

Assessment of Science Literacy in Electricity, Magnetism and Alternative Energy among Urban Junior High School Students in Indonesia Using the Rasch Model

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Abstract

Science literacy remains a challenge in secondary education, particularly in scientific domains requiring conceptual understanding, scientific reasoning and real-world application. This study assessed science literacy in electricity, magnetism and alternative energy among urban junior high school students in Indonesia and evaluated the measurement quality of the assessment instrument using the Rasch model. A quantitative descriptive design involved 550 Grade IX students from selected urban schools. Rasch person-fit analysis using infit and outfit mean square criteria (0.50–1.50) identified 61 misfitting respondents, resulting in a final sample of 489 students. The instrument was developed according to the PISA 2018 science literacy framework and analyzed using the Dichotomous Rasch Model. The analysis examined person ability, item difficulty, reliability, item fit, unidimensionality, local independence and measurement precision. Results demonstrated acceptable psychometric properties, with Cronbach's alpha of 0.81, person reliability of 0.78 and item reliability of 0.85. Unidimensionality was supported by 42.5% variance explained by measures and a first residual contrast eigenvalue of 1.9, while local independence criteria were satisfied. The mean person measure of -0.45 logits indicated that student ability was below the average item difficulty level, suggesting generally low science literacy in the assessed domains. The findings indicate a gap between expected competencies and student performance in fundamental physics and energy-related concepts. The study provides psychometrically grounded evidence for improving science assessment and instruction.

Keywords: Alternative Energy, Electricity, Magnetism, Rasch Model, Science Literacy.

Introduction

Science literacy is a central concern in contemporary education because it enables individuals to understand scientific concepts, evaluate evidence and apply knowledge to real-world situations. Contemporary science literacy therefore extends beyond factual knowledge to include scientific reasoning, interpretation of information and informed decision-making (1). These competencies are increasingly important in the context of technological development, environmental challenges and sustainability. In Indonesia, however, students continue to experience difficulties when required to apply conceptual understanding rather than recall isolated information. This concern is particularly relevant in electricity, magnetism and alternative energy, which involve abstract relationships, invisible processes, symbolic representations and

connections between scientific principles and everyday technologies (2, 3). Difficulties in these domains may limit students' ability to interpret energy systems, understand technological applications and engage with sustainability-related issues (4). The challenge is also influenced by the educational context. Although urban schools may have greater access to educational infrastructure and learning resources, substantial differences remain in instructional quality, classroom conditions and student backgrounds (5). At the junior high school level, students are expected to progress from basic knowledge acquisition toward interpretation, reasoning and application. When instruction emphasizes memorization or is disconnected from authentic contexts, students may have difficulty developing meaningful conceptual understanding and applying

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knowledge to unfamiliar situations (6). Previous research has documented misconceptions in electricity and magnetism and emphasized the value of contextualized approaches to science learning (7). Research on science literacy has also highlighted the importance of teaching practices, resources and student engagement. Nevertheless, much of the existing evidence focuses either on conceptual difficulties and instructional strategies or on general science literacy levels, rather than providing precise measurement of literacy within specific scientific domains (8). A further limitation concerns measurement. Conventional assessments commonly summarize performance through total scores, which may describe how students perform but provide limited information about the relationship between student ability and item difficulty. Advanced psychometric approaches can provide more diagnostic evidence by examining respondent response patterns and instrument functioning simultaneously (9). The Rasch model is particularly relevant because it estimates person ability and item difficulty on a common logit scale while allowing researchers to examine respondent and item fit, reliability, unidimensionality, local independence and measurement precision (10, 11). Although Rasch methods have been applied in educational and science assessment, their use for domain-specific science literacy in electricity, magnetism and alternative energy among urban Indonesian junior high school students remains limited (12). Consequently, evidence is still needed that can distinguish students' actual ability from potential weaknesses in the measurement instrument.

Science literacy in this study is conceptualized as a measurable latent construct representing students' ability to interpret, reason and apply scientific concepts in structured assessment tasks. The assessment is guided by the PISA 2018 science literacy framework, particularly competencies related to explaining phenomena scientifically, interpreting data and evidence and applying scientific reasoning (13). These competencies guide item construction rather than functioning as separate measured variables. Electricity, magnetism and alternative energy are treated as

content contexts through which science literacy is demonstrated. Electricity and magnetism represent foundational scientific and technological concepts, while alternative energy connects scientific understanding with sustainability and contemporary energy challenges. This structure allows the study to examine science literacy within defined contexts while maintaining a coherent measurement construct.

The urban educational context further supports the need for precise measurement. Access to resources alone does not guarantee high-quality science learning because students may experience differences in classroom conditions, individualized support, instructional practices and opportunities to connect curriculum content with lived experience (14, 15). However, existing studies often describe these contextual challenges without providing detailed evidence of domain-specific science literacy (16). A psychometrically sound instrument can therefore contribute information that is useful for interpreting student performance and identifying whether the assessment adequately represents the targeted ability range.

