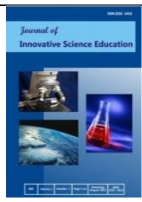
JISE 15 (1) (2026): 16-25

Journal of Innovative Science Education

https://journal.unnes.ac.id/journals/jise/



A Local Wisdom–Based Science Literacy Instrument for Junior High School Students: Development and Rasch Analysis

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Article Info

Article History :
December 2025
Accepted
February 2026
Published
April 2026

Keywords:
Local Wisdom Context, Rasch Model, Science Literacy Instrument

Abstract

The Kurikulum Merdeka implemented in Indonesia focuses on mastering 21st-century skills, including science literacy. However, the level of science literacy in Indonesia remains relatively low, partly due to the lack of instruments to measure it. This study develops a locally grounded science literacy instrument for junior high school students by integrating local wisdom with the PISA 2025 framework. Anchored in the cultural context of Batang Regency, the instrument positions local phenomena as core cognitive stimuli to enhance the contextual validity of science literacy assessment. Using a development approach and Rasch-based analysis, the results indicate that the instrument demonstrates strong psychometric quality and effectively differentiates students' science literacy levels. Beyond measurement robustness, the findings reveal that students' science literacy remains limited, underscoring the need for contextually responsive assessment tools. This study contributes a scalable model for a more valid science literacy assessment that bridges global competency standards with local educational contexts, offering important implications for science educators and assessment developers.

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p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

The Merdeka Curriculum, currently implemented in Indonesia, focuses on strengthening 21st-century skills, emphasizing literacy, numeracy, and character development to prepare students for global challenges (Sari & Suryelita, 2023). In science education, science literacy is a core competency that enables students to understand natural phenomena and make evidence-based decisions (Mukti, 2018; Vieira & Tenreiro-Vieira, 2016). However, Indonesian students' science literacy remains unsatisfactory, as indicated by the 2022 PISA results, which ranked Indonesia 67th out of 81 countries (OECD, 2023). This stagnation indicates a persistent gap between the goals of the national curriculum and actual student performance in the field (OECD, 2016).

A significant factor contributing to this low achievement is the lack of high-quality assessment instruments that reflect the multidimensional nature of science literacy. Many school-based assessments still prioritize lower-order thinking skills and fail to accurately differentiate student competency levels (Adi, 2025; Maulida & Sunarti, 2022). To bridge this gap, there is an urgent need for instruments that are not only aligned with international frameworks, such as PISA, but also contextually relevant to students' lived experiences (Atta & Aras, 2020; Chasanah et al., 2022). A comprehensive and valid measurement is essential for identifying specific areas where students struggle.

Integrating local wisdom into science education is a strategic approach to enhance engagement and conceptual understanding (Rahmi et al., 2023; Sudarmin, 2014). Through ethnoscience, abstract scientific concepts are connected to familiar cultural practices, making learning more meaningful and culturally relevant (Setyowati et al., 2023; Zahro & Fauziah, 2024). In Batang Regency, for instance, the traditional production of mlinjo chips provides a rich context for exploring heat transfer and chemical changes (Harefa, 2019; Ramadani, 2025). While this context is often used in teaching, its systematic integration into formal science literacy assessment remains underdeveloped and underutilized.

Beyond contextual relevance, the scientific accountability of an instrument depends on the analytical framework used to evaluate its psychometric quality (Lestari & Setyarsih, 2020). Traditional Classical Test Theory (CTT) has inherent limitations, as item characteristics and student abilities are interdependent, often leading to unstable measurements (Bahar et al., 2021; Hambleton & Swaminathan, 1985). In contrast, the Rasch model, a part of Item Response Theory, provides a more objective analysis by linearizing raw data and separating person ability from item difficulty (Bond & Fox, 2015; Planinic et al., 2019). This approach ensures consistency in measurement across different student groups.

Despite the growing interest in ethnoscience, research specifically focused on developing science literacy instruments that integrate local wisdom and are validated through the Rasch model remains limited. Most previous studies emphasize learning modules or general literacy measurements without utilizing local cultural stimuli as a basis for rigorous psychometric evaluation (Saepuzaman et al., 2021). This research fills the identified gap by developing an instrument based on the local heritage of Batang Regency, ensuring that the tool is both culturally responsive and scientifically sound. This novelty positions the study as a necessary step in modernizing science assessment at the junior high school level.

