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Analysis of Senior High School Students' Science Literacy in Understanding Static Fluids

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Abstract
This article aims to identify the scientific literacy skills of high school students in static fluid material. This type of research is quantitative descriptive with a study sample of 136 high school 12th grade students. The data collection technique is a test instrument in the form of 10 multiple choice questions reasoned had 0.741 reliability. The test results showed that the scientific literacy ability test scores of students with static fluid material were 16% at the SI level, 4% at the NSL level, 40% at the FSL level, 38% at the level CSL, and 2% at the MSL level.

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INTRODUCTION

Physics, as a scientific discipline, involves the examination of natural phenomena through systematic observation and experimentation. This condition aims to help students deeply understand basic concepts and refine their critical thinking skills (Wartono et al., 2016). Physics learning in senior high school provides basic knowledge while preparing students to engage in scientific research by the scientific method, both in the laboratory and in the context of the real world (Widarto et al., 2016). The goal is to foster student's ability to acquire essential knowledge that will foster a scientific mindset that can be applied in everyday life.

The central physics concept that students often encounter in everyday life is fluid statics, so students need to understand this concept thoroughly. However, misconceptions in fluid statistics can arise when students are exposed to fragmented experiences without a proper understanding of the underlying principles. Several studies have examined misconceptions in fluid mechanics, such as those conducted by Besson (2004), Pratiwi et al. (2013), and Nurmisanti et al. (2017), revealing that misconceptions are still common among students. More recent research addresses these misconceptions, highlighting the need for effective teaching strategies (Muller et al., 2019; Treagust & Duit, 2020). Rustaman (2017) pointed out that understanding complex scientific concepts such as fluid statistics is difficult. Therefore, adopting effective teaching methods, such as engineering approaches, is crucial to overcome these difficulties (Scherr & Robertson, 2021).

All students, whether pursuing careers in science or technology, should benefit from a science education that includes understanding the scientific aspects of phenomena encountered in everyday life (NGSS, 2018). Harlen (2006) underlines that science literacy involves understanding the impact of science and technology on everyday life and applying scientific principles, concepts, and processes in decision-making. This highlights the importance of expanding science education to produce science-literate citizens (Hofstein et al., 2011; Lederman & Lederman, 2019).

Sukowati et al. (2016) conducted a study that revealed that the average science literacy ability of students in schools implementing the 2013 curriculum was still below 50%, indicating that students had difficulty understanding basic physics principles and applying them to real-world problems (Turiman et al., 2011). Subsequent studies echoed these findings, emphasizing the need for education reform to improve science education (OECD, 2020; Tsai et al., 2021). According to the PISA framework (2015), science literacy is evaluated through competence, context, knowledge, and attitude. This study analyzes students' science literacy skills in understanding static fluids to provide an overview of their science literacy level. Bybe (1997) and NGSS (2018) recommend a comprehensive theoretical framework for assessing school science literacy. Soobard and Rannikmae (2011) proposed the following levels of science literacy: (1) scientific illiteracy, (2) nominal science literacy, (3) functional science literacy, (4) conceptual science literacy, and (5) multidimensional science literacy.

This article will discuss the current state of high school students' science literacy related to static fluid and how it reflects their overall understanding of scientific principles in a real-life context.

METHOD

This study was conducted at SMAN 7 Malang, involving 136 high school students from the 12th grade during the 2023/2024 academic year. These students had previously studied the topic of static fluids during the odd semester. The research employed a descriptive quantitative approach, utilizing a test-based data collection technique. The test consisted of 10 multiple-choice items, each with a reasoned answer format. The scoring criteria for the test were as follows: a score of 4 points was given for a correct answer with an appropriate explanation, 3 points for a correct answer with an incorrect explanation, 2 points for a wrong answer with a proper explanation, 1 point for a correct answer without a justification or with an incorrect rationale, and 0 points for an incorrect answer without any reason.

