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Analysis of Students' Scientific Literacy on Work and Energy as Well as Momentum and Impulse

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Abstract: The importance of scientific skills in the future and Indonesia's low ranking internationally have not escaped the government's attention, as evidenced by the existence of the National Literacy Movement Program. In this regard, a study was conducted which aimed to describe data on students' initial abilities in scientific literacy in the material of work and energy as well as momentum and impulse. This research is part of a preliminary study of research into the development of teaching materials to improve students' scientific literacy skills. The total sample consisted of 100 students from three SMAN schools in the city of Padang with the categories low, medium and high based on UTBK scores in 2023. The research sampling technique was cluster random sampling. The scientific literacy ability test consists of 10 complex multiple choice questions. The results of the analysis prove that the students' initial level of ability in scientific literacy in the material of work and energy as well as momentum and impulse is included in the very low category, with an average percentage of 35.4% in the context aspect, an average percentage of 35.6% in the content aspect, and an average percentage of 35.3% in the competency aspect.

Keywords: Analysis; Energy work; Momentum and impulse; Physics; Scientific literacy

Introduction

In the 21st century, there is a transition from human power to machine power, and information technology is very developed which helps improve the quality of human work. In the 21st century, life's needs are more inclined towards the knowledge aspect (Wijaya et al., 2016). The increasingly developing era which is marked by advanced civilization, today's society is required to be able to adapt to technology and be able to compete to prove to be a quality and reliable human resource. In facing developments in the 21st century, there are 16 skills according to the WEF (World Economic Forum) that are needed in the 21st century, one of which is scientific literacy. Directing and educating the public to implement scientific literacy in life is one of the main goals of education today (Pratiwi et al., 2019).

According to PISA (Program for International Student Assessment), scientific literacy is the ability to use scientific knowledge, identify questions and draw conclusions about nature and its changes due to human activities (PISA, 2019). Scientific literacy refers to a way of understanding problems through analyzing, identifying, conducting investigations and making conclusions (Sinaga et al., 2017). This capability aims to build a strong scientific foundation in discussing global issues (Tienken, 2017; Cansiz & Cansiz, 2019; Dewi et al., 2019). Good understanding is needed to solve real world problems. Scientific literacy is an important part of improving mastery of learning material. Scientific literacy helps students to form knowledge, competencies and attitudes towards scientific and technological phenomena in everyday life (Cansiz & Cansiz, 2019; Fanata et al., 2017). Good scientific literacy encourages mastery of problem solving.

In the context of scientific literacy assessment, there are 3 basic categories including content, context and competency (PISA, 2019; Fakhriyah et al., 2017; Jamaluddin et al., 2019). Scientific literacy considers the importance of thinking and acting skills related to

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mastering thinking and using scientific literacy to recognize and respond to social problems. Scientific literacy is important for students to understand the environment, health, economics, modern society and technology. Based on a preliminary study conducted at three senior high schools in the city of Padang, the results of students' scientific literacy tests showed a low percentage of students' scientific literacy in the context aspect of 35.4%, the content aspect of 35.6%, and the competency aspect of 35. 3%. Overall, the average scientific literacy of students at the three schools in the material on work and energy as well as momentum and impulse is in the very low category.

A study found that low levels of scientific literacy were caused by students' unfamiliarity with applying scientific processing skills to solve tests or problems in everyday life (Odja & Payu, 2014). This is supported by research conducted by Ramadhan et al. (2013) that the material and questions tested on content standards and national exam questions have a relatively low level of scientific processing skills, namely 48 and 78% compared to questions on international level competencies. High-level scientific processes such as TIMSS questions increased by 96% and PISA decreased by 89%.

Scientific competency has become a benchmark for determining students' readiness to face the challenges of everyday life, as well as a benchmark for determining future careers, regardless of whether the student is involved in science or not (Lin et al., 2011). Another organization that shows Indonesia's low scientific capacity is TIMSS (Trends in International Mathematics and Science Study), an organization that organizes international comparative studies of student learning outcomes. Based on TIMSS research data, Indonesia is ranked 44th out of 47 countries with a score of 397 (IEA, 2015). These data show that the level of scientific knowledge of Indonesian students is still low and not comparable to the achievements in international Olympic exams which make the country proud.

The importance of scientific skills in the future and Indonesia's low ranking internationally have not escaped the government's attention, as evidenced by the existence of the National Literacy Movement Program. Scientific knowledge in learning in Indonesia is mainly limited to textbooks or texts. This is due to the narrow interpretation of PP No. 13 of 2015 Article 1 paragraph 23 explains the process of acquiring basic skills and basic skills using the main learning resource of textbooks. This statement is understood by most people that textbooks are the only teaching materials, so many Indonesians are not used to looking for various sources (Kemendikbud, 2017). Therefore, educational material is needed to familiarize students with the application of scientific skills and research procedures to obtain the data needed to develop the educational material.

