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Measurement of Science Literacy Skills of Elementary School Teacher Education Students: Development and Validity Testing of Assessment Instruments

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ABSTRACT: This study aims to develop and test the validity and reliability of a scientific literacy instrument for students of the Elementary School Teacher Education (PGSD) Program. The instrument was designed to measure three dimensions of scientific literacy: content knowledge, procedural knowledge, and epistemic knowledge, focusing on Earth and Space Science topics. A total of 18 questions were constructed based on indicators that assess the ability to explain scientific phenomena, evaluate scientific investigations, and interpret scientific data. The instrument was tested on 33 PGSD students at Universitas Sebelas Maret (UNS) and analyzed using the Content Validity Index (CVI) and reliability tests via SPSS software.
The results indicated that most items were valid, with an S-CVI/Ave value of 0.981 and an S-CVI/UA value of 0.8333. However, one item was found invalid with an I-CVI score of 0.67. The reliability test showed that some questions had a good level of reliability, while others required revision due to low reliability. Additionally, analysis using the Item Response Theory (IRT) revealed that the questions varied in difficulty and discrimination, with most questions having positive discrimination values and a range of difficulty levels. Overall, the instrument was found to be valid and reliable for assessing the scientific literacy of PGSD students, although some questions need revision to improve consistency and accuracy.

KEYWORDS: Instrument, Item Response Theory (IRT), Scientific literacy.

INTRODUCTION

Based on the results of the PISA test, Indonesia ranked 68th out of 78 participating countries in the science domain, with a score of 398, which falls below the average PISA standard (OECD, 2023). The OECD has conducted assessments of scientific literacy among elementary school students. These results highlight the need to improve the scientific literacy skills of students pursuing education as future elementary school teachers (Kurniawan et al., 2022). Improving scientific literacy for future elementary school teachers is crucial, as they will play a significant role in delivering science education to young students at the elementary level . With strong scientific literacy, future teachers will not only be able to deliver material effectively but also create interactive learning environments that foster students' curiosity about science (Suyanto et al., 2024). They are also expected to help students grasp scientific concepts more thoroughly and deeply, which will positively impact the students' critical and analytical thinking skills (Akinbobola & Bada, 2022).

A well-designed learning environment by scientifically literate teachers will also be able to stimulate students to engage actively in the learning process and nurture their curiosity about science (Wijaya et al., 2023). Moreover, a reliable and accurate instrument is needed to measure the scientific literacy skills of PGSD (Elementary School Teacher Education) students, ensuring that they possess adequate understanding and skills in science, while also identifying areas that need further development in the learning process (Limiansih et al., 2021).

Therefore, efforts to enhance scientific literacy among prospective elementary school teachers have become an urgent need to ensure better-quality basic education in the future. The moderate scientific literacy skills of prospective teachers are a concern that requires attention in the field of education (Antika & Marpaung, 2023). Some studies show that prospective teachers with moderate scientific literacy skills have a good understanding of basic scientific concepts and are capable of teaching those concepts to students (Safira, 2021). However, there remain deficiencies in their scientific literacy, such as difficulties in understanding more complex scientific concepts. Additionally, prospective teachers with moderate scientific literacy tend to participate less in scientific activities and often lack a strong interest in science (Muhajir et al., 2021).

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In recent years, the Indonesian government has allocated substantial resources to improving the quality of education in Indonesia (Widyasari & Haryanto, 2022). One of the primary goals of these efforts is to enhance the quality of learning at the elementary school level. Therefore, PGSD students are expected to have strong skills in teaching science subjects. However, despite various efforts, many students still exhibit low scientific literacy skills (Suparya et al., 2022). These low literacy skills can hinder PGSD students in teaching, particularly in delivering effective science lessons, and may affect the quality of education at the elementary level (Muslihasari et al., 2022).

In a broader context, this research can help improve the quality of education in Indonesia, especially in science education. By enhancing the scientific literacy skills of PGSD students, they are expected to become more effective teachers and improve the quality of science learning in elementary schools.

Scientific literacy is one of the essential skills that students must possess in the current era of information and technology (Muliani et al., 2021). Scientific literacy not only focuses on mastering scientific concepts but also encompasses critical thinking, problem-solving, and the application of scientific knowledge in everyday life (Irsan, 2021). However, there is often a gap between the expected abilities and the actual scientific literacy competence of students. Therefore, there is a need for the development of instruments that can comprehensively and accurately measure students' scientific literacy levels. With the right instruments, educational institutions can design more focused and effective learning strategies to improve students' scientific literacy skills, better preparing them to face the challenges of the professional world.

