



The Developmental Mathematical Literacy Instruments for Junior High School Teachers: Construction and Validation Study

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Abstract

Teachers are required to facilitate students' mathematical literacy, but teachers' literacy skills are rarely considered due to the lack of instruments for assessing teachers' mathematical literacy. This study aims to develop a mathematical literacy instrument for teachers, focusing on the processes of instrument construction and validation. This Design-Based Research (DBR) adopts the Tessmer formative evaluation development model, consisting of preliminary, self-evaluation, expert reviews, one-to-one, small-group, and field tests. This study involved two experts as instrument validators (logical validity) and a total of 60 junior high school teachers in Yogyakarta Province to assess readability at the one-to-one stage and in small groups as subjects of field tests (empirical validation). The logical validation results were analyzed using the Aiken V index; readability test results were analyzed descriptively; and the results of empirical validation were analyzed using SPSS. The instrument construction process follows the principles of educational assessment development within the PISA framework and produces 25 literacy items, each involving 10 stimuli with varying contexts. The average V Aikens of 0.95 indicates a valid instrument, while the average readability test score of 4.14 indicates the instrument is in the good readability category. Based on the field test results, each item is valid because it has a Sig value ≤ 0.05 . Overall, the question instrument is reliable, with a Cronbach's alpha (α) of $0.860 > 0.7$. The instrument can measure mathematical literacy skills among teachers and assess all levels of thinking and question difficulty.

Key Words: desain-based research (DBR); junior high school; mathematical literacy; tessmer; validation study



INTRODUCTION

Mathematical literacy has become a global focus of attention because it is a crucial skill needed in everyday life (Holenstein et al., 2021) in the 21st century. Mathematical literacy is not just the ability to calculate (Kappassova et al., 2025), but also about the ability to reason (OECD, 2016, 2019, 2023), solve non-routine problems, and apply mathematical knowledge in a variety of everyday contexts (OECD, 2016; Tout et al., 2023); Omiraliyeva, 2024). These skills are essential for modern society to solve problems that require critical reasoning (Manfreda Kolar, V.M; Hodnik, 2021) as well as to read and make data-driven decisions on social, economic, and environmental issues (Chen et al., 2022), for example, climate change (Pulsiri et al., 2019). Furthermore, mathematical literacy is a key pillar in realizing the Sustainable Development Goals (SDGs) (McKay, 2018), which, in turn, contributes to holistic sustainable development (Kioupi & Voulvoulis, 2019). The existence of PISA, the Program for International Assessment, which measures students' mathematical literacy skills in countries belonging to the Organization for Economic Co-operation and Development (OECD), further underscores that mathematical literacy is an international concern (OECD, 2016).

Although essential, Indonesian students' mathematical literacy needs improvement. PISA results show that Indonesian students' mathematical literacy scores are far below the OECD average and have declined over the past three rounds, particularly in mathematics literacy. However, Indonesia's ranking in 2022 is better than in the previous period (OECD, 2023). Research findings at the elementary through high school levels also indicate that Indonesian students' mathematical literacy remains low (Aisyah Aisyah, 2022). A review of research in Indonesia also concluded that students' mathematical literacy skills remain low (Muhaimin et al., 2024).

The achievement of mathematical literacy among Indonesian students, as indicated by PISA results, is influenced by various factors (Yusmar & Fadilah, 2023), one of which is teacher ability and performance (Hwang & Ham, 2021). Teacher competence (pedagogical, moral, and instructional support) is significantly related to students' PISA mathematics scores (Hilmi & Kismiantini, 2024). The literacy skills of teachers in various regions of Indonesia vary widely, as do the challenges and obstacles they face (Citrawan et al., 2024). There is a significant relationship between low teacher competence and student academic achievement, including student literacy skills (Alfaruqi & Nurwahidayah, 2025). Teachers are required to foster mathematical literacy in students, but paradoxically, they themselves often lack adequate instruments to measure and develop these skills.