Therefore, this study aims to develop and analyze the quality of a science literacy instrument integrated with local wisdom using the Rasch model for junior high school students. By combining the PISA framework with ethnoscience and modern psychometric analysis, this research provides a scalable model for improving science literacy assessment within the Merdeka Curriculum. The results are expected to offer critical implications for educators seeking to bridge global competencies with local contexts. Ultimately, this study contributes to a more valid and culturally grounded measurement of science literacy in the Indonesian educational landscape.

METHODS

This study employs a Research and Development (R&D) approach using the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) model. ADDIE was selected as a systematic framework to ensure that the integration of local wisdom into the science literacy instrument remains consistent with the PISA 2025 framework through iterative refinement. The analysis stage identified student needs and the relevance of local wisdom, while the design stage focused on developing instrument specifications aligned with the scientific competencies of the local context in Batang Regency. The overall development flow and activities are visually summarized in Figure 1.

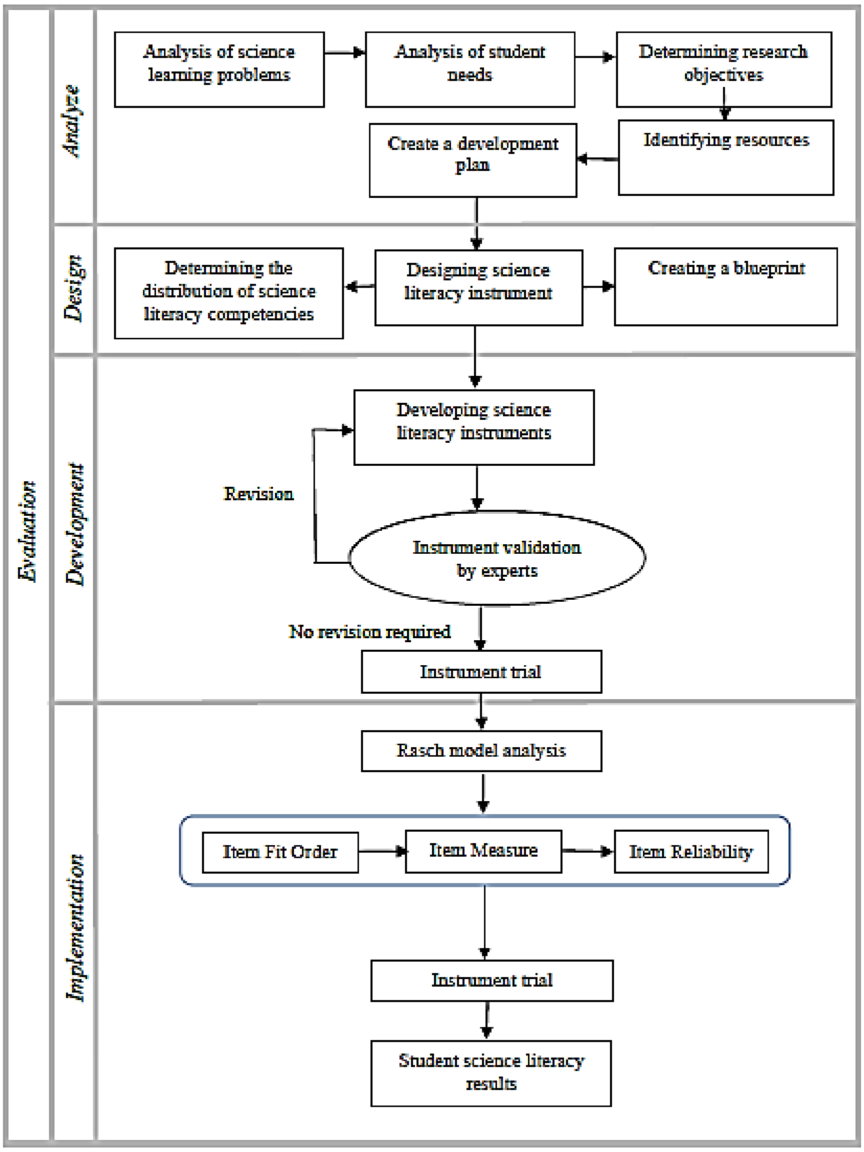


Figure 1. Development Procedures

The development phase involved constructing 20 multiple-choice items in accordance with the specifications in Table 1, followed by expert validation to ensure content alignment. The implementation stage consisted of a trial with 144 seventh-grade students at SMP Negeri 1 Bawang, Batang Regency, a sample size sufficient to provide stable estimates for Rasch analysis. Evaluation was conducted formatively throughout each ADDIE stage, utilizing continuous feedback to refine the items. This iterative process ensures that the final product achieves high scientific accountability and meets the measurement needs of the targeted junior high school level.

Table 1. Specifications of science literacy instruments

Material	Science Literacy Competence	Question Number	Cognitive Level
Substances and their Changes	Ability to explain phenomena scientifically	1, 5, 6, 9, 10	C4, C1, C2, C3, C4
	Construct and evaluate designs for science investigations and critically interpret science data and evidence	2. 4, 8	C5, C3, C2
	Research, evaluate, and use science information for decision-making and action	3, 7	C2, C2
Temperature, Heat, and Expansion	Ability to explain phenomena scientifically	4, 20	C5, C1
	Construct and evaluate designs for science investigations and critically interpret science data and evidence	11, 12, 15, 16, 18	C3, C4. C3, C3, C5
	Research, evaluate, and use science information for decision-making and action	13, 17, 19	C3, C2, C5

