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Measurement of Psychometric Attributes Scientific Literacy Tests for Madrasah Tsanawiyah Students

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Abstract: The purpose of this research is to measuring the validity and reliability of scientific literacy test instruments. Scientific literacy test instruments are reviewed from theoretical validity (construct, relevance and clarity), empirical validity, and reliability. This research was conducted using a quantitative approach. Data was collected using a questionnaire and tested to measure the eligibility of the test for use in exams. The scientific literacy test instrument tested for theoretical validity through expert judgment involving three validators. The scientific literacy test instrument is considered valid if it has a content validity coefficient value ≥ 0.667. After being declared theoretically valid, the scientific literacy test instrument was then tested on 100 students. The results of the scientific literacy test instrument trials are then analyzed to determine empirical validity and reliability. The results showed that 26 scientific literacy test instruments were declared theoretically valid with each aspect (construction, relevance and clarity) having a content validity coefficient value of ≥ 0.667. The test instrument is declared empirically valid where each question item has rcount > 0.195 (α=0.05 and n=100). The test instrument was declared reliable with a reliability coefficient value of 0.805 > 0.707.

Keywords: Psycometric attribute; Reliability; Scientific literacy test; Validity

Introduction

According to Pemendikbud No.12 tahun 2024, the curriculum used in Indonesian education is merdeka (Kemendikbudristek, 2024). According to BSKAP Kemendikbudristek's academic standards, literacy is the most important consideration in developing curricula. This is based on an evaluation of curriculum implementation during the COVID-19 pandemic, which indicates that students who use the curriculum would achieve higher levels of literacy based on PISA tests of literacy for reading, writing, and numeracy in 2022. As a result, the government must continue to develop curricula that are more comprehensive in order to provide significant benefits in the face of Indonesia's education crisis.

Literacy has grown in the field of education in Indonesia, including teaching and research. The development of literacies in education is based on the learning process (Irsan, 2021), assessment instruments (Indrawati et al., 2018), and research (Nurhasanah et al., 2020). In terms of developing literacy as a teaching tool, the Organisation for Economic Cooperation and Development (OECD) has conducted studies on the literacy skills of students known as the Programme for International Student Assessment (PISA). Students from several countries, including Indonesia, participated in this study. This study aims to evaluate educational systems around the world by assessing the capabilities and knowledge of 15-year-old students (Pusat Penilaian Pendidikan Balitbang Kemendikbud, 2019).

Indonesian students have participated in PISA studies for the eighth time, from 2000 to 2022. PISA

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results for Indonesian students are expected to rise in 2022, although there will be a decline in scholastic achievement across all subjects. With a focus on science literacy, the results of the study on Indonesian students revealed a similar trend. PISA studies for the year 2022 reveal that just 7.8% of Indonesian students have the ability to achieve a minimum level of literacy. Around 65.9% of Indonesian students have the ability to perform below the required level of competency. Out of the number of students with skills below the minimum level of competence, 41.1% are at the 1a level, while 24.8% are below the 1a level. This means that Indonesian students are still classified as having a low level of scientific literacy skills. These outcomes underscore a substantial disparity between Indonesia's education system and numerous other countries concerning student performance in these core subjects (Nurcahyoko et al., 2024).

According to data from the Asesmen Kompetensi Madrasah Indonesia (AKMI) 2023 conducted by Ministry of Religion Affair, 72.74 percent of madrasah students had literacies in the category of competent, with a national average of 54.15. Referring to this, test results for madrasah students in Aceh Province also show the same thing. The scientific literacy ability of madrasah students in Aceh Province is categorized as red with a lower value range of 50.13. At lower regional levels such as districts/cities, students' literacy skills show results that are still not optimal. According to Afkar (2023) research, 50% of the sample of MAN 1 Aceh Besar students have poor literacy skills, with only 3% having good ones.

Students' literacy skills are strongly related to the influence of reading and learning interests (McGeown et al., 2015). Meanwhile, A variety of factors contribute to students' poor literacy skills. One factor is that students are not used to working on scientific literacy test questions and have little understanding of how to analyze tables and graphs (Hidayah et al., 2019). This can be related to the school's evaluation process. Many schools not use topics related to daily phenomena and focus on concepts and knowledge, making them cannot measure scientific literacy skills (Pratiwi et al., 2019). The ability to Explain phenomena scientifically, Construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically, and Research, evaluate and use scientific information for decision making and actionmust all be included (OECD, 2023). This emphasizes the need for schools to conduct evaluations using instruments that might improve literacies, particularly in science learning. One of the another causes of low science literacy is the lack of science literacy instruments developed (Aziza et al., 2020).