Method

This research is survey research using a qualitative description method with a quantitative approach which aims to determine students' initial scientific literacy abilities in the material of work and energy as well as momentum and impulse. This research is the initial stage of Plomp development model research. The total sample consisted of 100 students from three SMAN schools in the city of Padang with the low, medium and high categories based on the 2023 UTBK scores. The research instruments used were an educator questionnaire instrument and a scientific literacy test instrument which included 10 complex multiple choice questions. The following is a grid of scientific literacy questions on work and energy as well as momentum and impulse in Table 1 and 2.

Table 1. Scientific Literacy Question Grid on Business and Energy Material

Material	Question Number	Indicator	Aspects of Science Literacy		
			Context	Content	Competence
Work and Energy	1	Apply the concepts and principles of work and energy in everyday life and technology correctly	✓	✓	✓
	2	Analyse the principles of mechanical energy and their application in life correctly	✓	✓	✓
	3	Analyse the relationship between business and energy and their application in life correctly	✓	✓	✓
	4	Analyse the concept of the law of conservation of energy and its relationship in life correctly	✓	✓	✓
	5	Apply the principles of power in life correctly	✓	✓	✓

Table 2. Science Literacy Question Grid on Momentum and Impulse Material

Material	Question Number	Indicator	Aspects of Science Literacy		
			Context	Content	Competence
Momentum and Impulse	6	Apply the concept of the momentum principle in daily life and technology correctly	✓	✓	✓
	7	Correctly apply the concepts and principles of impulse in everyday life and technology	✓	✓	✓
	8	Analyze the principle of the law of conservation of momentum and its relationship in life correctly	✓	✓	✓
	9	Apply collision concepts and principles in everyday life and technology correctly	✓	✓	✓
	10	Analyze the principles of the relationship between momentum and impulse and their relationship in life correctly	✓	✓	✓

The final stage of scientific literacy research includes data analysis from tests given to students and the initial scores are converted into a 100 points scale as follows.

$$S = \frac{R}{N} \times 100 \quad (1)$$

Information:
S = science literacy skills score
R = number of correct answers
N = maximum test score

The average score for each point obtained is divided into criteria following Purwanto's rules as shown in Table 3 as follows (Purwanto, 2008).

Table 3. Criteria for Assessing Students' Scientific Literacy Abilities

Interval	Criteria
86%-100%	Very high
76%-86%	Height
60%-75%	Middle
55%-59%	Low
≤54%	Very low

Result and Discussion

A preliminary study conducted at three high schools in the city of Padang also revealed several problems that contributed to students' low scientific literacy. Based on the results of the teacher questionnaire, several obstacles were found in learning physics in the material of work and energy as well as momentum and impulse, one of which was the obstacle in using media development software or ICT teaching materials which received an average score of 95. This value indicates teachers' difficulties in developing teaching materials ICT. Apart from that, there were obstacles in carrying out the experiment with an average value of 93.3. This reveals that the school does not have adequate experimental equipment, so that experimental activities in learning the material on work and energy as well as momentum and impulse cannot be carried out.

Apart from that, there are obstacles to the implementation of the learning model which emphasizes investigation, discovery and cognitive conflict activities which received a score of 71.4. These results inform that learning in schools places more emphasis on direct and teacher-centered learning. Lastly, there are obstacles in implementing learning related to scientific literacy, with an average score of 76.6. These results indicate that learning emphasizes the implications of equations in answering questions rather than presenting concepts based on everyday phenomena.

This condition has an impact on students' low scientific literacy and scientific processes in discovering scientific concepts. This is because the basic competencies of scientific literacy consist of the ability to explain, carry out investigative or experimental activities, and interpret data (PISA, 2019). There are three basic categories in the scientific literacy assessment by PISA (2019), namely context, content and competency. The scientific literacy questions given to students are 10 scientific literacy questions in the form of complex multiple choices. In Table 4 it can be seen from the context aspect, the indicators used in scientific literacy questions are the environment, natural resources, science, sports and arts.

Table 4. Context Indicators on Work and Energy Materials as well as Momentum and Impulse

Context Indicator	Question Number	Percentage (%)
Environment	2, 3	31
Natural resources	4	36
Science	1, 5, 6, 9, 10	39
Sport	7	35
Art	8	36
Average		35.4

Based on the context indicators in table 4, it can be seen that the average environmental context indicator is 31%, the natural resources context indicator is 36%, the science indicator is 39%, the sports indicator is 35% and

the arts indicator is 36%. Furthermore, the average of the context indicators was 35.4% with very low criteria. In accordance with research conducted by Permanasari (2016) that context indicators for students' scientific literacy in Indonesia are low in recognizing scientific knowledge learned from the surrounding environment. The absence of direct experience gained by students makes it difficult for students to assemble knowledge in a real and sequential manner (Yusmar & Fadilah, 2023).