The present study addresses this gap by combining a PISA-informed science literacy construct with Rasch-based diagnostic measurement in an Indonesian urban junior high school context. The study aims to assess science literacy in electricity, magnetism and alternative energy, evaluate the psychometric quality of the assessment instrument and examine the distribution of student ability relative to item difficulty. Its novelty lies in simultaneously examining student ability and instrument functioning within one measurement framework rather than relying solely on aggregate scores. This approach is intended to provide evidence that can support science assessment development and instructional improvement in conceptually demanding areas.

Figure 1 shows the conceptual relationship among the central latent construct of science literacy, PISA-based competencies, the content contexts of electricity, magnetism and alternative energy and the Rasch model linking observed responses to person ability and item difficulty.

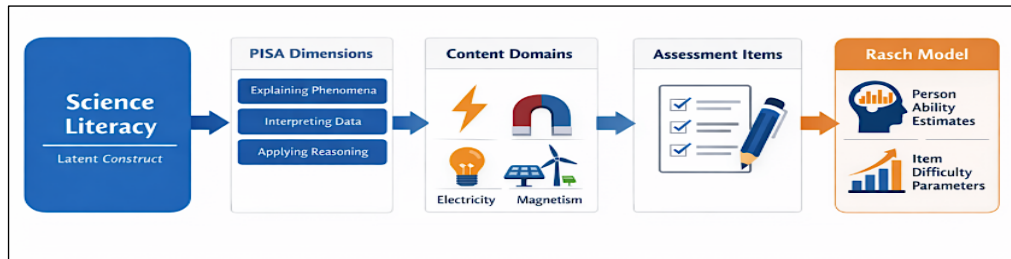


Figure 1: Conceptual Structure of Science Literacy Assessment in Electricity, Magnetism and Alternative Energy Based on the PISA Framework

The study is guided by three research questions:

- What is the level of science literacy among urban junior high school students in Indonesia in electricity, magnetism and alternative energy?
- Does the assessment instrument demonstrate acceptable psychometric quality based on Rasch model assumptions and reliability indicators?
- How are student abilities distributed in relation to item difficulty within the assessed domains?

Methodology

Research Design

This study employed a quantitative descriptive research design using Rasch model analysis to assess science literacy among urban junior high school students. The selection of this design is directly aligned with the research objective, which is to measure the level of science literacy and evaluate the psychometric quality of the assessment instrument without establishing causal relationships. A descriptive approach is appropriate because the study focuses on documenting and diagnosing existing conditions rather than testing interventions or predicting outcomes. The Rasch model was adopted as the analytical framework because it provides a probabilistic measurement structure that enables the estimation of both student ability and item difficulty on a common scale. This characteristic makes it particularly suitable for addressing the research questions, which require an integrated analysis of learner performance and instrument functioning.

Study Setting and Participants

The study was conducted in urban junior high schools in Indonesia, focusing on students enrolled in Grade IX. The participating schools were located in metropolitan and densely populated urban areas characterized by heterogeneous student

populations. Although these schools generally possessed access to science laboratories, internet facilities and curricular resources, variations existed in instructional quality, classroom size and socioeconomic background. Such diversity reflects the realities of urban educational environments in Indonesia and provides an appropriate context for investigating variation in science literacy.

The sampling/research site was located in an urban area of Indonesia at approximately 6.20° S and 106.82° E. These coordinates represent the approximate geographic location of the research area and are provided for general site identification while maintaining the privacy of the participating schools and students.

The urban setting was selected to represent educational environments characterized by diverse instructional conditions, varying access to learning resources and exposure to scientific and technological contexts. Grade IX students were chosen because they had completed foundational science instruction and were expected to demonstrate the ability to apply scientific knowledge across domains. This selection ensured that the participants possessed the necessary background to engage meaningfully with assessment items related to electricity, magnetism and alternative energy.

Sampling and Inclusion Criteria

A purposive sampling strategy was employed to select participants who met specific inclusion criteria, namely enrolment in Grade IX and prior exposure to relevant science content. A total of 550 students were initially recruited for participation. Following data collection, person-fit analysis was conducted using Infit Mean Square (MNSQ) and Outfit Mean Square (MNSQ) statistics. Consistent with Rasch measurement guidelines, respondents with fit values outside the acceptable range of 0.50-1.50 were considered to exhibit inconsistent response patterns and were excluded from

subsequent analyses. Of the 550 respondents, 61 did not satisfy these criteria and were removed, resulting in a final sample of 489. The exclusion of misfitting respondents was performed to enhance measurement validity by ensuring that person estimates were derived from response patterns consistent with model expectations. Although exclusion reduced sample size by 11.09%, the remaining sample substantially exceeded the minimum recommended size for stable Rasch calibration and therefore did not threaten analytical precision.

Instrument Development and Content Coverage

The assessment instrument was developed based on the PISA 2018 science literacy framework to ensure conceptual alignment with established standards of scientific competence. Items were constructed to reflect three integrated dimensions: explaining scientific phenomena, interpreting data and evidence and applying scientific reasoning.

