis

The data analysis technique used is in the form of a test by adding up the scores of each question. The score obtained on each number will vary based on the type of question and indicator, then calculate how many total scores are obtained then divided by the maximum score and multiplied by 100, so that the maximum score that each student can get is 100.

$$Score = \frac{total\ score\ obtained}{maximum\ score} \times 100 \quad (1)$$

The analysis of students' science literacy skills is reviewed from the scores obtained by students from the test results that have been carried out. The results of students' science literacy ability scores are then categorized based on the criteria in Table 2.

Tabel 2. Science Literacy Categories

Score Interval	Category
86 - 100	Very High
76 – 86	High
60 – 75	Mediium
55 – 59	Low
≤ 54	Very Low

(Purwanto, 2019)

The research flowchart is presented as follows to provide a clear and systematic overview of the stages and procedures carried out in this study.

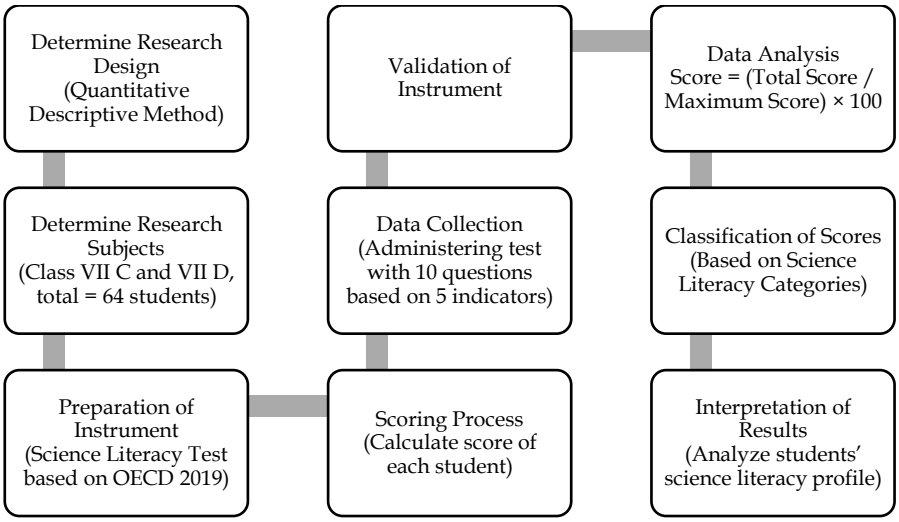

Figure 1. Research flowchart

Result and Discussion

Table 3 shows that of the ten questions tested to students, different categories were obtained for each indicator of science literacy skills. Based on the research that has been conducted, the overall level of science literacy skills of SMPN 09 Gresik students in the science subject of environmental pollution material is included in the moderate category with a percentage of 60.91%. The highest percentage is in the indicator of identifying questions explored in the given scientific study which is 73.96%, and the lowest percentage is in the indicator of converting data from one representation to another which is 50.45%.

The average score obtained by students in the "medium" category is because today's learning does not focus on improving students' science literacy skills. In line with research conducted by Nurdin (2019) that students' interest in reading science and applying the knowledge they have gained in their daily lives is very low. Students cannot collaborate the knowledge gained at school with the latest scientific developments, even students consider the abilities that have been obtained at school to be sufficient so there is no need to learn the pattern of today's developments. Apart from the students' point of view, the selection of curriculum and education system, teaching methods and models by teachers, human resources, minimal use of learning media, selection of monotonous teaching materials, and school management also contribute to the low science literacy skills of students. This is in line with research by Ardianto dan Rubini (2016) which states that the use of multimedia in the learning process can motivate students in learning, students can get material that cannot be seen directly in the classroom, for example the process of environmental pollution due to human activities, and the impact of pollution on the environment in the long term.

Table 3. Results of Science Literacy Ability for Each Indicator

Competency Aspect	Science Literacy Skill Indicator	Question No	Percent age	Average	Category
Explaining Scientific Phenomena	Recall and apply appropriate science knowledge	1	68.44%	69.22%	Medium
		6	70.00%		
Evaluating and Designing Scientific Inquiry	Identify questions explored in a given scientific study	2	69.27%	73.96%	Medium
		7	78.65%		
	Describe and evaluate the various methods used by scientists to ensure data reliability and objectivity along with general explanations.	3	57.29%	56.38%	Low
			55.47%		
		8			
Interpreting Scientific Data and Evidence	Transforming data from one representation to another	4	50.89%	50.45%	Very Low
		9	50.00%		
	Analyze, interpret data, and draw appropriate conclusions	5	55.73%	54.56%	Low
		10	53.39%		
	Average			60.91%	Medium