Research to develop mathematical literacy instruments in Indonesia has been extensive, but most of it focuses on students. Nadila & Lestiana (2024) designed PISA-based items that reflect Indonesian culture for junior high school students. Chiu et al (2024) developed an AI-supported instrument for students. Apriandi et al (2024) and Amin (2025) focused on preservice teachers through instruments related to calculus and AKM topics. Furthermore, existing teachers' mathematical literacy instruments are limited to measuring pedagogical skills, as UNESCO has noted in relation to teachers' challenges in mastering mathematical and scientific literacy (UNESCO, 2024), or to measuring their understanding of routine mathematical content (Kandil & Işıksal-Bostan, 2019). For example, research by Helstad on teachers' pedagogical skills indicates a tendency to ask more procedural questions, using routine questions that measure numeracy, as in traditional mathematics instruction. However, such instruction poses greater challenges for developing students' mathematical literacy skills (Helstad et al., 2017). While previous research focused on instruments measuring teachers' mathematical literacy insights (Umbara & Suryadi, 2019), this study specifically offers an instrument to measure teachers' mathematical literacy skills. This instrument is designed to measure teachers' ability to solve non-routine problems or problems requiring a high level of mathematical literacy that are rarely used.

This research offers a novel contribution by developing a mathematical literacy instrument and conducting a comprehensive construction and content validation process specifically designed for junior high school mathematics teachers. The results of this mathematical literacy instrument development will not only serve as a measurement tool but also as a diagnostic tool to identify areas where teachers need professional development. In addition, this instrument is expected to serve as a model for teachers to create similar questions in class.

METHOD

This study employs a Design-Based Research (DBR) approach, utilizing Tessmer's Formative Evaluation Model. Tessmer's model includes preliminary study, self-evaluation, expert review, one-to-one, small group, and field testing (Tessmer, 2005).

Participants included 60 junior high school mathematics teachers from the Yogyakarta Special Region (DIY), Indonesia, and two mathematics education lecturers who acted as expert validators. The first validator is a doctor of mathematics education with a Ph.D. and research experience related to PISA. The second validator is a lecturer and author of a book on numeracy literacy. The depth, track record, and expertise of the assessors are more crucial than the number of assessors (Diamond, 2014; Shrotryia & Dhanda, 2019). Following the small-group phase, the research continued with a forum group discussion involving two math teachers to further confirm the small-group results. The research procedure, adapted from Tessmer's model, is summarized in Figure 1