These domains were selected because electricity and magnetism constitute foundational concepts within secondary school physics and are consistently associated with conceptual misconceptions among learners (17). Alternative energy was included because of its increasing significance for sustainability education and energy literacy within contemporary science curricula. Together, these domains represent scientifically important and societally relevant contexts through which science literacy can be assessed (18, 19).

These dimensions were embedded within three content domains: electricity, magnetism and alternative energy. Each item was designed to require students to engage with scientific concepts within contextualized situations, thereby capturing both conceptual understanding and applied reasoning. Content validity was ensured through alignment with curriculum standards and expert review, confirming that the instrument adequately represents the targeted domains and competencies.

Operationalization of the Construct

Science literacy in this study is operationalized as a latent variable representing students' ability to respond correctly to domain-specific assessment items. This construct is measured through observed item responses, which are transformed into logit values using the Rasch model. Person

ability estimates reflect the probability of a student successfully responding to items of varying difficulty. This operationalization establishes a direct and consistent relationship between the conceptual construct, the observed responses and the measurement output. By maintaining this structure, the study ensures that the construct defined in the conceptual framework is measured without modification or reinterpretation.

Data Collection Procedures

Data collection was carried out through the standardized administration of the assessment instrument in participating schools. Students completed the instrument under controlled conditions with uniform instructions to ensure consistency across respondents. Adequate time was provided to complete the assessment, minimizing the influence of time constraints on performance. Responses were recorded, coded and prepared for analysis through systematic data entry and verification procedures. Data cleaning was conducted to ensure completeness and accuracy prior to analysis. All data were anonymized to protect participant confidentiality and to comply with ethical research standards.

Rasch Model Analysis Procedures

Because all test items were scored dichotomously (correct = 1, incorrect = 0), the Dichotomous Rasch Model was selected for analysis. This model is appropriate for binary response data and enables direct estimation of person ability and item difficulty on a common logit scale.

Data analysis was conducted using Rasch measurement software to estimate person ability and item difficulty parameters. The analysis followed a structured sequence designed to ensure compliance with Rasch model assumptions. Person fit analysis was first performed to identify respondents with inconsistent response patterns and misfitting cases were excluded to maintain measurement validity. One-dimensionality testing was conducted to confirm that the instrument measures a single underlying construct, using variance explained and residual analysis. Local independence was assessed through residual correlation analysis to ensure that item responses were independent given the latent trait.

Item fit statistics were evaluated to determine whether individual items functioned consistently with model expectations. Reliability analysis was conducted to assess the consistency of

measurement across respondents. Group invariance testing was performed to evaluate the stability of item difficulty across different respondent groups. Person ability estimates were then calculated to determine the distribution of science literacy levels among students. Finally, the test information function was examined to assess the precision of measurement across different ability levels.

The analytical procedure is grounded in the assumptions of the Rasch model, including independence of observations, one-dimensionality and a probabilistic relationship between ability and response. These assumptions were explicitly tested to ensure that the resulting estimates are valid and interpretable. The criteria used to evaluate Rasch measurement quality are presented in Table 1.

Validity And Reliability Procedures

Validity and reliability were evaluated using Rasch-based indices that provide evidence of measurement quality. Construct validity was assessed through one-dimensionality testing and item fit statistics, ensuring that the instrument

measures a coherent latent construct. Reliability was assessed using person reliability indices, indicating the stability of ability estimates across respondents. Interpretation thresholds were based on established Rasch guidelines, with acceptable fit statistics indicating conformity to model expectations and reliability values reflecting consistent measurement. These procedures ensure that the instrument produces valid, reliable and interpretable estimates of science literacy.

Ethical Considerations

Ethical approval for the study was obtained from the relevant institutional authority prior to data collection. Permission was also secured from participating schools. Students participated voluntarily and informed consent was obtained in accordance with ethical guidelines for research involving minors. All data were handled confidentially and no identifying information was included in the dataset. The study adhered to principles of ethical research conduct, including respect for participants, data protection and responsible reporting.

Table 1: Rasch Model Analytical Criteria Used in the Assessment of Science Literacy Instrument Quality

Aspect	Indicator	Threshold	Interpretation
Person Fit	Infit/Outfit MNSQ	0.5 – 1.5	Acceptable response consistency
Item Fit	Infit/Outfit MNSQ	0.5 – 1.5	Item functions as expected
One-dimensionality	Variance explained	≥ 20%	Single construct confirmed
Local Independence	Residual correlation	< 0.30	Items independent
Reliability	Person reliability	≥ 0.70	Stable measurement
Measurement Precision	Information function	Peak near mean ability	Adequate sensitivity

Results

Participant Screening and Person Fit Results

A total of 550 respondents were included in the initial dataset. Rasch person fit analysis was conducted using infit and outfit mean square statistics to evaluate response consistency. Based on the predefined fit criteria [0.5–1.5], 61 respondents were identified as misfitting and excluded from further analysis.