Scientific literacy in science learning has a very important role in preparing students who are qualified, reliable, and able to compete internationally (Irsan, 2021). For a child, his scientific literacy skills can optimize his reasoning abilities and explain problems in his life (Nugraha, 2022). Implementation of evaluations that produce instrument content with scientific literacy supports the role of scientific literacy. The experience of carrying out evaluations with scientific literacy instruments will familiarize students with being faced with these forms of questions. So that participants can improve their scientific literacy skills.

The provision of assessment instruments that resemble the PISA 2025 test is important as an effort to familiarise students with the form of questions tested. The provision of these instruments can be done by making instruments and ensuring that the instruments are valid and reliable in accordance with the competencies tested in the PISA 2025 test. Sugiyono (2019) states that a good instrument must fulfil valid and reliable criteria. This shows that this research is important to do as an effort to provide instruments in accordance with the PISA 2025 framework. Research on the PISA 2025 framework has not been so much done in terms of instruments. There are many reasons why the PISA 2025 framework has yet to be widely researched, among other things because the PISA 2025 framework is relatively new, and scientific research takes time to plan, implement, and analyse data (Deta et al., 2024).

The method that can be used to improve students' literacy skills is to provide authentic and reliable literacy instruments (Rusilowati, 2018). Valid and reliable literacy instruments can be used throughout the learning process. Literacy instruments used in education can improve learning processes (Anggreni et al., 2022). Efforts to train science literacy to students, can be implemented in learning that is designed and adapted to the social context and community context, including assessment as an integral part of the learning process including assessment as an integral part of the learning process (Windyariani et al., 2017). It is hoped that this increase will improve students' understanding and provide a positive impact on their scientific literacy skills.

The results of observations at MTsN 5 Aceh Besar obtained from interviews with teachers stated that students still use instruments designed with knowledge competencies based on Bloom's taxonomy. Then the teachers also said they needed scientific literacy instruments to be used in learning evaluation. Therefore, because of the many advantages of scientific literacy test instrument, it is necessary to apply it to science learning evaluation so that students are trained in their abilities.

The development of test instruments that use the PISA test competencies has been carried out for several purposes, such as improving the ability of teachers (Setyawarno et al., 2021), use by students (Affriyenni et al., 2022) and to measure and improve students' literacy skills (Amri et al., 2023). In fact, all development research conducted is still based on the literacy competencies of the PISA test before the publication of the PISA 2025 framework. Based on this, the authors conducted research on instruments made based on literacy competencies in the PISA 2025 Framework so that they could be used for habituation in students.

Method

This research is conducted with quantitative approach. The data collection method used in this study is questionnaire instrument and test. Quistionnaire data is used to theoretical validity and data from tests are used to evaluate empirical validity and reliability.

The questionnaire used contains a value scale in the form of numbers. The number form used is 1 to 5, where the value 5 is the number with the highest value on the questionnaire. The questionnaire from this research contains 3 aspects that are assessed, namely construction, clarity and relevance. Theoretical validity was carried out by 3 experts.

Data collection using tests was carried out on students. The sample in this study was 100 people who used a purposive sampling technique. The sample was selected from class VIII students at the Madrasah Tsanawiyah in Aceh Besar district.

Data Analysis

Theoretical validity will be analized with calculate content validity coefficient using the following formula (Azwar, 2012).

$$V = \frac{(\sum r - lo)}{|n(c-1)|} \quad (1)$$

Point biserial correlation is used to analyze validity empirically (Yusrizal et al., 2020).

$$r_{pbi} = \frac{(M_p - M_t)}{SD}\sqrt{\frac{p}{q}} \quad (2)$$

And to analyze reliability using the following formula.

$$r_{21} = \frac{n}{n-1}\left(1 - \frac{\bar{X}(n-\bar{X})}{nS_t^2}\right) \quad (3)$$

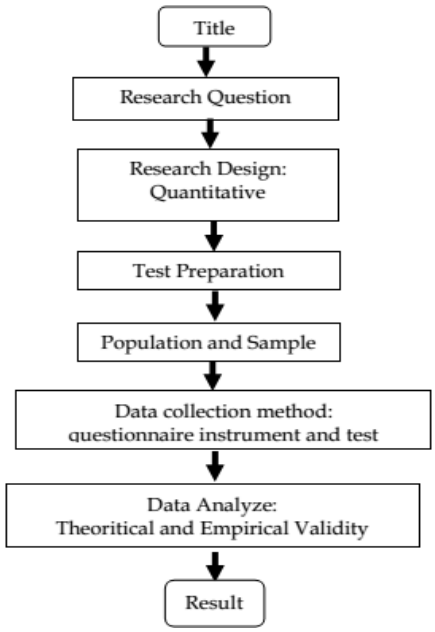

Figure 1. Research design flowchart

Result and Discussion

An instrument designed using scientific literacy indicators according to the PISA program was prepared. The instrument's validity and reliability are then measured. Item indicators for the instrument design are presented in table 1.