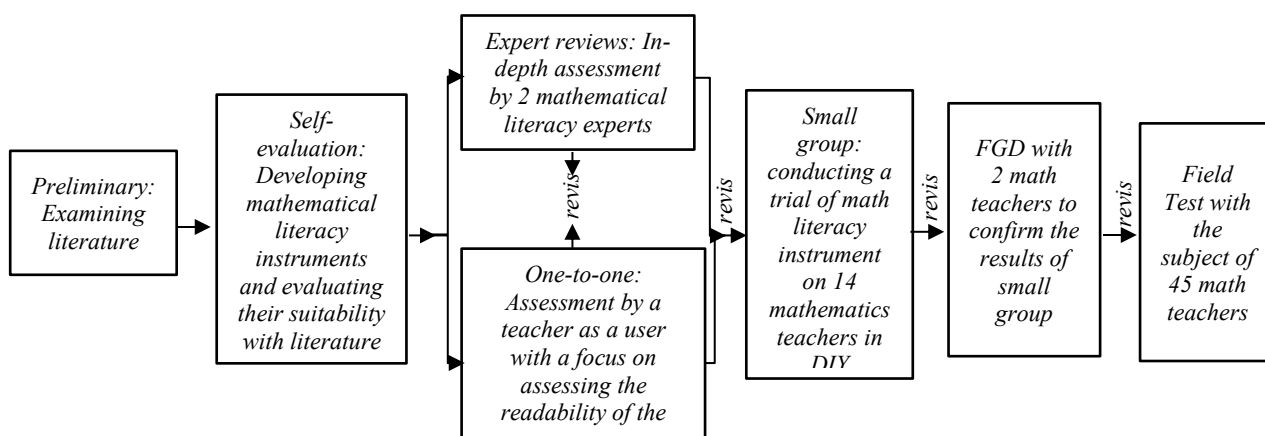


Figure 1. Research Stages: Adopting Tessmer's Model

In a preliminary stage, researchers reviewed the PISA mathematical literacy, curriculum analysis, and teacher needs assessment to ensure contextual relevance (Nieveen, N., & Folmer, 2013). In the self-evaluation stage, researchers created a draft instrument that began with the development of the context and test items, and then evaluated their suitability within the PISA framework (McKenney & Reeves, 2018). Two experts validated the draft instrument for an assessment using a validation sheet covering content, construct, language, and norms (McKenney & Reeves, 2018; Tessmer, 2005). Concurrently with the validation process, the draft questions were assessed by a mathematics teacher to evaluate the readability of the instrument's context and questions (Nieveen, N., & Folmer, 2013) using the instrument readability sheet. Input from the validator and readability experts served as the basis for revising the instrument. The revised instrument was subjected to a small-group test conducted by 14 teachers to determine the difficulty index (Tessmer, 2005) and to assess the practicality of the questions using a practicality questionnaire. The results were confirmed through FGDs with 2 teachers from the small-group subjects. The instrument was then administered to 45 teachers to empirically assess the quality of the questions as part of the field test.

Items on the validation sheet, readability sheet, and practicality questionnaire were rated on a 5-point Likert scale. The results of the content validity test from the two validators were analyzed using Aiken's V-index (Merino-Soto, 2023) with the formula:

$$V = \frac{\sum s}{n(c-1)} \quad (1)$$

where $s = r - l_0$ (r is the validator's score, l_0 is the lowest score on the scale), c is the number of rating categories ($c = 5$), and n is the number of validators ($n = 2$). The denominator in formula (1) is 8. Based on Aiken's (Aiken, 1985) significance table, the absolute minimum value that must be met to achieve statistical significance at $\alpha = 0.05$ is 0.88.

The readability of the one-to-one stage and the practicality of the small-group stage were analyzed by calculating the average score, and the averages were then categorized according to Table 1—Readability and Practicality Criteria.

Table 1. *Readability and Practicality Criteria*

Mean Score Range	Category	Recommendation
4.21–5.00	Excellent	No revision needed
3.41–4.20	Good	Minor revision needed
2.61–3.40	Fair	Moderate revision needed
1.81–2.60	Poor	Major revision needed
1.00–1.80	Very Poor	Complete overhaul needed

(Sugiyono, 2019)

A small-group test with 14 teachers was conducted to assess item difficulty and to support the descriptive analysis. Teachers completed questionnaires and gave written feedback to refine the instrument. Their open-ended responses were analyzed qualitatively following Miles and Huberman's three-step process: data reduction, data display, and conclusion drawing, along with insights from focus group discussions (2014).

The questionnaire was administered to 45 teachers as part of the field test. Validity and reliability tests were conducted at this stage as part of the questionnaire's development phase, as described by Benson & Clark (1982). The validity analysis of the questions used the Pearson Product-Moment Correlation (questions were valid if $\text{Sig} \leq 0.05$), and reliability was assessed using Cronbach's alpha. An α value > 0.70 was considered acceptable (DeVellis, 2003). Both were analyzed using SPSS software.

RESULTS

Preliminary

The instrument development process began with a review of the mathematical literacy literature, following the PISA framework, as a preliminary stage. This process took into account the literacy assessment development principles of Stacey, Kaye, and Turner (2015), which begin with analyzing mathematical literacy constructs, identifying real-world contexts, determining competencies, designing a blueprint, and writing draft test items. The preliminary process and results are shown in Table 2.

Table 2. *Mathematical Literacy Instrument Construction Process*

Step	Study Results	Basic Theories	Purpose
Analyzing the construction of mathematical literacy questions	It consists of 4 contexts (personal, occupational, societal, and scientific), 4 Content domains (quantity, space and shape, change and relationships, and data and uncertainty). It includes 2 main components: the stimulus and the questions.	Golla & Reyes (2022); Stacey (2022); OECD (2021)	Ensures each item comprehensively measures mathematical literacy.
Identification of Real-World Contexts	Selected contexts from daily life (science, society, environment, and technology).	Blum & Leiss (2020); OECD (2021)	Ensures items are meaningful and connected to real situations.
Determination of Competencies	Defined the main competencies: <i>formulate</i> , <i>employ</i> , and <i>interpret/evaluate</i> .	Golla & Reyes, (2022); Tout et al., (2023)	Aligns the instrument with key literacy processes.
Blueprint Design	Create a matrix containing context, content, and competencies, accompanied by Multiple Choice (MC), Complex MC, Short Answer, and Essay question formats.	Mislevy et al.(2021); Wijaya et al.(n.d.)	Become the basis for writing questions consistently
Draft Item Writing	Developed item drafts based on the blueprint, complete with stimulus (text/image), question, and key answer.	Nitko & Brookhart, (2022); Treagust & Chandrasegaran, (2020)	Ensure questions are clear.