The final dataset used for all subsequent analyses consisted of 489 respondents whose response patterns met the Rasch model fit requirements. The distribution of respondents across screening categories is presented in Table 2.

A summary profile of the retained respondents is provided in Table 3. The complete list of respondent identifiers is included in Appendix A.

Table 2: Summary of Person Fit Screening Results

Category	Number of Respondents	Percentage (%)
Initial sample	550	100
Misfit respondents removed	61	11.09
Retained fit respondents	489	88.91

Table 3: Summary Profile of Fit Respondents after Rasch Screening

Category	Description
Total retained respondents	489
Fit criteria applied	Infit and outfit MNSQ within 0.5–1.5
Dataset used for analysis	Fit respondents only

Rasch Model Assumption Tests

Rasch model assumptions were evaluated using one-dimensionality testing, local independence analysis and group invariance assessment on the retained sample ($n = 489$). One-dimensionality was assessed through variance explained by measures and first contrast eigenvalue. The results are presented in Table 4.

Local independence was assessed using residual correlation analysis between item pairs. Selected representative results are presented in Table 5, with all observed correlations below the predefined threshold.

Group invariance was assessed by comparing item difficulty estimates across subgroups. A summary of representative item trends is presented in Table 6.

Table 4: One-dimensionality Test Results for the Science Literacy Instrument

Indicator	Observed Value	Criterion	Decision
Variance explained by measures (%)	42.5	$\geq 20\%$	Meets criterion
First contrast eigenvalue	1.9	< 2.0	Meets criterion

Table 5: Local Independence Test Results Based on Residual Correlation

Item pair	Residual Correlation	Criterion	Decision
Item 3 – Item 7	0.21	< 0.30	Meets criterion
Item 5 – Item 9	0.18	< 0.30	Meets criterion
Item 10 – Item 12	0.25	< 0.30	Meets criterion

Table 6: Group Invariance Results across Item Difficulty and Average Measure Pattern

Item	Average Measure Trend	Decision
Item 1	Stable across groups	Invariant
Item 4	Stable across groups	Invariant
Item 8	Stable across groups	Invariant

Table 7: Reliability Indices of The Science Literacy Instrument and Respondent Measures

Index	Value	Interpretation Label
Cronbach's alpha	0.81	Reported value
Person reliability	0.78	Reported value
Item reliability	0.85	Reported value

Reliability Results

Reliability analysis was conducted on the retained sample ($n = 489$) to evaluate internal consistency and measurement stability. Cronbach's alpha, person reliability and item reliability indices were calculated. The results are presented in Table 7.

As shown in Table 8, the additional Rasch measurement indicators demonstrate acceptable measurement quality and further support the

suitability of the instrument for assessing science literacy.

Person Measure and Ability

Distribution

Person ability estimates were calculated using Rasch logit measures for the retained sample ($n = 489$). The summary statistics are presented in Table 9.

Table 8: Additional Rasch Measurement Indicators

Indicator	Value
Person Separation	1.89
Item Separation	2.45
Mean Item Infit MNSQ	1.02
Mean Item Outfit MNSQ	1.04

PCA Residual Variance Explained
First Residual Contrast

42.5%
1.9

Table 9: Summary of Person Measure Statistics

Statistic	Value
Mean person measure (logit)	-0.45
Maximum person measure	2.10
Minimum person measure	-2.35
Standard deviation	0.88