The test questions focused on key subtopics within static fluid material, namely hydrostatic pressure, Pascal's law, and Archimedes' law, which were derived from prior research by Rizqiana (2015), with a reliability coefficient 0.741. The students' science literacy levels were categorized into five distinct levels: (1) Scientific Illiteracy (SI), (2) Nominal Science Literacy (NSL), (3) Functional Science Literacy (FSL), (4) Conceptual Science Literacy (CSL), and (5) Multidimensional Science Literacy (MSL). Based on the assessment of students' understanding, these categories were used to evaluate their proficiency in applying scientific concepts related to static fluids in real-world scenarios.

RESULTS AND DISCUSSION

The initial stage of this research was the preparation of a science literacy test and guidelines for categorizing student answers according to the level of science literacy. The categories of science literacy skills prepared by Soobard & Rannikmae (2011) are presented in table 1.

Table 1. Categories of Student Answers by Science Literacy Level.

No	Level	Description
1.	Illiteracy	Students cannot connect or respond to a question that requires reasoning about science. Students lack the vocabulary, concepts, context and cognitive ability to identify questions scientifically.
2.	Nominal	Students recognised science-related concepts but the correct level of understanding indicated misconceptions.
3.	Functional	Students can explain a concept correctly, but their understanding is still limited

4.	Conceptual/Procedural	Students develop some understanding of the schema of the subject concepts and connect the schema to the students' general understanding of science.
5.	Multidimensional	The science literacy view incorporates a broad understanding of science beyond subject concepts and scientific procedures. Students develop some understanding and appreciation of science and technology as it relates to everyday life. Especially as they begin to make connections between science and technology and issues in society.

After the test was conducted on 136 students, the results showed that students' science literacy in static fluid material was 16% at the scientific illiteracy (SI) level, 4% at the nominal science literacy (NSL) level, 40% at the functional science literacy (FSL) level, 38% at the conceptual science literacy (CSL) level, and 2% at the multidimensional science literacy (MSL) level. Students' science literacy skills are presented in Figure 1 below.

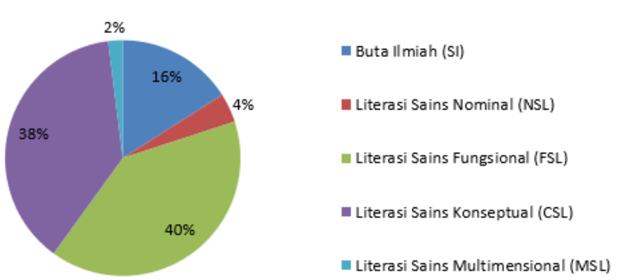

Figure 1. Percentage of students' science literacy skills in static fluid material

The test results show that most students are in the functional and conceptual categories. This shows that students' abilities are still limited to writing down facts but are unable to describe the relationship between static fluid concepts. Meanwhile, students who have a conceptual category can already show understanding and interdisciplinary links but are still unable to connect the concept of static fluid with everyday life.

Discussion

The competency domain science literacy questions completed by students were based on the indicators set out in PISA 2015. The results of the analysis of 136 students' answers to the competency domain science literacy questions are presented in Figure 2

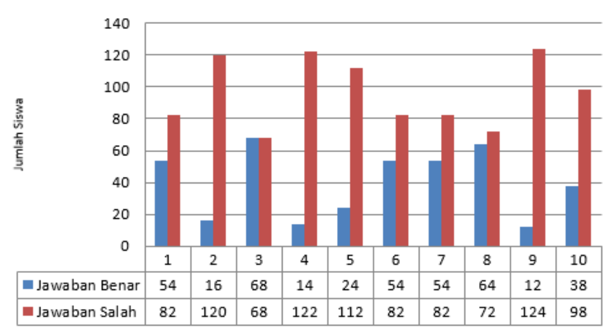

Figure 2. Graph of the number of students who answered science literacy questions

Based on the information in Figure 2, it was found that the number of students who answered incorrectly was more than those who answered correctly, and this occurred in questions number 1, 2, 4, 5, 6, 7, 8, 9, and 10. In question number 3, the number of correct answers was the same as the wrong answers and this ranked top in answering questions correctly, while the lowest rank occurred in question number 9.