Self-Evaluation

The instrument construction process continued by developing each step in Table 2, taking into account the question context, content, cognitive processes, and question form. These results are shown in Table 3.

Table 3. *Distribution of content, context, cognitive processes, and question form*

Content	Cognitive Processes	Contexts	Question Formats
Quantity (5 items)	Formulate, Employ, Interpret-Evaluate	COVID-19 (Societal), Vaccine Drinking Water Needs (Scientific), Flower Bouquets (Personal)	Short Answer, Multiple Choice (MC), Complex MC, Essay
Change and Relationship (7 items)	Formulate, Employ, Interpret-Evaluate	Sales of Jogja Batik (Occupational), Flower Bouquets (Personal), Drinking Water Needs (Scientific)	Complex MC, Multiple Choice, Matching, Short Answer, Essay
Space and Shape (7 items)	Formulate, Employ, Interpret-Evaluate	Shop Floor Design (Occupational), Gift Boxes (Personal), Crystal Shapes (Scientific)	Short Answer, Complex MC, Matching, Multiple Choice, Essay
Uncertainty and Data (6 items)	Formulate, Employ, Interpret-Evaluate	Olympics 2024 (Societal), Indonesian Temperature Data Analysis (Scientific)	Multiple Choice, Complex MC, Short Answer, Essay

Referring to Table 3. The distribution of content, context, cognitive processes, and question form in the developed literacy instrument, as a self-evaluation phase, comprises 10 stimuli across four contexts, with each stimulus containing 2-3 literacy questions, for a total of 25 math literacy items. The 25 questions used as a draft of the mathematical literacy assessment instrument were rechecked for conformity to the grid before proceeding to the next stage: expert reviews and one-to-one assessments. Figure 3 is an example of a personal context, showing content space and shape, with short-answer questions.

Expert Review and One-to-One Results

The expert review stage assesses the validity of the questions through a logical validation process, while the one-to-one assessment assesses their readability. The results of the expert reviews, which measured the content, construction, language, and norms aspects of the literacy instrument, are shown in Figure 2. Mean Aiken's V ($\bar{V}$) Scores

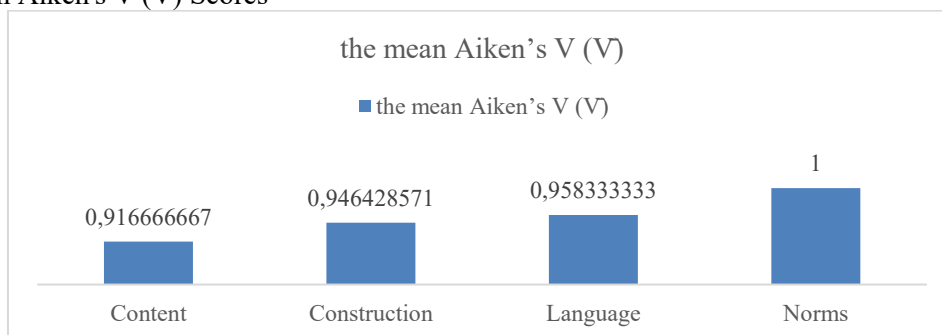


Figure 2. Mean Aiken's V ($\bar{V}$) Scores

The quality of the mathematical literacy instrument had the highest average scores in the construction, language, and norms aspects. Comprehensive content validation across all aspects was calculated using equation 1 and an average validation index $V^- = 0.95$, indicating high validity, with only minor revisions needed for wording and clarity. Furthermore, all these values exceeded the rejection threshold ($V^- > 0.88$), indicating that the agreement between the two experts was statistically significant, strong, and free from random judgment.

One validator suggested reviewing the answer key for number 11. The initial answer resembles the one used by many teachers in Figure 4, while the revised answer key is shown in Figure 3b. Let us look at the context and problem in Figure 3. Rechecking the answer key is necessary because, mathematically, the area required to make 10 gift boxes is 4 times the area of F4 paper. However, in the context of the

problem, 1 F4 paper can only make 2 boxes, requiring a minimum of 5 F4 papers is required. In this process, a visualization process is required, not just mathematical calculations.