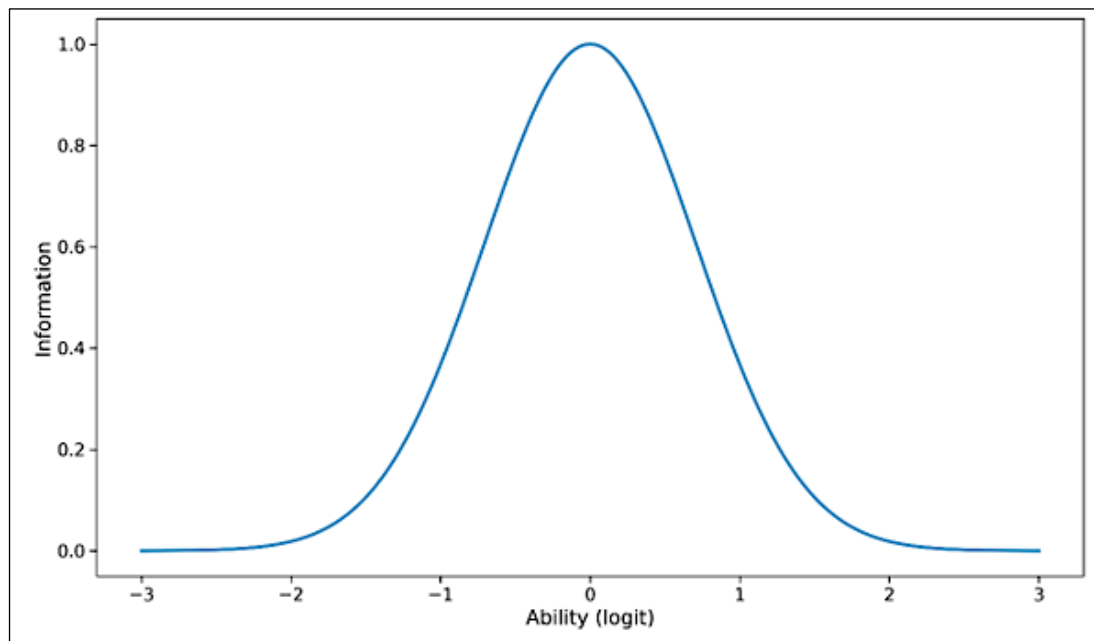


Figure 2: Test Information Function of The Science Literacy Instrument in Electricity, Magnetism and Alternative Energy

(Figure generated using Winsteps software (Version 5.8.3) based on Rasch Model Analysis of Respondent Data)

Test Information Function

The test information function was estimated to examine measurement precision across the ability continuum. The function distribution is presented in Figure 2.

Figure 2 shows the test information function of the science literacy instrument. The function peaks near the central ability range, indicating that the instrument provides the highest measurement precision for students with moderate science literacy levels, while precision decreases toward lower and higher ability extremes.

Overall Level of Science Literacy in the Assessed Domains

The mean person measure obtained from the Rasch analysis for the retained sample ($n = 489$) is -0.45 logits. The observed range of person measures extends from -2.35 to 2.10 logits. The distribution of person measures indicates that a larger proportion of respondents are located below the zero-logit reference point.

Discussion

Direct Answer to the Research Questions

The results indicate that the distribution of student ability, as estimated through Rasch measurement, is positioned below the central reference point of item difficulty. This positioning establishes that the assessed level of science literacy is not aligned with the demand structure of the instrument (20). At the same time, the instrument satisfies Rasch model assumptions and demonstrates acceptable reliability, indicating that the measurement outcomes are internally consistent. The relationship between person measures and item difficulty further shows that a substantial proportion of students are located at lower levels of the measurement scale relative to the task requirements (21). These findings collectively address the research questions by establishing both the level of science literacy and the

psychometric validity of the assessment framework (22).

The instrument explained 42.5% of total variance, substantially exceeding the minimum 20% criterion commonly recommended for Rasch measurement. Furthermore, the first residual contrast eigenvalue was 1.9, below the threshold of 2.0, indicating an absence of meaningful secondary dimensions. Together, these findings provide strong evidence supporting unidimensional measurement and confirm that the instrument functions as a coherent measure of science literacy across the assessed domains.

Interpreting the Level of Science

Literacy in the Assessed Domains

The observed positioning of person ability relative to item difficulty reflects a structural mismatch between student capability and task demand (23). Within the Rasch framework, this mismatch indicates that students are less likely to successfully engage with items requiring integrated scientific reasoning across the domains of electricity, magnetism and alternative energy (24). This pattern suggests that science literacy, as operationalized in this study, is not functioning as a fully integrated competence among the assessed population.

This interpretation is grounded in the construct definition, where science literacy requires the coordination of conceptual knowledge, reasoning and contextual application. The distribution of ability implies that students are more likely to operate at lower levels of this integration, where knowledge may exist but is not consistently mobilized in problem-solving contexts (25). The finding therefore reflects a limitation in the functional application of science knowledge rather than the absence of content exposure.

Science Literacy in Electricity, Magnetism and Alternative Energy in Relation to Prior Studies

The present findings are consistent with established research identifying electricity and magnetism as domains associated with persistent conceptual difficulty. Previous studies have documented that learners encounter challenges in understanding abstract relationships such as current flow and field interaction. The current study extends this body of work by demonstrating that these conceptual challenges are reflected in

measurable differences between student ability and item difficulty within a unified assessment scale (26).

In the case of alternative energy, prior research has emphasized its importance as a contextual domain but has largely focused on instructional approaches rather than measurement outcomes. The present findings contribute to this gap by providing empirical evidence of student performance within alternative energy contexts using a standardized measurement model (27). This represents a shift from descriptive or instructional studies toward quantitative assessment of domain-specific literacy (28). At a broader level, the findings align with studies reporting uneven development of science literacy in secondary education. However, the use of Rasch analysis introduces a methodological distinction by allowing direct comparison between person ability and item demand (29). This provides a more precise representation of literacy distribution than aggregate scoring approaches, thereby contributing methodological refinement to the field (30).