Explaining scientific phenomena is the ability to recognize, offer and assess explanations of various natural and technological phenomena, while evaluating and designing scientific discoveries is describing and assessing scientific investigations and proposing ways to answer questions scientifically. The highest percentage was found in the indicator of identifying questions explored in a given scientific study, which amounted to 73.96% and in general in the competency aspects of explaining scientific phenomena and evaluating and designing scientific investigations. In line with research Rosidi (2021) shows that the ability of science literacy in the competency aspect is dominated by the aspect of explaining scientific phenomena, namely 45.09%. This shows that students' abilities have only mastered at the level of remembering and explaining. This factor is caused by the learning process which still focuses on the process of memorizing and remembering (Salmi et al, 2023; Hendri, 2020; Ryen, 2020). Therefore, the process of meaningful learning is very important to be taught so that students do not just memorize concepts and generalize the knowledge gained into cognitive structures. Thus, meaningful learning is able to process new information in the mind and associate it with previously obtained information (Raharjo, 2023). The tendency of science learning is now only oriented towards science as a product. This can be seen from the number of students who learn science only by memorizing concepts, principles, laws, and theories of science (Trimawati et al. 2020). As a result, the dimensions of attitude, process, and application cannot be received by students optimally (Depdiknas, 2011).

In the last competency aspect, namely interpreting data and evidence scientifically, namely examining and evaluating scientific data, claims, and giving opinions in various representations and drawing conclusions appropriately. This aspect is divided into 2 indicators of science literacy skills, namely converting data from one

representation to another; and analyzing, interpreting data, and drawing appropriate conclusions. The lowest percentage was in the indicator of converting data from one representation to another, which was 50.45% with a very low category; and analyzing, interpreting data, and drawing appropriate conclusions of 54.56% with a low category. In line with research conducted by Permatasari (2022) that in the competency aspect, namely interpreting data and evidence scientifically in the indicators mentioned above, the percentages are 30.77% and 15.38%, respectively. This shows that the subject matter is not taught in a way that supports science literacy skills, students are not accustomed to working on problems that involve discourse, and the learning process does not support science literacy skills (Schildkamp, 2019). In addition, learning outcomes can not only be assessed through cognitive tests, but the process is also a result of learning. Critical thinking learning models, science literacy-based question instruments, and learner- centered learning can improve students' science literacy skills, discovery-based LKPD (student worksheets) can also improve students' process skills (Molloy et al, 2020).

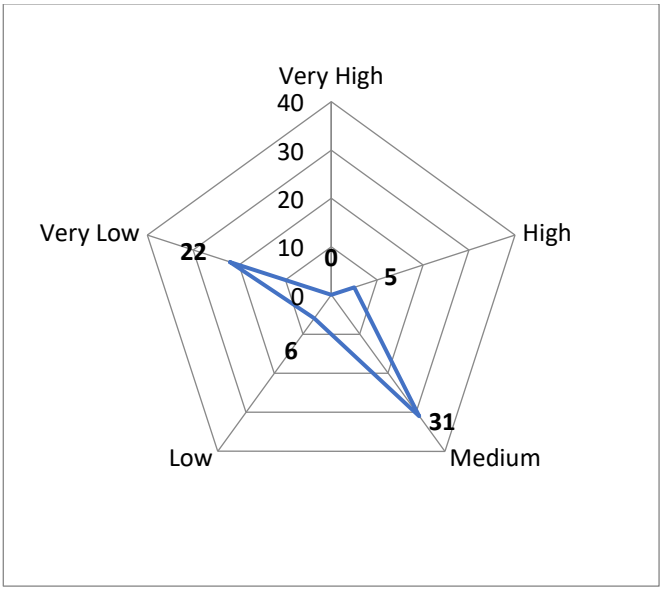

Figure 1. Profile of Students' Science Literacy Ability in Review of Competency Aspect Indicators

Based on Figure 1, it shows that the category of students' science literacy skills in terms of competencies that have been tested on a total of 64 students shows 31 students are in the medium science literacy category, 22 students are in the very low category, 6 students are in the low category, and the remaining 5 students are in the high category. Students who got a very high science literacy category amounted to 0. This shows that students are not familiar with the questions tested in the form of science literacy. Students who have science literacy skills must have knowledge and relate to the community around their environment, ethics in learning, understanding of science in everyday life.