Bacalah teks berikut untuk menjawab soal nomor 10-11

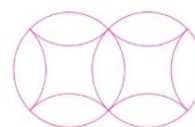
Irma berencana memberikan kado untuk temannya yang sedang berulang tahun. Ia ingin mencari kemasan kado yang unik, namun dari semua toko yang dikunjungi tidak ada kemasan kado yang menarik. Semua kemasan kado berbentuk kubus atau balok. Irma berinisiatif untuk membuat sendiri kemasan yang menarik dari kertas karton manila. Ia mencari-cari inspirasi kemasan kado di internet dan mendapati sebuah desain kemasan kado yang unik. kemasan kado tersebut berbentuk seperti gambar di bawah ini.



Sumber: <http://www.creativeinchicago.com/2014/11/how-to-make-a-pillow-gift-kemasan.html>

Untuk membuat kemasan tersebut, Irma mendesain terlebih dahulu polanya. Desain pola yang dibuat Irma sebagai berikut dengan diameter lingkaran 14 cm.

(a)



(b)

11. Irma ingin mencoba membuat kemasan dengan menggunakan kertas *buffalo* F4 berukuran 21,6 cm x 33 cm. Harga kertas *buffalo* F4 adalah Rp 750 per lembar. Jika Irma hendak membuat 10 kemasan kado di mana 1 kotak kado berasal dari satu lembar kertas (bukan potongan-potongan kertas), berapa biaya yang harus disiapkan untuk membeli kertas? Jawaban:

Satu kertas *buffalo* F4 dapat menghasilkan 2 kemasan kado (karena 1 kotak kado berasal dari satu lembar kertas (bukan potongan-potongan kertas).

Untuk membuat 10 kemasan kado artinya membutuhkan 5 kertas *buffalo* F4 Sehingga Irma harus menyiapkan biaya minimal Rp 3.750

Figure 3. Context personal (a) and problem number 11 (b)

The one-to-one phase was conducted concurrently with the expert reviews phase. Teachers assessed readability based on the clarity of the test instructions, each stimulus, and the purpose of each question; the communicative wording of the stimulus and questions; the absence of ambiguity; understandable illustrations; and the workability of the questions. The average score obtained from the one-to-one assessment was 4.14, placing the mathematical literacy instrument in the good category for readability. This category requires minor revisions. Revisions were made by clarifying the test instructions for each stimulus. The revised instrument was then subjected to small-group and focus group discussions.

Quality of the Small Group and Focus Group Discussion Instrument Results

All respondents, 14 junior high school mathematics teachers from all regencies/cities in Yogyakarta, completed 25 mathematical literacy questions within 2 hours (80 minutes), meaning the time to complete the questions fit within the available time. After completing the questions, teachers completed a questionnaire via GForm to confirm the questions' difficulty, practicality, and the obstacles or challenges they faced in completing them. Analysis of teacher responses revealed that five questions required more time than others. In addition to these questions, the remaining questions were easy or moderate. After confirming the difficulty index analysis, these five questions fell into the moderate and difficult categories. A more detailed analysis of the difficulty indices for the five questions is presented in Table 4.

Table 4. Questions requiring more time to complete and their difficulty indices.

No	Content	Context	Mathematical reasoning	Questions format	Difficulty index	Difficulty Level
10	space and shape	Personal	Employ	complex multiple choice	0,64	Medium
11	space and shape	Personal	Interpret and evaluate	short answer	0,14	Hard
15	change and relationship	Scientific	Employ	complex multiple choice	0,43	Medium
19	space and shape	Occupational	Employ	essay	0,36	Medium
24	space and shape	Scientific	Interpret and evaluate	short answer	0,57	Medium

In Table 4 above, the greatest difficulty was observed for item 11, with a difficulty index of 0.14. The error occurred because the teacher did not consider the question's context and the overall visualization process, as shown in Figure 4. Example of Teacher's Answer. This type of question focuses on short answer questions, focusing on the content of space and shape, and the reasoning level of interpretation and evaluation. Furthermore, teachers found the content difficult, particularly space and shape, which require mathematical reasoning, employing, interpreting, and evaluating. Therefore, teachers should focus

more on developing higher-level reasoning skills. Based on the question format, complex multiple-choice and short-answer questions dominated the question types teachers considered difficult.

$$\begin{aligned} \text{Luas } L_1 &= 21,6 \text{ cm} \times 33 \text{ cm} = 712,8 \text{ cm}^2 \\ L_2 &= 280 \text{ cm}^2 \\ L_3 &= 10 \times 280 = 2800 \text{ cm}^2 \\ \text{banyak kertas} &= \frac{2800}{712,8} = 3,928 \\ &\approx 4 \text{ lembar} \\ 750 \times 4 &= 3000 \end{aligned}$$

Figure 4. Example of Teacher's Answer

The results of the qualitative analysis of teachers' responses to the questions are shown in Figure 5 below.