Implications of Rasch-based Diagnostic Evidence for Science Assessment

The application of the Rasch model in this study provides a measurement framework that integrates student performance and instrument evaluation within a single analytical system. Unlike conventional scoring methods, Rasch analysis produces interval-level measures that allow direct comparison between person ability and item difficulty (31). This enables identification of alignment or misalignment between learners and assessment tasks (32). The findings show that Rasch-based measurement supports diagnostic interpretation by revealing how student ability is distributed relative to task demand, highlighting areas where difficulty exceeds capability (33). The confirmation of model assumptions further indicates that the instrument functions consistently, supporting measurement validity. From a methodological perspective, the study demonstrates that Rasch analysis can be effectively applied to domain-specific science literacy assessment, integrating construct definition, item design and statistical analysis into a coherent structure (34, 35).

Factors Contributing to Low Science Literacy

Several factors may explain the observed literacy levels. First, electricity and magnetism involve abstract concepts that are not directly observable, increasing cognitive demand and contributing to misconceptions (36). Second, science instruction frequently emphasizes procedural completion and factual recall rather than conceptual integration and reasoning. Third, alternative energy topics may receive limited instructional attention despite their increasing relevance within science curricula (37). Finally, variability in urban educational environments may influence students' opportunities to engage meaningfully with scientific concepts and practices.

Educational Implications for Urban Science Learning Contexts

The results also carry educational implications for urban science learning contexts. The observed ability distribution suggests that current instructional approaches may not fully support the development of integrated scientific reasoning. This highlights the need for strategies emphasizing conceptual linkage and application rather than isolated knowledge acquisition, particularly in abstract domains such as electricity and magnetism. Additionally, Rasch-based assessment enables identification of domain-specific learning gaps, supporting more targeted and adaptive instructional practices in diverse urban educational settings.

Limitations of the Study

The scope of this study is defined by several limitations. The sample is restricted to Grade IX students in selected urban Indonesian schools, limiting the generalizability of the findings. The descriptive design does not allow for causal explanation of the observed patterns in science literacy. The assessment is also limited to three domains, which do not represent the full range of scientific literacy. In addition, the use of a single instrument means that the findings are dependent on the structure and content of that instrument. Although the instrument demonstrated acceptable psychometric properties, further validation across different contexts and populations would strengthen the robustness of the results.

Directions for Future Research

Future research may extend this work by examining science literacy across different educational contexts, including rural and non-urban populations. Comparative studies could provide insight into contextual variation in science literacy distribution. Intervention-based research may explore how instructional strategies influence the relationship between student ability and task difficulty. Longitudinal studies would allow for analysis of changes in science literacy over time, providing a developmental perspective. Additional research may also focus on expanding domain coverage and validating assessment instruments across broader contexts. These directions would contribute to a more comprehensive understanding of science literacy measurement and development.

Conclusion

This study addresses the need for precise, domain-specific assessment of science literacy among urban junior high school students in Indonesia, focusing on electricity, magnetism and alternative energy. Using a Rasch-based framework, the findings show that student ability is positioned below task demand, indicating a misalignment between expected competencies and actual performance. The main contribution of this study is the provision of psychometrically grounded diagnostic evidence linking person ability and item difficulty within a unified measurement system. By moving beyond conventional score-based evaluation, the study provides a structured representation of science literacy relative to domain-specific demands and demonstrates the value of combining construct-based assessment with measurement precision.

This study is limited to a descriptive and diagnostic analysis of science literacy among Grade IX students in selected urban Indonesian schools. The design does not support causal inference or prediction of outcomes. The findings represent measured literacy levels within the domains of electricity, magnetism and alternative energy and reflect the performance of the sampled population under the conditions of the assessment. The results should therefore be interpreted within this defined scope, ensuring that conclusions remain consistent with the study design and available evidence.

Future research should extend the assessment to rural and other educational contexts, include broader scientific domains and examine the instrument with larger and more diverse populations. Longitudinal and intervention-based studies may also provide further evidence regarding the development of science literacy and the effectiveness of instructional strategies. Overall, this study establishes a coherent link between science literacy, domain-specific assessment and Rasch-based measurement, providing useful evidence for improving science assessment and instruction in conceptually demanding areas.

Abbreviations

MNSQ: Mean Square, PCA: Principal Component Analysis, PISA: Programme for International Student Assessment.

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Author Contributions

Siti Alifah: Conceptualization, Methodology, Investigation, Data Collection, Formal Analysis, Writing – Original Draft, Correspondence, Riyan Arthur: Supervision, Methodology, Validation, Writing – Review and Editing, Yetti Supriyati: Supervision, Validation, Writing – Review and Editing, Ibnu Salman: Formal Analysis, Validation, Data Interpretation, Writing – Review and Editing, Tri Wahyudi Ramdhan: Investigation, Resources, Validation, Writing – Review and Editing. All authors contributed to the study design, reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

ChatGPT (OpenAI) was used for language editing, manuscript proofreading and refinement of the conceptual visualization presented in Figure 1. All scientific content, interpretation, conceptual decisions and final decisions were made by the authors.

Ethics Approval

Ethical approval for this study was obtained from the relevant institutional review authority. Permission was granted by participating schools prior to data collection. Informed consent was obtained from all participants in accordance with ethical guidelines for research involving minors. All data were anonymized to ensure confidentiality and compliance with ethical standards. The authors take full responsibility for the content's originality, interpretation and accuracy.