Students' science literacy skills are very important. The ability to understand science concepts and applications in real life is called science literacy. Students who have science literacy will be able to solve existing problems because they not only understand the concepts but also understand how their knowledge can be applied in real life (Powell et al, 2019). Students' low science literacy test results indicate that science learning is not meaningful (Du & Wong, 2019). Teachers should encourage students and create learning strategies that suit students' potential and conditions.

Natural science learning is a type of learning that connects the ideas learned to students' daily lives. Achievement in science that includes the application of basic principles of science knowledge is defined as science achievement. Utilizing technology is very important to increase interest in learning science (Nita et al, 2023). This technology will help teachers explain science concepts contextually so that students can understand physical science found in everyday life. In addition, technology can also assist scientific inquiry in improving science learning (Aryadoust & Ang, 2021; Lutfi & Hidayah, 2021). Technology and scientific research are closely related to each other. One of the weaknesses of students in assessing science literacy competencies is the lack of experience with PISA equivalent question types. In addition to the experience factor with PISA equivalent question types, lack of knowledge of terms, inability to use scientific concepts, inability to make predictions, inability to recognize questions, lack of learning facilities, and lack of motivation to learn (Sirén & Sulkunen, 2023; Lutfi et al, 2019).

School internal and external factors are the two factors responsible for students' low science literacy skills. Internal factors cause students to lack in counting and reading. Many students still have difficulty reading and counting (Lutfiyah & Zakiyanita, 2023; Raharjo et al, 2023; Marc & Morrain, 2019). This has an impact on the teaching and learning process, especially in science lessons. Schools also still lack supporting media that can be used by teachers for learning practicum. In addition, there are very few teaching materials used by students. Science literacy-based educational materials can be developed by incorporating questions related to science literacy into reading books (Illøkken et al, 2022; Putri & Rachmadiarti, 2022).

In addition to internal school factors, external factors also affect students' ability in science literacy. Students' science literacy skills are influenced by their parents' education. Highly educated parents have a very good understanding of what children need to learn, how

to provide facilities, and help children learn at home (Lau et al, 2021; Kähler et al, 2020). School status factors can also affect their ability to understand information accurately. School status is influenced by admission selection. Most students who have potential will go to schools with good status, while students who are not selected in the admission selection at schools with status will go to schools in remote areas. As a result, schools in remote areas cannot be compared with high-status schools (Sletten et al, 2023; Hartati, 2022; Abu Bakar et al, 2020).

Another factor that affects students' science literacy skills is the learning process that focuses too much on textbooks and using textbooks as learning resources. Using learning resources with content that is in accordance with science literacy indicators can improve students' science literacy skills (Khayati & Raharjo, 2020). Influential factors include not understanding the lesson concept correctly or having misconceptions about the subject matter or question. Misconceptions in reading questions affect the understanding of answering questions, while misconceptions with the material can make students lost with the concept of science for a long time (Zetterqvist & Bach, 2023; Omarchevska et al, 2022). Non-contextualized subject matter also makes it difficult for students to understand the material. Learning that links science concepts with information from everyday life is called contextual learning. Contextual learning will make it easier for students to understand the teacher's material, including exam questions. Contextual learning can be applied with learning materials that contain text, visuals and audiovisuals (Toropova et al, 2021; König et al, 2020). The utilization of visual and audiovisual texts is still included in the definition of literacy.

Conclusion

This research was conducted using quantitative descriptive research method which aims to analyze the profile of students' science literacy skills in terms of competency aspect indicators in learning science material on environmental pollution. The data collection technique used a test form with a science literacy instrument in terms of competency aspects that tested 5 indicators and tested on 64 students. In the indicators tested, the highest average success obtained was in the indicator of identifying questions explored in a given scientific study with a percentage of 73.96%, and the lowest indicator obtained in converting data from one representation to another with a percentage of 50.45%. The average of all indicators tested obtained a total percentage of 60.91% with a moderate category. The category of students' science literacy skills in terms of competencies that have been tested on a total of 64 students shows 31 students are in the medium science literacy category, 22 students are in the very low category, 6 students are in the low category, and the remaining 5 students are in the high category.

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Conceptualization, D.I and R.; methodologi, R and A.L.; formal analysis, D.I and R.; resource, A.L.; writing-original draft preparation, D.I and A.L.; All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest

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