The research subjects were divided into two groups: 144 students for the instrument trial and one separate class (28 students) selected via cluster random sampling for science literacy profiling. This separation ensures that the psychometric evaluation of the items is not confounded by the descriptive mapping of student achievement. Content validity was assessed in two rounds by three experienced science teachers using Aiken's V index. Beyond quantitative scores, qualitative feedback regarding the clarity of the local wisdom stimuli was prioritized to ensure that the cultural context effectively supported, rather than hindered, the measurement of scientific competencies.

The core of the methodology lies in the application of the Rasch model, which was chosen for its ability to produce objective, sample-independent measurements by separating item difficulty from student ability. Data from the trial were analyzed using Winsteps software to evaluate the instrument's psychometric properties. Unlike Classical Test Theory, the Rasch model enables a detailed analysis of item-person interactions, ensuring that the instrument is a valid tool for measuring the progression of science literacy within a specific cultural context. This approach aligns with the research objective of developing a robust, replicable assessment tool.

To ensure methodological transparency, the instrument's quality was evaluated against specific Rasch criteria. Item fit was determined using Outfit Mean Square (Outfit MNSQ) values within the .5 to 1.5 range (Linacre, 2002). Item difficulty was classified into five levels based on logit measures, mean values, and standard deviations (Sumintono & Widhiarso, 2015). Furthermore, the study targeted item reliability coefficients above .90 and separation indices greater than 1.5 to ensure that the instrument consistently distinguishes between at least three strata of student ability (Linacre, 2002). These thresholds ensure that the final instrument is psychometrically sound for broader educational use.

RESULTS AND DISCUSSION

This study began with a needs analysis, which confirmed that science literacy has not been a central focus of assessment at SMP Negeri 1 Bawang, where existing evaluations predominantly emphasize academic achievement and content mastery. These findings align with previous literature, which highlights that while science literacy is essential, its systematic integration into school assessments remains a significant challenge (Purnawati & Yakin, 2025; Pursitasari et al., 2022). Consequently, there is an urgent need for an instrument that bridges the gap between theoretical literacy competencies and the contextual realities of science learning in junior high schools.

Following the analysis, the instrument was designed based on the PISA 2025 science literacy framework, targeting three core competencies: explaining phenomena scientifically, interpreting scientific data, and making evidence-based decisions

(OECD, 2025). The development of 20 multiple-choice items integrated local wisdom from Batang Regency, positioning cultural phenomena not merely as background but as a primary cognitive stimulus (Putra et al., 2024). This ethnoscience-based approach ensures that scientific concepts such as matter changes and thermal expansion are measured within a contextually relevant and familiar reality for students.