Table 1. Scientific Literacy Test Instrument Indicator

Scientific Literacy Skill	Item Indicator	Item Number
Explain phenomena scientifically	Recall and apply appropriate scientific knowledge	1, 19
	Use different forms of representations and translate between these forms	4, 22
	Make and justify appropriate scientific predictions and solutions	7, 25
	Identify, construct, and evaluate models	10, 29
	Recognise and develop explanatory hypotheses of phenomena in the material world	13, 26
	Explain the potential implications of scientific knowledge for society	16, 30
Construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically	Identify the question in a given scientific study	2, 14, 31
	Propose an appropriate experimental design	5, 17, 27
	Evaluate whether an experimental design is best suited to answer the question	8, 20
	Interpret data presented in different representations, draw appropriate conclusions from data and evaluate their relative merits	11, 23

Scientific Literacy Skill	Item Indicator	Item Number
Research, evaluate and use scientific information for decision making and action	Search, evaluate and communicate the relative merits of different sources of information (scientific, social, economic and ethical) that may have significance or merit in arriving at decisions on science-related issues, and whether they support an argument or a solution	3, 18
	Distinguish among claims based on strong scientific evidence, expert vs. nonexpert, and opinion, and provide reasons for the distinction	6,21
	Construct an argument to support an appropriate scientific conclusion from a set of data	9,24
	Critique standard flaws in science-related arguments using epistemic and procedural knowledge e.g., poor assumptions, cause vs. correlation, faulty explanations, generalisations from limited data;	12. 28
	Justify decisions using scientific arguments, either individual or commu nal, that contribute to solving contemporary issues or sustainable development.	15, 32

The scientific literacy test instrument was theoretical validated by three validators consisting of one Physich lecture at Universitas Pendidikan Indonesia, one Widyaiswara at Balai Besar Guru Penggerak Jawa Barat and one Chemistry teacher at MAN IC Pekalongan. All validators have experience in developing national level scientific literacy instruments organized by AKMI program at Ministry of Religion Affair. Validation of the science literacy test instrument at this stage is a theoretical validation consisting of construction, relevance and clarity of the test instrument. Each aspect assessed has a maximum value of 5 and a minimum value of 1. Each validator can suggest advice to improve the test instrument quality, but the validity criteria is using content validity coefficient which must be ≥ 0.667 in each aspect.

Based on Table 2 which show the result of theoretical validity from validator, that is can show with graph in figure 2. Based on Table 1 and Figure 2, it can be seen that not all items reach the validity criteria. There are items that are considered not to reach the validity criteria in all aspects by the validators. Research by Syafitri et al. (2023) showed similar results that is not all item reached the valid criteria of 0.707. Meanwhile, Nabil et al. (2022) found that there were 18 valid items and 2 invalid items in the validity test using Aiken's formula for the instrument tested. This indicates that the item is not suitable for use in the test for students. It can be concluded that there are 26 items that are considered valid based on theoretical validation.

Items 3, 15, 18 and 32 were considered not measuring science literacy skills according to the indicators by 2 validators. This was assessed from the construction of the questions designed. The validators considered the questions made in the construction had not measured the indicators. The validators suggested changing the questions on the items so that they can measure science literacy skills according to the indicators. The not valid item in this research is not revise, so not be include in measuring of empirical validity and reliability. This is in accordance with Anggraeni et al. (2020), if not revised, invalid thoritical validation items are not included in the next process.

Table 2. Instrument Validation Results of Scientific Literacy Skills Test by Validator

Item	Aspect			Validity
	Contruct	Relevance	Clarity	
1	0.750	0.750	0.750	Valid
2	0.833	0.750	0.750	Valid
3	0.167	0.333	0.417	Not Valid
4	0.750	0.583	0.500	Not Valid
5	0.750	0.750	0.750	Valid
6	0.750	0.750	0.833	Valid
7	0.667	0.750	0.917	Valid
8	0.750	0.833	0.917	Valid
9	0.750	0.833	0.833	Valid
10	0.750	0.750	0.750	Valid
11	0.750	0.833	0.750	Valid
12	0.667	0.750	0.750	Valid
13	0.750	0.750	0.750	Valid
14	0.750	0.833	0.750	Valid
15	0.083	0.250	0.333	Not Valid
16	0.750	0.917	0.833	Valid
17	0.750	1.000	0.917	Valid
18	0.167	0.250	0.250	Not Valid
19	0.750	1.000	0.917	Valid
20	0.750	1.000	0.917	Valid
21	0.750	0.833	0.833	Valid
22	0.750	0.750	0.583	Not Valid
23	0.750	1.000	1.000	Valid
24	0.750	1.000	1.000	Valid
25	0.833	1.000	1.000	Valid
26	1.000	0.917	1.000	Valid
27	0.750	0.917	0.833	Valid
28	0.833	0.750	0.833	Valid
29	0.833	0.750	0.750	Valid
30	0.750	0.750	0.750	Valid
31	0.750	0.917	0.917	Valid
32	0.167	0.250	0.417	Not Valid

