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Scientific literacy in school assessments: An analysis of competency and knowledge aspects

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Abstract
This study aims to analyze the profile of science literacy, viewed from the competency and knowledge aspects, in the Final Semester Assessment (PAS) Science questions for grades 7th and 8th at Junior High School based on the PISA 2025 framework. The novelty of this research lies in the analysis of local school assessment instruments (PAS) against global science literacy standards, which is rarely conducted in the context of final semester evaluations. This research uses a descriptive qualitative method. The primary data are the PAS Science questions for grades 7 and 8 in the 2024/2025 academic year. The data analysis technique employed the Miles & Huberman model, involving the grouping of test items and calculating the percentage of attainment of science literacy sub-indicators. The results show that the PAS questions have a strong foundation in measuring Content Knowledge (P1) and the basic competency of Explaining Scientific Phenomena (K1). However, there is a significant imbalance, where test items for higher competencies such as Interpreting Data (K2), Evaluating and Designing Inquiry (K3), as well as Procedural Knowledge (P2) and Epistemic Knowledge (P3) are very limited or non-existent. It is concluded that the assessment instrument is not yet comprehensive in measuring all dimensions of PISA science literacy. The implication of this research is to provide evaluation material for Science teachers to review and revise the question instruments to cover the unmeasured science literacy dimensions, thereby improving the quality of Science learning continuously

1. Introduction

The Industrial Revolution 4.0 has fundamentally changed the scope and complexity of human activities. This era demands the renewal of innovative learning systems and the formation of graduates who master 21st century skills (Osman et al., 2013). These skills are classified into three groups: "*way of thinking*" (critical and creative thinking), "*way of learning*" (science literacy and *soft skills*), and "*way of interacting with others*" (personal and social responsibility) (Griffin & Care, 2015). These 21st century skills are vital competencies that individuals need to be active in learning, the world of work, and social tasks in the contemporary era (Sibarani et al., 2019).

In Indonesia, the Industrial Revolution 4.0 is a big challenge to explore the advancement of science and technology in order to become superior human resources (Jufrida et al., 2019; Ristina et al., 2019). One of the essential skills that can be improved through education to answer this challenge is science literacy skills. Science literacy is defined as an understanding of *the Nature of Science* (NOS) and a person's capacity to identify problems and articulate scientific information (Oh, 2017). Through science literacy, students not only learn concepts, but also about procedures and practices in scientific research and how science develops (Asniati, 2019).

Although important, international survey data shows that the science literacy competence of Indonesian students is very low. The *Programme for International Student Assessment* (PISA) which is held every three years, and *the Trend in International Mathematics and Science Study* (TIMSS) which is held every four years, consistently rank Indonesia at the bottom. In the 2015 TIMSS survey, Indonesia only got a score of 397, far below the international average of 500 (Hadi & Novaliyosi, 2019).

More recent PISA 2022 data confirms this trend. The global average standard for science literacy is 485, but Indonesia's average score is only 383 (OECD, 2023a). Although Indonesia's ranking rose

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from 71 in 2018 to 67 in 2022, the fact is that Indonesia's science literacy score has actually decreased by 13 points and is still 102 points adrift from the global average. This decline indicates that students' science literacy skills are still low (Suparya et al., 2022).

According to the PISA 2025 framework (OECD, 2023b), science literacy consists of four main components: context, competence, knowledge, and science identity. The aspect of competence and knowledge is the main foundation and is essential to prepare students for the challenges of the 21st century. This science literacy has been adopted into national curricula, such as the Merdeka Curriculum, which aims to create flexible and more contextual learning (Chabalengula et al., 2008). In order to achieve this goal, the scope of science mastery must be integrated in all forms of assessment systems (Amanda, 2019).

With the low achievement of science literacy, evaluation of assessment instruments is a must. Assessment instruments are tools to measure the achievement of student competencies. In schools, the main assessments include Mid-Semester Assessments (PTS) and Final Semester Assessments (PAS), which are often prepared by teachers in each school. Although many studies have measured high-level thinking skills, science literacy analysis in Final Semester Assessment (PAS) questions for science subjects is still rare. Therefore, this study aims to analyze the aspects of science literacy competence and knowledge in the 7th and 8th grade PAS Science questions at Junior High School.