RESEARCH METHOD

The development of the scientific literacy test instrument in this research follows the ADDIE development model (Hafni Sahir, 2022). The ADDIE model includes five stages: 1) Analyze, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation (Sumarni, 2020). In the Analyze stage, an analysis is conducted on the core competencies, basic competencies, and the establishment of scientific literacy indicators related to the topics of Earth and space. The Design stage involves the design of the test instrument's blueprint. During the Development stage, the test instrument is developed based on the blueprint, and the assessment rubric is constructed. The Implementation stage involves testing the test instrument on 33 third-semester PGSD (Elementary School Teacher Education) students at Sebelas Maret University. The Evaluation stage encompasses assessing the appropriateness and accuracy of the Analyze, Design, Development, and Implementation stages, as well as calculating the validity, reliability, difficulty level, and discrimination power of the test instrument. The validity of the instrument is assessed based on expert validation, while reliability is tested using SPSS and evaluated using the 2-Parameter Item Response Theory (IRT). IRT, or Item Response Theory, is an evaluation system that assigns values to each question based on the level of difficulty and ease of the items (Danni et al., 2021). The parameters used are discrimination power and difficulty level.

RESULTD AND DISCUSSION

Result

A. Analyze Stage
Scientific literacy is one of the basic competencies that must be mastered by students in the Elementary School Teacher Education (PGSD) program. The need for an instrument that can measure the scientific literacy abilities of PGSD students becomes very important considering their future role as educators who must be able to effectively teach science to elementary school students (Hasnawati et al., 2023). Therefore, this research aims to identify the components that must be included in the instrument to provide a comprehensive measurement of the scientific literacy of students.

B. Design Stage
The main materials and sub-materials of the instrument are related to Earth and Space Science. These materials cover various important aspects that explain phenomena and structures present in outer space and our planet. The sub-materials of the instrument include theories of solar system formation, solar system members, characteristics of planets, rotation and revolution of planets, atmosphere and hydrosphere, space flight, and exploring concepts and technologies behind space exploration, including manned and robotic missions.

C. Development Stage This instrument is designed with a total of 18 questions, consisting of various types of questions aimed at measuring specific aspects relevant to the tested topics. Each question is formulated based on predetermined indicators, with

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detailed descriptions to ensure that the instrument encompasses all dimensions necessary for measuring scientific literacy skills as follows :

Table 1. Blueprint for Elementary School Students' Scientific Literacy Instrument

No.	*Indicator*	*Dimension*	*Question Number*
1	Explaining phenomena scientifically.	*Content knowledge*	1, 10
		Procedural knowledge	2, 11
		Epistemic knowledge	3, 12
2	Evaluating and designing scientific investigations	*Content knowledge*	4, 13
		Procedural knowledge	5, 14
		Epistemic knowledge	6, 15
3	Interpreting data and evidence scientifically.	*Content knowledge*	7, 16
		Procedural knowledge	8, 17
		Epistemic knowledge	9, 18

D. Implementation Stage

This instrument has been tested on 33 third-semester students of the PGSD program at Universitas Sebelas Maret (UNS) to measure its validity and reliability in assessing scientific literacy abilities. The results of this trial are expected to provide an accurate picture of the instrument's effectiveness in measuring various aspects of scientific literacy in students.

E. Evaluation Stage

Expert validity analysis is conducted using the Content Validity Index (CVI), which involves expert assessments to determine the relevance of items in the instrument. The CVI is calculated based on ratings using a Likert scale to evaluate the suitability of items with the developed instrument (Chasanah et al., 2022).

Table 2. Expert Validity of the Instrument

Item	*Expert 1*	*Expert 2*	*Expert 3*	*CVI*	*Description*
1	3	3	3	1	Valid
2	3	3	3	1	Valid
3	3	3	3	1	Valid
4	3	3	3	1	Valid
5	3	4	3	1	Valid
6	3	4	3	1	Valid
7	3	3	3	1	Valid
8	3	3	3	1	Valid
9	3	3	3	1	Valid
10	3	3	3	1	Valid
11	3	3	3	1	Valid
12	3	3	3	1	Valid
13	3	1	3	1	Valid
14	2	3	3	0.67	Invalid
15	3	3	3	1	Valid
16	3	3	3	1	Valid
17	3	3	3	1	Valid
18	3	3	3	1	Valid
Total				17,61	
S-CVI/Ave				0,981	
S-CVI/Au				0,8333	

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The assessment results from three experts for the 18 items show that all items are rated valid, with the Content Validity Index (CVI) varying between 0.67 and 1. I-CVI above 0.78 is considered good, while S-CVI/Ave and S-CVI/UA above 0.80 indicate good and strong validity. Most items have a CVI of 1, indicating high validity, although some items with a CVI of 0.67 are considered invalid. Overall, the instrument is declared valid based on expert assessments. All 18 questions underwent a reliability testing process using SPSS software, aimed at ensuring the consistency and reliability of the measuring instrument in assessing the intended construct. The results of the tests are as follows :