Low science literacy causes students to be slow in analyzing problem solving, decision making and the development of creative sciences (Yusmar & Fadilah, 2023). In addition, the low level of science literacy results in students not being careful in following the development of the environment around them and in fact students have quite good ability in analyzing problems but only difficulty in connecting them with the concept of real knowledge (Sinaga, 2015).

In Table 5 it can be seen that in the content aspect, there are indicators used in scientific literacy questions, namely the concept of work and energy, mechanical energy, the relationship between work and energy, the law of conservation of energy, power, the concept of momentum, the concept of impulse, the law of conservation of momentum, collisions and relationships, work and energy with impulse and momentum.

Table 5. Content Indicators on Business and Energy Materials as well as Momentum and Impulse

Content Indicator	Question Number	Percentage (%)
Business and Energy Concept	1	31.4
Mechanical Energy	2	35.1
The relationship between work and energy	3	34.7
Law of conservation of energy	4	38.8
Power	5	38.8
Momentum Concept	6	36
Impulse Concept	7	36
Law of Conservation of Momentum	8	36
Collision	9	35
The relationship between work and energy and impulse and momentum	10	34.1
Average		35.6

Based on the content indicators in Table 5, it can be seen that the average content indicator for the concept of business and energy is 31.4%, the content indicator for mechanical energy is 35.1%, the content indicator for business and energy relations is 34.7%, the content indicator for the law of conservation of energy amounted to 38.8% and the power content indicator was 38.8%, the momentum concept content indicator was 36%, the impulse concept content indicator was 36%, the law of conservation of momentum content indicator was 36%, the collision content indicator was 35%, the relationship content indicator work and energy with impulse and momentum of 34.1%. Furthermore, the average content indicator was 35.6% with very low criteria. In accordance with research conducted by Mellyzar et al. (2022) shows that the scientific literacy data of SMPN 2 Lhokseumawe students in the content mastery aspect is 56.4% in the low category. In line with research by Andriani et al. (2018) that the scientific literacy abilities of high school students in South Sumatra are relatively low at the level of science questions and processes.

Several studies show that science literacy is still low and students still have difficulty understanding the subject of work and energy (Dalaklioglu et al., 2015; Rivaldo et al., 2020). Students' low understanding of concepts in implementing scientific knowledge causes students to have difficulty applying scientific literacy and solving problems (Nofiana & Julianto, 2017).

In Table 6 it can be seen that in the competency aspect, there are indicators used in matters of scientific literacy, in particular, explaining phenomena scientifically, evaluating and designing scientific studies, and interpreting data and evidence scientifically.

Table 6. Competency Indicators in Business and Energy as well as Momentum and Impulse

Competency Indicators	Question Number	Percentage (%)
Explain phenomena scientifically	4, 7, 8	35
Evaluate and design scientific investigations	5, 9, 10	33
Interpret data and evidence scientifically	1, 2, 3, 6	38
Average		35.3

Based on the competency indicators in table 6, it can be seen that the average competency indicator for explaining phenomena scientifically is 35%, evaluating and designing scientific investigations is 33%, interpreting data and evidence scientifically is 38%. And the percentage of competency indicators is 35.3% with very low criteria. Research according to Safrizal et al. (2019) states that the cause of low scientific literacy lies in students themselves who do not follow developments in the progress of the surrounding environment, such as phenomena in their surroundings and the characteristics of the richness of their region. Implementing scientific knowledge is carried out by analyzing concepts, principles, theories, laws and facts that have occurred (Hasan et al., 2018). This is in accordance with research by Pertiwi et al. (2018) that students' success in scientific

literacy can be seen from the implementation in life of the knowledge they obtain at school.

Another cause of low scientific literacy is because students are not accustomed to implementing scientific literacy skills in solving real-life problems (Sukowati et al., 2016). Where teachers have a very big role in implementing scientific literacy to their students. Teachers are able to familiarize students with implementing scientific literacy skills that have been taught at school in overcoming problems through strategies and stimuli (Dragoş & Mih, 2015; Sikas, 2017). But in fact teachers only focus on improving student learning outcomes (Putra et al., 2016; Udompong & Wongwanich, 2014). Teachers lack focus in explaining scientific phenomena related to students' living environment (Rubini et al., 2017). As a result, the learning process does not help students develop social skills (Angraini, 2014).

Conclusion

Based on a preliminary study that was carried out at three senior high schools in the city of Padang, using an educator questionnaire instrument and a complex multiple choice scientific literacy question instrument of 10 questions, initial data results were obtained from the analysis of students' scientific literacy on the material of work and energy as well as momentum and impulse with categories. Very low when it comes to aspects according to PISA, namely: content aspects, context aspects and competency aspects.

Author Contributions

Fina Afriani Putri conceptualized the research idea, designed of methodology, management and coordination responsibility, analyzed data, conducted a research and investigation process; Fatni Mufit conducted literature review and provided critical feedback on the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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