2. Method

This study uses a qualitative descriptive design. The research was carried out at Junior High School from January 2025 to July 2025. The primary data used are the Odd Final Semester Assessment (PAS) question documents for science subjects in grades 7 and 8 for the 2024/2025 school year, as well as the results of interviews with science teachers. Secondary data in the form of relevant similar research on science literacy analysis. The sampling technique uses purposive sampling, where all PAS questions are analyzed to determine the science literacy profile (Sugiyono, 2017). The data validity test was carried out using data triangulation, namely by comparing the results of the teacher's interview about the process of making questions with the results of the question validation by expert validators. The validity of the research instrument (analysis sheet) was tested using the validity of the content by two validators, and the results were calculated using Aiken's V formula (Aiken, 1985). In this study, the measurement results on each aspect were averaged to obtain the average achievement of the science literacy aspect (Table 1). The data analysis technique uses the Miles & Huberman (1992) model, which includes three steps: grouping question items based on science literacy indicators (data reduction), calculating the percentage of achievement of each sub-indicator, and drawing conclusions.

Table 1. Criteria for achievement of science literacy aspects (Slavin, 2018)

Interval Value	Category
90-100%	Very high
80-89%	High
70-79%	Moderate
60-69%	Low
<60%	Very Low

3. Results and Discussion

This study analyzed 35 7th grade PAS questions and 35 8th grade PAS questions, which included multiple-choice questions, short fills, matchmaking, and essays. The focus of the analysis is the competency and knowledge aspects of the PISA 2025 framework. The results of interviews with two science teachers confirmed that the PAS material covers all of the material in one semester. The questions were compiled by science teachers at the school, not by the MGMP team. The question validation process is carried out by fellow science teachers and school principals. Both teachers stated that PAS questions have applied science literacy, with an estimated percentage of implementation between 65% to 70%.

3.1. Average Achievement of Competencies and Knowledge Aspects

This study analyzed 35 PAS Science questions for grade 7 and 35 questions for PAS Science grade 8 for the 2024/2025 school year. The analysis focuses on two main aspects of PISA 2025

science literacy: Competency (K) and Knowledge (P). The results of the data analysis show that overall, the average percentage of PAS questions has applied science literacy at a relatively good level (Figure 1). In Grade 7, the average achievement of the competency aspect is 88% (High category) and the knowledge aspect is 79% (Moderate category). A similar pattern was found in Grade 8, with the competency aspect reaching 89% (High category) and the knowledge aspect 76% (Moderate category).

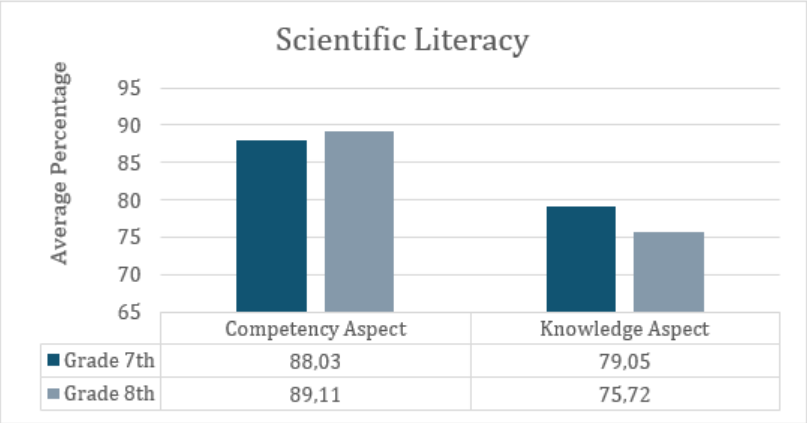

Figure 1. Average percentage of science literacy competency and knowledge aspects

3.2. The Imbalance of the Science Literacy Profile and Its Implications

Although the overall average value appears to be high, a more in-depth analysis of each sub-indicator shows a very significant imbalance. Test instruments at both grade levels showed a very strong dominance on the low-level aspect, and ignored the high-level aspect (Table 2). The main findings show that the test instrument has a strong foundation in measuring Content Knowledge (P1) and the basic competence of Explaining Scientific Phenomena (K1). In Grade 7, 25 out of 35 questions (71%) focused on P1. Meanwhile, in Grade 8, 27 out of 35 questions (77%) focused on P1. This shows that the main function of the current PAS questions is to measure students' ability to remember and understand basic concepts of science.

A striking gap is seen in the question items that measure more complex competencies and knowledge. The competence of Evaluating and Designing Scientific Research (K3) and Epistemic Knowledge (P3) is not represented in both instruments at all. This indicates that test instruments do not measure students' ability to reflect on scientific processes, evaluate the validity of experiments, or understand how scientific knowledge is constructed.