The content validation process, analyzed through Aiken's V index, yielded an average value of 1.00, confirming that the items optimally align with the intended science literacy indicators (Aiken, 1985). Beyond quantitative agreement, qualitative feedback from experts led to critical refinements in item wording and distractor quality, ensuring the stimuli were both scientifically accurate and culturally appropriate. This rigorous validation phase served as a foundation for ensuring that the local wisdom integrated into the items effectively triggers the targeted cognitive processes without introducing linguistic bias, as illustrated in Table 2.

Table 2. Revision of science literacy instrument test items

Before revision	**After revision**
 https://www.tempo.co/gaya-hidup/cara-mudah-membuat-sendiri-emping-dari-biji-melinjo--533645 Emping mlinjo is a typical snack widely produced in Batang Regency. The manufacturing process involves several traditional steps. Ripe mlinjo seeds are harvested, then roasted until cooked and peeled. The mlinjo seeds are pounded flat with a hammer or a special tool. These raw mlinjo sheets are then dried in the sun until dry and ready to be fried into crispy emping. Mr. Ahmad is an emping mlinjo entrepreneur in Limpung District. One day, Mr. Ahmad observed that freshly pounded raw mlinjo emping felt more pliable and easier to flatten than unroasted mlinjo seeds. After drying in the sun for several hours, the mlinjo emping sheets hardened and became brittle. Which best explains the changes in the physical properties of mlinjo during the emping-making process? a) Roasting causes chemical changes in the mlinjo seeds, producing a new, softer substance, while drying in the sun removes the water content, making the emping hard. b) Roasting reduces the water content in the mlinjo seeds, making them drier and easier to peel and flatten. Drying in the sun causes the water to evaporate, making the emping hard. c) Pounding is a chemical process that changes the structure of the mlinjo seeds, making them flatter. Sunlight causes a chemical reaction that hardens the emping. d) Roasting and drying in the sun are both physical processes that change the shape and form of the mlinjo without altering its chemical composition.	 https://www.tempo.co/gaya-hidup/cara-mudah-membuat-sendiri-emping-dari-biji-melinjo--533645 Emping mlinjo is a typical snack widely produced in Batang Regency. The manufacturing process involves several traditional steps. Ripe mlinjo seeds are harvested, then roasted until cooked and peeled. The mlinjo seeds are pounded flat with a hammer or a special tool. These raw mlinjo sheets are then dried in the sun until dry and ready to be fried into crispy emping. Mr. Ahmad is an emping mlinjo entrepreneur in Limpung District. One day, Mr. Ahmad observed that freshly pounded raw mlinjo emping felt more pliable and easier to flatten than unroasted mlinjo seeds. After drying in the sun for several hours, the mlinjo emping sheets hardened and became brittle. Which best explains the changes in the physical properties of mlinjo during the emping-making process? a) Roasting causes chemical changes in the mlinjo seeds, producing a new, softer substance. b) Roasting causes chemical changes in the mlinjo seeds, reducing their water content, making them drier and easier to peel and flatten. c) Pounding causes a physical change that changes the structure of the mlinjo seeds, making them flatter. d) Sun-drying causes a physical change that changes the shape and form of the mlinjo because sunlight causes a reaction that hardens the chips.

Empirical trials involving 144 students using the Rasch model confirmed the instrument's robust psychometric properties. The Outfit MNSQ values (.67 to 1.25) indicate that all items function effectively for measurement and consistently represent the science literacy construct without distortion (Afifi et al., 2023; Amelia et al., 2021; Linacre, 2002). Unlike classical test theories, this Rasch-based analysis provides stable evidence that the instrument is a reliable tool for mapping student abilities along a clear difficulty continuum. The summary of these item characteristics, demonstrating the precision of the developed tool, is presented in Table 3.