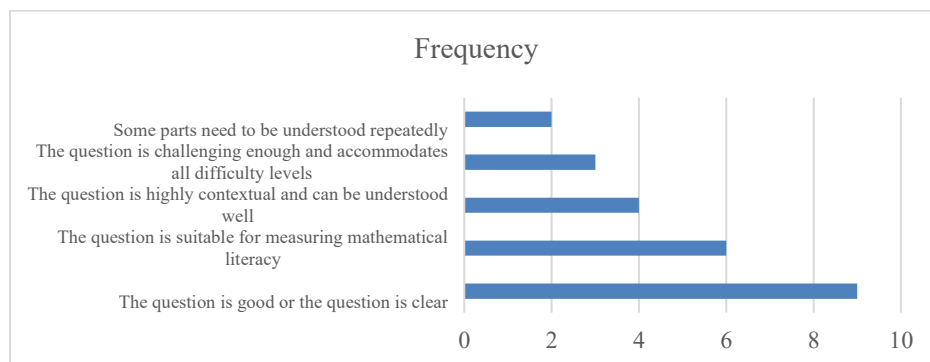


Figure 5. Teacher Response Analysis

The majority of teachers (64.3%) stated that the questions were good and clear. Six teachers stated that the questions were appropriate for measuring literacy, and only two felt they needed to be read repeatedly. The results indicate that the literacy instrument can be used to measure teachers' literacy skills and accommodates all levels of difficulty.

Field Test

The results of the field test on 45 teachers showed that each of the 25 developed questions had a sig value ≤ 0.05 , or, when compared to the r table with $df = 43$ ($45-2$), the Pearson correlation for each question item was > 0.2940 . Therefore, the analysis of the questions shows that each question developed is valid. In addition, the Cronbach's alpha was 0.860, which is > 0.7 (Figure 6). This shows that, overall, the developed question instrument is reliable and consistent. The difficulty index at the field test stage has the same results as the small group stage. From the discriminant power analysis, question number 11 is difficult, as are the easy and medium-level questions. This means there is consistency between the small group and field test results. Therefore, the question instrument is considered reliable. Thus, in addition to meeting the validity criteria for constructs, the developed questionnaire also demonstrates empirical validity.

Reliability Statistics	
Cronbach's Alpha	N of Items
.860	25

Figure 6. Reliability Results from SPSS Output

DISCUSSION

The process of constructing mathematical literacy instruments for teachers aligns with the principles of educational assessment development (Stacey, Kaye & Turner, 2015). The literacy instrument integrates real-world contexts, namely Flower Bouquets and Gift Boxes (personal context), the 2024 Olympics and Covid Vaccine Distribution (Societal context), Sales of Jogja Batik and Shop Floor Design (Occupational context), and Drinking Water Needs, Crystal Shapes, and Indonesian

Temperature Data Analysis (scientific context). The use of these contexts avoids abstract mathematical structures, transforms them into easily understood contexts, and makes the test items more meaningful (Blum & Leiss, 2020).

The numeracy literacy questions developed not only test procedural skills but also engage a more comprehensive cognitive process, in both content and reasoning. Based on the answer to question 11, teachers need a thinking process that includes formulating, applying, and interpreting/evaluating, as outlined in the PISA framework (Golla & Reyes, 2022b; OECD, 2023; Tout et al., 2023). Although the questions are based on PISA, their contexts are adapted to local settings (Citrawan et al, 2024), such as batik, weather patterns in Indonesia, and other locally relevant data. In contrast, PISA employs broader problem contexts. This constitutes the distinctive feature that sets the questions developed in this study apart from those used in PISA.