Table 2. Percentage of each science literacy sub-indicator

Class	Indicator	Sub Indicator	Number of Questions
Grade 7th	Explaining scientific phenomena (K1)	K1.1 – K1.5	12
	Interpreting data and scientific proof (K2)	K2.1 – K2.5	3
	Evaluating and designing scientific research (K3)	K3.1 – K3.4	0
	Content Knowledge (P1)	P1.1 – P1.2	25
	Procedural Knowledge (P2)	P2.1 – P2.4	10
	Epistemic Knowledge (P3)	P3.1 – P3.2	0
Grade 8th	Explaining scientific phenomena (K1)	K1.1 – K1.5	10
	Interpreting data and scientific proof (K2)	K2.1 – K2.5	3
	Evaluating and designing scientific research (K3)	K3.1 – K3.4	0
	Content Knowledge (P1)	P1.1 – P1.2	27
	Procedural Knowledge (P2)	P2.1 – P2.4	8
	Epistemic Knowledge (P3)	P3.1 – P3.2	0

In addition, the question items for the competencies of Data Interpretation (K2) and Procedural Knowledge (P2) are also very limited. Although there are 10 questions in grade 7 and 8 questions in grade 8 that touch on P2, this number is very small compared to P1. This limitation reflects the focus of the question on simple calculations or sequences, rather than on reasoning or a deep understanding of scientific methodology.

These findings are in line with other studies that highlight the low science literacy skills of Indonesian students in more complex aspects (Pratama et al., 2024; Yusmar & Fadilah, 2023). Analysis of the ability of junior high school students often shows the category of "*very lacking*" or "*low*", especially in the K2 and K3 dimensions (Suparya et al., 2022; Abdul Rahman, 2024). The novelty of this study is the affirmation that the gap in this assessment instrument is fundamentally not in line with the demands of the Independent Curriculum and the PISA 2025 Science Framework. PISA 2025 specifically expands the focus to students' role as "*Anthropocene Agents*", i.e. the ability to research, evaluate, and use scientific information for decision-making and ethical action against the environment (OECD, 2025). The PAS instrument that is currently being analyzed has completely failed to capture this novelty. The absence of K3 (Evaluating and Designing Research) and P3 (Epistemic Knowledge) shows that students are not trained or measured in their ability to evaluate data validity or reflect on scientific processes skills that are at the core of the PISA 2025 framework. Novelty in instrument development must include the integration of contextualization based on socio-scientific issues (SSI), such as climate change or local wisdom, which requires students to explicitly use P2 and P3 (procedural and epistemic knowledge) to Evaluate and Design Scientific Research (K3), beyond just content (Ningsetyo, 2024).

Several studies show that the development of PISA-based science literacy instruments, even those that emphasize the three competencies (K1, K2, K3), still produce a student ability profile that is dominated by the "*high*" category in the aspect of Explaining Scientific Phenomena (K1) (Patigu et al., 2024). This indicates that a good P1 and K1 foundation as measured by the instrument is a prerequisite that has been successfully achieved, before students can move on to higher competencies. Rusilowati et al (2018) conducted research to develop a science literacy assessment instrument with the theme of cycle and compared with the instrument from PISA it resulted that the questions that had been developed did not reach 50% in applying science literacy. Rusilowati et al (2018) said that improving science literacy requires collective interaction skills and the need to demonstrate reasoning about what makes sense. The results of science literacy will increase if the aspect of science attitudes related to emotional factors to gain a sense of interest and comfort when learning science.

Based on these findings, the suggested practical implications are the need to improve the question instruments to cover the dimension of science literacy that has not yet been measured (Setiawan, 2019; Putri, 2020). This requires intensive training for science teachers on PISA taxonomy (especially P2, P3, K2, and K3) and valid high-level question preparation techniques (Setyawarno et al., 2021). In addition, schools need to be encouraged to shift the focus of learning from just the transmission of P1 (content) towards the implementation of inquiry-based learning models, such as Project-Based Learning (PjBL) or Problem-Based Learning (PBL), which have been proven to be effective in improving the K2 and K3 competency domains (Fuadi et al., 2020; Meidiana & Pertiwi, 2024).

4. Conclusion

Based on the results of the analysis, it can be concluded that the assessment instrument (PAS questions) is not comprehensive in measuring all dimensions of PISA science literacy. The analysis of the 7th grade PAS Science questions showed the "High" category for the competence of Explaining Scientific Phenomena (K1) and Content Knowledge (P1). However, the question of getting the "Low" category for Data Interpretation (K2) and Procedural Knowledge (P2), as well as the "Very Low" category for Evaluating and Designing Research (K3) and Epistemic Knowledge (P3). Meanwhile, the analysis of the 8th grade PAS Science questions showed an identical pattern: the "High" category for K1 and P1; "Low" category for K2 and P2; and the "Very Low" category for K3 and P3. Overall, the average competency aspect is classified as "High" and the knowledge aspect is "Moderate", this instrument is very uneven and fails to measure the dimension of higher science literacy that is essential for students.

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