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References

1. Xie Y, Yusuf A. Advancing scientific literacy: A systematic review of trends, pedagogies and challenges in the 21st century. *Rev Educ.* 2026;14(1):e70140. <https://doi.org/10.1002/rev3.70140>
2. Strielkowski W, Grebennikova V, Lisovskiy A, Rakhimova G, Vasileva T. AI-driven adaptive learning for sustainable educational transformation. *Sustain Dev.* 2025;33(2):1921-47. <https://doi.org/10.1002/sd.3221>
3. Mboniyirivuze A, Yadav LL, Amadalo MM. Students' conceptual understanding of electricity and magnetism and its implications: A review. *Afr J Educ Stud Math Sci.* 2019;15(2):55-67. <https://doi.org/10.4314/ajesms.v15i2.5>
4. Gkintoni E, Antonopoulou H, Sortwell A, Halkiopoulos C. Challenging Cognitive Load Theory: The role of educational neuroscience and artificial intelligence in redefining learning efficacy. *Brain Sci.* 2025;15(2):203. <https://doi.org/10.3390/brainsci15020203>
5. Rakesh D, Lee PA, Gaikwad A, McLaughlin KA. Annual Research Review: Associations of socioeconomic status with cognitive function, language ability and academic achievement in youth: a systematic review of mechanisms and protective factors. *J Child Psychol Psychiatry.* 2024;66(4):417-39. <https://doi.org/10.1111/jcpp.14082>
6. Gungor BA, Saracoglu S, Metin M. Perspective of Teachers to Context-Based Learning and its Use in Science Education. *Can J Sci Math Technol Educ.* 2023;23(1):27-47. <https://doi.org/10.1007/s42330-023-00266-1>