26 Items that are considered valid instrument in theoretical validation are then tested on students to

collect data to analyze empirical validity and reliability. A group of 100 students was used to test the instrument. Empirical validity was assessed using point biserial correlation. The results of empirical validity assessment are shown in table 3.

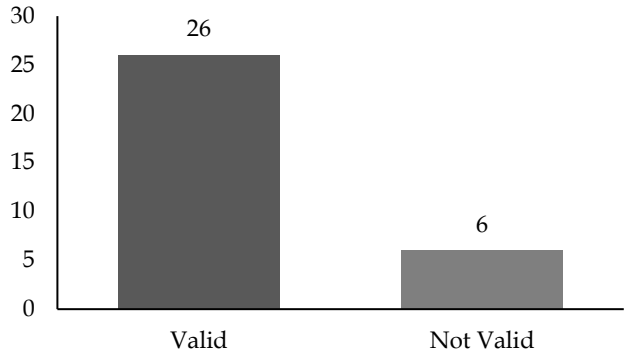

Figure 2. Instrument validation results of scientific literacy skills test by validator

Table 3. Instrument Validation Results of Scientific Literacy Skills Test by Test

No. Item	r_{table}	r_{pbi}	Validity
1	0.195	0.733	Valid
2	0.195	0.627	Valid
5	0.195	0.409	Valid
6	0.195	0.230	Valid
7	0.195	0.546	Valid
8	0.195	0.350	Valid
9	0.195	0.306	Valid
10	0.195	0.542	Valid
11	0.195	0.339	Valid
12	0.195	0.293	Valid
13	0.195	0.601	Valid
14	0.195	0.347	Valid
16	0.195	0.222	Valid
17	0.195	0.578	Valid
19	0.195	0.328	Valid
20	0.195	0.229	Valid
21	0.195	0.590	Valid
23	0.195	0.332	Valid
24	0.195	0.250	Valid
25	0.195	0.474	Valid
26	0.195	0.347	Valid
27	0.195	0.281	Valid
28	0.195	0.554	Valid
29	0.195	0.392	Valid
30	0.195	0.505	Valid
31	0.195	0.355	Valid

Empirical validity was obtained from point-biserial correlation coefficient (r_{pbis}) analysis. Point-biserial correlation coefficient is a statistic used to estimate the degree of relationship between a naturally occurring dichotomous nominal scale and an interval (or ratio) scale (Brown, 2001). The r_{table} value for 95% confidence degree and n=100 is 0.195. Items are considered empirically valid if $r_{pbis} > 0.195$. The results of the analysis showed that 26 items were considered to have reached the criteria of empirical validity. Bashooir et al. (2018) states Items that fall within this range can be used for the purpose of measuring learners' science literacy skills. These results mean that all the items can measure what is being measured or declared empirically valid (Susetyo et al., 2021).

A reliable instrument is an instrument that if used will give the same results on measuring the same construction (Kamper, 2019). The reliability of the science literacy test instrument was analysed using the Kuder-Richardson 21 formula (r21). a test instrument is considered reliable if the reliability coefficient is ≥ 0.70.

Table 4. Reliability Test Result

N	S_t^2	$\bar{X}$	r_{21}	Reliability
26	28.78	13.55	0.805	Reliable

Based on calculation in table 4, the scientific literacy test instrument can be trusted, with a reliability coefficient value of 0.805 which is greater than 0.70. This reliability coefficient value indicates that the science literacy test instrument can be used consistently to produce the same measurement results with each use.

Conclusion

Measurements made on the science literacy test instrument can be declared valid and reliable. Theoretical validation test conducted by 3 validators stated 26 out of 32 items were declared valid with a content validity coefficient value of each aspect > 0.667. The biserial point correlation was used to determine the empirical validity of the 26 instrument items that were considered valid with a value of r> 0.195. In addition, the Kuder-Richerdson 21 test was used to test the reliability of 26 statement items, and the results showed that 26 items of the instrument were reliable.

Author Contributions
The following statements should be used conceptualization SB, HR, AU contributed to the data collection process, data processing, article writing.

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Conflicts of Interest
Regarding this study, the author declares that there is no conflict of interest.

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