Competency Domain Science Literacy Level

Problem numbers 1, 2, 3, 4 and 8 contain the subdomain of explaining scientific phenomena. Problem numbers 6 and 10 feature the subdomains of evaluating and designing scientific enquiry. While questions number 5, 7 and 9 contain the subdomain of interpreting scientific data and evidence.

The detailed results of the percentage of correct student answers to student science literacy questions in the competency domain are presented in Table 2.

Table 2. Percentage of Students' Correct Answers for each Competency Subdomain.

Competency Subdomain	Number of questions	Percentage of correct answers
Explaining scientific phenomena	5	31,76%
Evaluate and design scientific enquiry	2	33,82%
Interpreting scientific data and evidence	3	22,06%

Based on the information in Table 2, the percentage of correct answers to the subdomain questions explaining scientific phenomena was 31.76% of the 5 questions. The percentage of correct answers on the subdomain questions evaluating and designing scientific investigations is 33.82% of 2 questions. Meanwhile, the percentage of correct answers on the subdomain question of interpreting data and scientific evidence was 22.06% of 3 questions. The percentage of correct answers is obtained from the comparison of the average student score with the maximum score of correct answers. The results of the analysis in Table 2 show that the subdomain of competence most mastered by students is evaluating and designing scientific investigations related to static fluid material, namely 33.82%. Thus, there are no students who can answer correctly on competency domain questions more than 50%.

Knowledge Domain Science Literacy Level

Problem numbers 1, 3, 8, 9 and 10 contain content subdomains, which explain some important concepts and relate to real life. Problem numbers 4, 6 and 7 feature procedural subdomains that explain research steps and relationships between variables. While questions number 2 and 5 contain epistemic subdomains in the form of scientific knowledge and designing hypotheses.

In detail the results of the percentage of correct student answers to student science literacy questions in the knowledge domain are presented in Table 3.

Table 3. Percentage of Students' Correct Answers for each Knowledge Subdomain.

Knowledge Subdomain	Number of questions	Percentage of correct answers
Content	5	35%
Procedural	3	30%
Epistemic	2	15%

Based on the information in Table 3, the percentage of correct answers to the content subdomain questions is 35% of the 5 questions. The percentage of correct answers on procedural subdomain questions is 30% of 3 questions. While the percentage of correct answers to the epistemic subdomain questions was 15% of 2 questions. The percentage of correct answers is obtained from the comparison of the average student score with the maximum score of correct answers. The analysis results in Table 3 show that the sub-domain that has the highest percentage is content at 35%.

CONCLUSION

This study identifies students' science literacy skills in static fluid material. The sample of this study was 136 12th grade high school students who had taken static fluid material. The data collection technique uses a test instrument in the form of 10 questions, which contains indicators that have been determined by PISA 2015 in the competency and knowledge domains. The test results show that the test scores of students' science literacy skills in static fluid material are 16% at the scientific illiteracy level (SI = Scientific Illiteracy), 4% at the nominal level (NSL = Nominal Scientific Literacy), 40% at the functional level (FSL = Functional Scientific Literacy), 38% at the conceptual level (CSL = Conceptual Scientific Literacy) and the remaining 2% at the multidimensional level (MSL = Multidimensional Scientific Literacy).

The results emphasize the need for innovative instructional approaches, particularly those integrating technology and active learning strategies, to enhance students' scientific literacy (Tsai et al., 2021; Roberts & Bybee, 2022). Future research should focus on designing and implementing effective pedagogical interventions to elevate students' literacy levels, particularly in physics education.

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