Table 3. Summary of Item Characteristics

Item	Outfit MNSQ	Item Measure (logit)	Item Measure Category
1	1.09 (fit)	1.12	Difficult
2	1.23 (fit)	2.65	Very difficult
3	1.00 (fit)	-.27	Easy
4	.69 (fit)	-2.33	Very easy
5	.98 (fit)	.07	Difficult
6	.98 (fit)	-1.74	Very easy
7	.90 (fit)	-1.12	Easy
8	.85 (fit)	1.02	Difficult
9	.95 (fit)	.59	Difficult
10	1.07 (fit)	1.09	Difficult
11	.92 (fit)	-.27	Easy
12	.83 (fit)	.85	Difficult
13	.67 (fit)	-1.74	Very easy
14	1.07 (fit)	.43	Difficult
15	1.08 (fit)	1.12	Difficult
16	1.14 (fit)	.07	Difficult
17	1.25 (fit)	.64	Easy
18	.89 (fit)	.80	Easy
19	1.16 (fit)	.60	Easy
20	.92 (fit)	.00	Currently

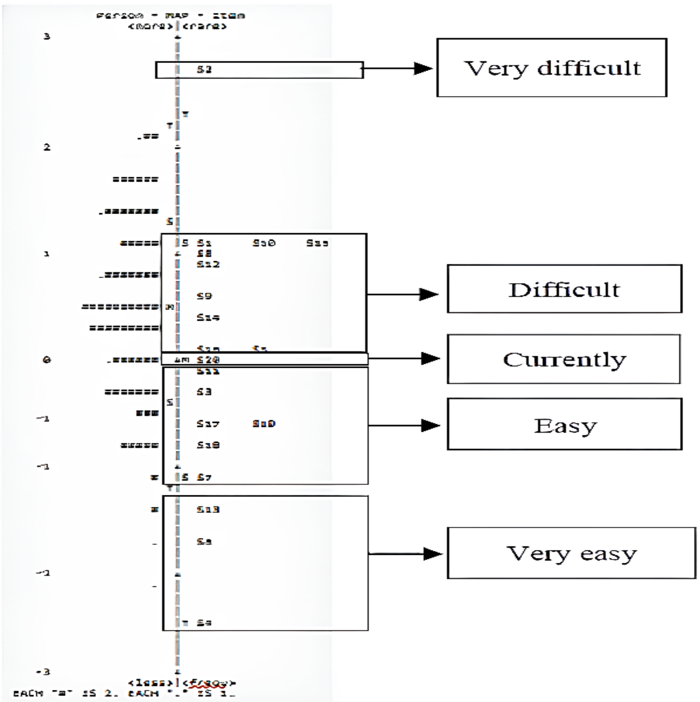
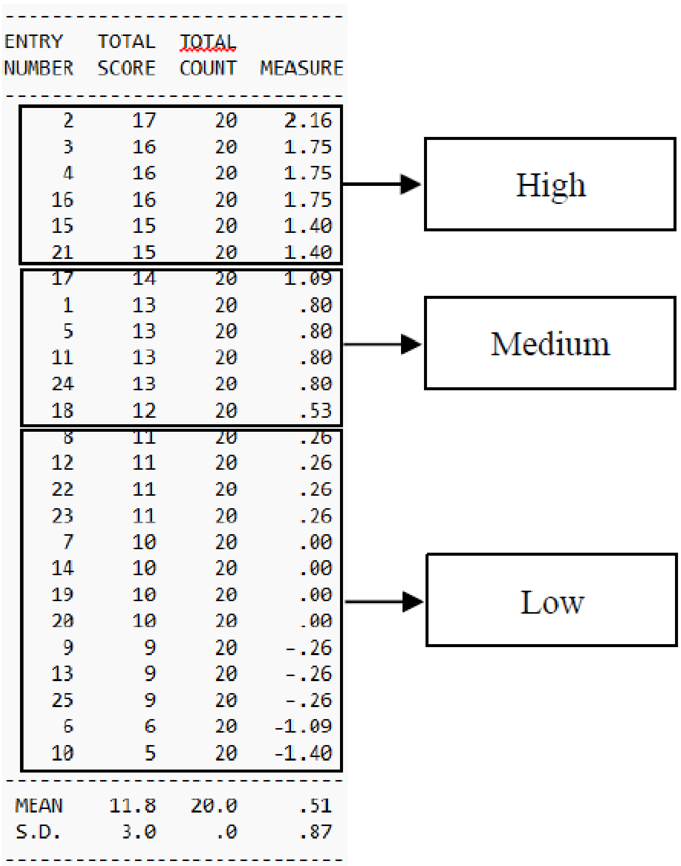