The suitability of the construction process is further reflected in the results of expert validation. The average Aiken index ($V = 0.95$) exceeds the minimum statistical significance threshold of the Aiken Table (0.88). The instrument achieved a perfect score (5) in the content aspect because the stimulus is up-to-date and not multi-interpretable, and the questions can measure literacy skills and have answer options that can be solved. It achieved a maximum score in the construction aspect because the questions align with the content, context, and level of reasoning being measured. This is because the questions were well-structured following the PISA framework. The instrument achieved a maximum score in the norms aspect because the stimuli and questions do not touch on ethnicity, religion, race, or intergroup relations (SARA), politics, or pornography. The language aspect scored lower than the other aspects because several sentences in the stimuli and questions needed to be reviewed to comply with proper and correct EYD. The follow-up process involved revising the questions and stimuli to conform to proper and correct language.

In addition to meeting content validity, the small-group results strengthened the validity findings because teachers stated that the instrument was contextual, addressed current issues, and aligned with the mathematical literacy framework of PISA (OECD, 2021). The question format conforms to the AKM (Academic Skills Standards)(Wijaya et al., n.d.). The questions can vary in difficulty, so the instrument also includes items at different difficulty levels. Many teachers found it challenging to solve contextual problems that demanded reasoning beyond procedural steps. This aligns with previous research showing that teachers need stronger skills in higher-order thinking and contextual problem-solving (OECD, 2021a; Tout et al., 2017; Wijaya et al., 2024).

The process of developing the question instrument from the preliminary stage to the field test stage indicates that the instrument has undergone a complete development cycle. The outcome of this phase was the testing of the instrument on 45 junior high school mathematics teachers. These respondents exceeded the minimum pilot reliability requirement of 30 respondents in the initial Cronbach's alpha/KR-20 test (Suciati et al., 2020; Wong et al., 2023). This research process strengthened the instrument development phase of Benson and Florence Clark (Benson & Clark, 1982), which includes planning, construction, quantitative evaluation, and validation.

Empirical data from both small-group and field tests found that the Space and Shape content domain presents a unique challenge for teachers because it requires challenging spatial reasoning. This is consistent with research by Sinclair et al. (2016), which found that the development of spatial reasoning and geometry is often a major obstacle due to a lack of visualization. This condition occurs not only among newly graduated teachers but also in teacher-training contexts. Educators tend to be accustomed to procedural algebraic geometric proofs and experience difficulties when faced with non-routine conceptual visualization and spatial interpretation tasks.

CONCLUSION

This study produced 25 test items as a valid and reliable quality teacher mathematical literacy assessment instrument. The instrument construction process is in accordance with the principles of developing educational assessment and mathematical literacy in the PISA framework. Each test item is aligned with a real-world context that facilitates a different reasoning process than routine questions that prioritize procedural knowledge. The test instrument has a high content-validation category, with an

average Aiken index of 0.95 (Aiken's $\bar{V} = 0.95$). The instrument has a good readability aspect (mean = 4.14). The field test results show that each test item has a Sig. ≤ 0.05 value in the correlation test, or a correlation coefficient > 0.2940 . The Cronbach's Alpha value is 0.860, which is > 0.7 , so the instrument is also reliable. These results indicate that the literacy instrument can measure mathematical literacy both theoretically and practically, as it also has a diverse difficulty index. The literacy instrument has great potential to enrich teachers' ability to create literacy questions. This instrument can theoretically serve as an alternative PISA-based mathematical literacy measurement tool that is teacher-oriented, as well as a practical guide for educators in designing innovative, non-procedural classroom assessments.

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DECLARATIONS

- Author : **Niluh Sulistyani**: Conceptualization; methodology; formal analysis; writing the original draft. **Albertus Hariwangsa Panuluh**: Conceptualization; methodology; investigation; review and editing; translation. **Kintan Limiansih**: validation, writing, resources; data curation; visualization; supervision; project administration. **Margaretha Madha Melissa**: review and editing; instrument development. All authors have read and approved the published version of the manuscript.
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- Statement
- Conflict of Interest : The authors declare no conflict of interest. All procedures in this study were conducted in accordance with ethical standards for educational research. The research team obtained permission from the Yogyakarta Provincial Education Office and from the Regency/City Education Offices throughout the province. Respondent participation and consent were voluntary. The confidentiality of all respondent data was strictly maintained.
- AI Use : We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.
- Statement
- Additional Information : Additional information is available for this paper.

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