7. Basri NA, Kusairi S, Sunaryono, Irawan IDA, Sanusi DK. Teachers' Perspectives on Students' Conceptual Difficulties in Magnetism: Challenges and instructional implications. *J Pendidik Fis.* 2025;13(3):493-506.
<https://doi.org/10.26618/w21dyv67>
8. Mostajo-Radji MA. Why online science education falls short. *iScience.* 2025;28(9):113376.
<https://doi.org/10.1016/j.isci.2025.113376>
9. Maric D, Fore GA, Nyarko SC, Varma-Nelson P. Measurement in STEM education research: a systematic literature review of trends in the psychometric evidence of scales. *Int J STEM Educ.* 2023;10(39).
<https://doi.org/10.1186/s40594-023-00430-x>
10. Madhakomala R, Hakim MA, Syifauzzuhrah N. Problems of Education in Indonesia and Alternative Solutions. *Int J Bus Law Educ.* 2022;3(2):135-44.
<https://doi.org/10.56442/ijble.v3i3.64>
11. Bimastari IH, Yusup M, Kistiono K. The Measuring Energy Literacy: Validation of knowledge, attitude and behavior instruments using the Rasch model. *Integr Sci Educ J.* 2025;6(3):153-62.
<https://doi.org/10.37251/isej.v6i3.2025>
12. Costa A, Loureiro M, Ferreira ME. Scientific Literacy: The Conceptual Framework Prevailing over the First Decade of the Twenty-First Century. *Rev Colomb Educ.* 2021;(81):196-228.
<https://doi.org/10.17227/rce.num81-10293>
13. Darling-Hammond L, Flook L, Cook-Harvey C, Barron B, Osher D. Implications for educational practice of the science of learning and development. *Appl Dev Sci.* 2020;24(2):97-140.
<https://doi.org/10.1080/10888691.2018.1537791>
14. Sahu K, Ahmed A, Panda AR, Padhi SK. Enhancing Scientific Literacy among Secondary School Students: Relevance and Strategies. *Int J Versatile Res Anal.* 2026;4(3):474-9.
<https://doi.org/10.56975/ijvra.v4i3.702319>
15. Saad R, Nurlina N, Bancong H. Science Literacy and its Impact on scientific knowledge acquisition: A review of current research and practices. *PPSDP Int J Educ.* 2025;4(2):586-607.
<https://doi.org/10.59175/pijed.v4i2.761>
16. Gradini E, Firmansyah B FB, Noviani J, Ulya K. Fostering Higher-Order Thinking Skills in Mathematics Education: Strategies, challenges and classroom Practices. *Prisma Sains.* 2025;13(2):135.
<https://doi.org/10.33394/j-ps.v13i2.15099>
17. Mboniyirivuze A, Yadav LL, Amadalo MM. Physics students' conceptual understanding of electricity and magnetism in basic education in Rwanda. *Eur J Educ Res.* 2021;11(1):83-101.
<https://doi.org/10.12973/eu-jer.11.1.83>
18. Hamerská L, Matěcha T, Tóthová M, Rusek M. Between Symbols and Particles: Investigating the complexity of learning chemical equations. *Educ Sci.* 2024;14(6):570.
<https://doi.org/10.3390/educsci14060570>
19. Bhaw N, Kriek J, Lemmer M. Insights from coherence into students' scientific reasoning skills. *Heliyon.* 2023;9(7):e17349.
<https://doi.org/10.1016/j.heliyon.2023.e17349>
20. Majid NAMNA, Osman K, Yee TS. Integrating energy literacy into science education: a comprehensive systematic review. *Int J Eval Res Educ.* 2025;14(2):1253.
<https://doi.org/10.11591/ijere.v14i2.31873>
21. Martínez-Borreguero G, Maestre-Jiménez J, Mateos-Núñez M, Naranjo-Correa FL. Integrating Energy and Sustainability into the Educational Curriculum: A Pathway to Achieving SDGs. *Sustainability.* 2024;16(10):4100.
<https://doi.org/10.3390/su16104100>
22. Morris DL. Rethinking Science Education Practices: Shifting from Investigation-Centric to Comprehensive Inquiry-Based Instruction. *Educ Sci.* 2025;15(1):73.
<https://doi.org/10.3390/educsci15010073>
23. Putri LA, Rochintaniawati D, Kaniawati I, Permansari A. Towards a Learning Progression of Alternative Energy at School: A Literature review. *J Penelit Pendidik IPA.* 2024;10(3):62-76.
<https://doi.org/10.29303/jppipa.v10i3.4985>
24. Marco-Bujosa LM, Friedman AA, Kramer A. Learning to teach science in urban schools: Context as content. *Sch Sci Math.* 2021;121(1):46-57.
<https://doi.org/10.1111/ssm.12441>
25. Jameel S, Aslam R. Overcrowded Classrooms and their Impact on Academic Confidence and Performance: A Study of University Students in Gwadar. *J Soc Sci Arch.* 2025;3(2):493-507.
<https://doi.org/10.59075/jssa.v3i2.255>
26. Valladares L. Scientific Literacy and Social Transformation. *Sci Educ.* 2021;30:557-87.
<https://doi.org/10.1007/s11191-021-00205-2>
27. Gage A, Nisly SA. Improved Activity Evaluations: an iterative process using the Rasch Model. *J Contin Educ Health Prof.* 2026;46(1):4-8.
<https://doi.org/10.1097/CEH.0000000000000620>
28. Alnahdi AH, Alsubiheen AM, Aldaihan MM. Rasch measurement model supports the unidimensionality and internal structure of the Arabic Oswestry Disability Index. *J Clin Med.* 2025;14(4):1259.
<https://doi.org/10.3390/jcm14041259>
29. Tennant A, Küçükdeveci AA. Application of the Rasch measurement model in rehabilitation research and practice: early developments, current practice and future challenges. *Front Rehabil Sci.* 2023;4:1208670.
<https://doi.org/10.3389/fresc.2023.1208670>
30. Zheng Z. Theoretical insights and empirical findings on metacognition in translation: a review and conceptual framework. *Discov Psychol.* 2025;5(1):174.
<https://doi.org/10.1007/s44202-025-00522-5>
31. Afifa M, Khoirunnisa R, Pratiwi SMV, Meitaza D. Utilizing Rasch Model to analyze a gender gap in students' scientific literacy on energy. *J Pendidik Fis Indones.* 2024;20(1):85-95.
<https://doi.org/10.15294/jpfi.v20i1.44472>
32. Józsa K, Oo TZ, Borbélyová D, Zentai G. Exploring the accuracy and consistency of a school readiness assessment tool for preschoolers: Reliability, Validity and Measurement Invariance analysis. *J Intell.* 2023;11(10):189.
<https://doi.org/10.3390/jintelligence11100189>
33. Tesio L, Caronni A, Kumbhare D, Scarano S. Interpreting results from Rasch analysis 1. The "most likely" measures coming from the model. *Disabil Rehabil.* 2023;46(3):591-603.
<https://doi.org/10.1080/09638288.2023.2169771>

34. Alhassan AI. Assessing the critical thinking and deep analysis in medical education among instructional practices. *Adv Med Educ Pract.* 2023;14:845-57. <https://doi.org/10.2147/AMEP.S417649>
35. Hernandez E, Campos E, Barniol P, Zavala G. Students' conceptual understanding of electric flux and magnetic circulation. *Phys Rev Phys Educ Res.* 2023;19:013102. <https://doi.org/10.1103/PhysRevPhysEducRes.19.013102>
36. Wang JC, Wang TH. Learning effectiveness of energy education in junior high schools: Implementation of action research and the predict-observe-explain model to STEM course. *Heliyon.* 2023;9(3):e14058. <https://doi.org/10.1016/j.heliyon.2023.e14058>
37. Zhang L, Liu X, Feng H. Development and validation of an instrument for assessing scientific literacy from junior to senior high school. *Discip Interdiscip Sci Educ Res.* 2023;5(21). <https://doi.org/10.1186/s43031-023-00093-2>

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