Figure 2. Wright Map Person-Item

The item difficulty analysis reveals a proportional distribution, ensuring the instrument is sensitive enough to capture variations in student ability across all levels (Sumintono & Widhiarso, 2015). This balanced distribution is further visualized in the Wright Map Person-Item (Figure 2), which shows excellent targeting between item difficulty and student ability. This alignment ensures that the instrument provides meaningful measurement information for both high-achieving and struggling students, meeting the criteria for a high-quality assessment tool that supports accurate and equitable interpretation of literacy profiles (Hambleton & Swaminathan, 1985).

The instrument's internal consistency is evidenced by an item reliability of .97 and a separation index of 5.39, indicating that the item hierarchy is stable and replicable (Boone et al., 2014; Tavakol & Dennick, 2011). These high separation values allow the instrument to provide nuanced information across various difficulty strata, advancing existing assessment practices by offering a more precise diagnosis of student literacy. When applied to a measurement class, the results provided an objective mapping of students' abilities on a logit scale, where higher values directly correlate with better scientific reasoning (Hernandes & Yusmaita, 2023).

Profiling results, as shown in Figure 3, indicate that the majority of students fall into the low-science-literacy category, reflecting a critical gap in their ability to reason about phenomena and interpret data. This finding is consistent with broader studies indicating that Indonesian junior high students continue to struggle to bridge scientific theory with practical application (Alfarizy & Jauhariyah, 2025; Rizky et al., 2024). By integrating local wisdom, this instrument highlights that students' literacy achievement is deeply tied to their familiarity with scientific contexts. This underscores the theoretical implication that contextualized assessment is vital for accurately diagnosing and improving literacy outcomes.



ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE
2	17	20	2.16
3	16	20	1.75
4	16	20	1.75
16	16	20	1.75
15	15	20	1.40
21	15	20	1.40
17	14	20	1.09
1	13	20	.80
5	13	20	.80
11	13	20	.80
24	13	20	.80
18	12	20	.53
8	11	20	.26
12	11	20	.26
22	11	20	.26
23	11	20	.26
7	10	20	.00
14	10	20	.00
19	10	20	.00
20	10	20	.00
9	9	20	-.26
13	9	20	-.26
25	9	20	-.26
6	6	20	-1.09
10	5	20	-1.40
MEAN	11.8	20.0	.51
S.D.	3.0	.0	.87

Figure 3. Output person measure

In conclusion, the application of the ADDIE model in this study demonstrates that science literacy assessment can be effectively localized without compromising psychometric rigor. While this study is limited to the cultural context of Batang Regency, it offers a scalable model for developing culturally responsive assessments that align with established literacy indicators. This research provides an empirical foundation for future studies to further investigate how ethnoscience-based assessments can stimulate scientific reasoning. Ultimately, this instrument serves as both a valid measurement tool and a potential stimulus for science learning, connecting school concepts with students' daily realities.

CONCLUSION

This study successfully developed a science literacy instrument that effectively bridges global competency frameworks with localized ethnoscience contexts. The findings demonstrate that integrating local wisdom into assessment does not compromise psychometric rigor; rather, it provides a stable, objective tool for measuring higher-order thinking skills among junior high school students. The primary contribution of this research lies in its empirical evidence that contextualized stimuli can accurately map students' literacy profiles, revealing a significant gap between theoretical knowledge and its practical application in daily life.

The practical implications of this research suggest that educators and policymakers should prioritize the development of culturally responsive assessments to enhance the relevance of science instruction. By utilizing familiar local phenomena, assessments can serve as both a diagnostic tool and a learning stimulus that fosters scientific reasoning. Future research should expand the application of this ethnoscience-based framework across more diverse cultural contexts and larger student populations to test its generalizability. Ultimately, this research provides a scalable foundation for advancing science literacy assessment practices that are both locally grounded and aligned with modern educational demands.

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