Table 3. Results of Instrument Reliability Testing

Question Number	*r count*	*Description*
1	0.457	Sufficent
2	0.449	Sufficent
3	0.483	Sufficent
4	0.246	Low
5	0.220	Low
6	0.432	Sufficent
7	0.408	Sufficent
8	0.396	Low
9	0.342	Low
10	0.265	Low
11	0.427	Sufficent
12	0.164	Very low
13	0.432	Sufficent
14	0.467	Sufficent
15	0.222	Very Low
16	0.199	Very Low
17	0.510	Sufficent
18	0.469	Sufficent

Some questions have good consistency, while others exhibit low reliability. Questions with low scores need improvement to make the measuring instrument more accurate and reliable. All 18 questions were tested using Item Response Theory (IRT) with Python to analyze the discrimination power and difficulty level of the questions (Maulani & Supriady, 2022). The Statsmodels module was used for statistical analysis and the logit model in the IRT approach. The results are as follows :

Table 4. IRT Analysis Results with Python Programming

Question	Difficulty Level *(b)*	Discrimination Power (*a*)
1	0.217	0.852
2	0.974	-0.425
3	0.056	0.964
4	0.217	0.852
5	0.132	0.909
6	-0.145	1.124
7	-0.084	1.067
8	0.132	0.909
9	0.132	0.909
10	0.056	0.964
11	1.215	1.041

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12	-0.207	1.181
13	0.132	0.909
14	0.974	-0.425
15	0.084	1.067
16	0.529	1.373
17	-0.018	1.012
18	0.132	0.909

Discussion

Based on the research results, the scientific literacy instrument for students in the Elementary School Teacher Education (PGSD) program has undergone various stages, from needs analysis to evaluation of validity and reliability. The following is a discussion based on the results of each stage:

1. **Analyze Stage**
   This research began with the identification of the need for a comprehensive scientific literacy instrument. Scientific literacy is crucial for PGSD students, considering their role as future educators who must be able to teach science effectively (Syofyan & Amir, 2018). Therefore, an instrument that can accurately measure this competency is needed to ensure the readiness of students as science teachers in the future.
2. **Design Stage**
   The designed instrument encompasses materials related to Earth and Space Science, with subtopics such as the formation of the solar system, characteristics of planets, and space exploration. The selection of these topics is appropriate given the importance of basic understanding of natural phenomena in the universe for an elementary school teacher (Syofyan & Amir, 2019). The structure of the instrument, divided based on dimensions of content knowledge, procedural knowledge, and epistemic knowledge, demonstrates that the main aspects of scientific literacy are well represented in the constructed questions.
3. **Development Stage**
   The instrument, consisting of 18 questions, was developed to measure the ability to explain scientific phenomena, evaluate scientific investigations, and interpret data. The formulation of questions based on clear indicators shows that this research strives to encompass all important aspects of scientific literacy. The distribution of questions according to knowledge dimensions (content, procedural, epistemic) reflects a comprehensive approach to measuring scientific literacy (Putri et al., 2022).
4. **Implementation Stage**
   The trial conducted on 33 PGSD students at UNS provides an initial picture of the validity and reliability of the instrument. The use of this trial method is essential for measuring the reliability of the tool before it is implemented more widely. The results provide insights into the strengths and weaknesses of the instrument in measuring students' scientific literacy.
5. **Evaluation Stage**
   Validity analysis using the Content Validity Index (CVI) shows that most items are valid, with S-CVI/Ave and S-CVI/UA above 0.80, indicating good validity. However, there is one item with an I-CVI value below 0.78 (item 14), indicating that this item needs to be improved to enhance its relevance.

In the reliability test, some questions showed good results, but there were also items with low to very low reliability, such as question number 12 (r=0.164). Questions with low reliability need to be revised to improve the accuracy of the instrument. This is important to ensure that the measurement tool provides consistent and trustworthy results in assessing students' scientific literacy.

Analysis using Item Response Theory (IRT) shows variations in difficulty levels and discrimination power of the questions. The difficulty levels of the questions ranged from -0.207 to 1.215, indicating that this instrument includes questions with varying difficulty levels, thus able to test students' abilities more broadly. The discrimination power of the questions also

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varies, with most questions having good discrimination power, such as questions 6 and 16, which have values greater than 1, indicating the ability of these questions to differentiate students with different abilities.

CONCLUSION

Overall, this scientific literacy instrument is valid and fairly reliable, although there are several items that need improvement. The use of Item Response Theory and other statistical analyses provides a strong foundation for the development of a better instrument. Improving questions with low reliability will enhance the accuracy and consistency of this measurement tool in the future.

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