Profile of Pre-Service Physics Teachers' Scientific Literacy Based on Competence Aspects

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Abtract. The rapid development of scientific information impacts students' ability to solve problems in daily life based on each student's ability to manage the information. This study aims to analyze and describe the scientific literacy of pre-service teachers in the physics education study program in the second semester. This research method is a descriptive method with a quantitative approach. The data collection technique is a test using a test sheet instrument containing 11 questions about scientific literacy, which consists of 3 aspects: explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically. Experts have validated the instruments used. The results showed that the overall scientific literacy competence of students was in a low category. One indicator shows the value in the medium category, while the other indicators show the low category. These results indicate that students' scientific literacy skills need to be improved. These findings can be used as a basis for evaluating the learning process by emphasizing the development of students' scientific literacy skills.

Keywords: analysis; competence; profile; scientific literacy.

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INTRODUCTION

Education is one of the most important parts in supporting the progress of the life of the nation and state. A good education process can produce intellectuals who can compete globally to support the progress of the country. This has also been regulated in a constitution that explains the purpose of national education is to develop capabilities and build the character and civilization of a dignified nation in the context of the country's intellectual life. Education also aims to develop the potential of students to become human beings who believe and fear God, have noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens.

Based on that goal, education must be able to create graduates who can encounter some challenges in globalization as it is today. Critical thinking, creativity, problem-solving, metacognition, communication, collaboration, and some literacy skills are skills needed in the 21st century [1]. One of the literacies that need to be provided to students as pre-service teachers is scientific literacy. Scientific literacy is one of the 16 21st century skills required by students [2]. Developing scientific literacy can make students have good scientific thoughts and attitudes. Scientific literacy is the ability to engage with science-related issues, and with scientific ideas, as a reflective society [3]. The development of scientific literacy is recognized as one of the main goals in science learning [4]. When students have scientific literacy skills, they will be able to build a more advanced nation. But, based on the results of previous studies that students as pre-service teachers have low scientific literacy skills [5,6].

Students' scientific literacy abilities are diverse and low because the learning process is emphasized on low-level abilities, such as memorizing, understanding, and applying [4]. The current curriculum supports the achievement so that students have good scientific literacy. But, the implementation of the curriculum is still running in stages, so that scientific literacy is still the main achievement and as an educational target always to be improved and developed so that students are well equipped with this literacy. Another cause is the rapid development of scientific information on the internet. The diverse abilities of students' scientific literacy lead to different abilities to solve problems in

everyday life.

Based on the Human Development Index (HDI), Indonesia ranks below [7]. This shows that the low quality of human resources means that education in Indonesia is still weak. As a result, the human resources produced have capabilities below neighbouring countries such as Singapore, which are already included in the category of high human development. So that the development of scientific literacy is very important in our education so that the realization of human resources which have high competitiveness, are skilled and have a character in work. Scientific literacy consists of scientific knowledge and processes that can make students have strong scientific thoughts and attitudes and are needed by students in decision making, cultural and economic productivity.

There are many challenges and low results related to their achievement of scientific literacy, so it is necessary to analyze and describe the scientific literacy competencies of students as pre-service teachers in physics education, UNSIQ. The analysis of pre-service is based on three aspects described by the OECD [3]. These aspects include explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically.

METHOD

This research method is a descriptive method with a quantitative approach. The subjects in this study were students of the physics education study program, UNSIQ. The sample in this study were 52 students. Sampling was done randomly, with the overall data of students being homogeneous. The procedure in this study includes three stages: preparation, implementation and analysis. The preparation stage includes making research instruments in the form of test grids, scientific literacy test instruments, and assessment rubrics. Experts validated the instruments compiled. The implementation stage includes giving scientific literacy tests to students and scoring the results of scientific literacy tests. The analysis phase includes analyzing the data and concluding the data obtained from the scoring results. The data collection technique in this study was a test technique. The test instrument used was 11 essay questions derived from 3 aspects of scientific literacy. The indicators of scientific literacy instruments are presented in Table 1 below.

Table 1. The indicators of scientific literacy

No.	Aspect	Indicators
1.	Explain phenomena scientifically	Identify, use, and generate explanatory models and representations
		Correcting or confirming the predictions given
		Offers an explanatory hypothesis
		Describe the potential implications of scientific knowledge for society
2	Evaluate and design scientific investigations	Identification of questions that are explored in a particular scientific study;
		Discern the questions that are possible to investigate scientifically
		Propose questions to be explored scientifically
3	Interpret data and evidence scientifically	Transformation of data with many forms of representation
		Analyze, interpret data, and conclude
		Identify assumptions and evidence from information relating to science
		Make arguments or explanations based on scientific data and theory

The data obtained in the form of quantitative data in students' science literacy skills scores. After scoring, the data is converted into a percentage using the following formula:

$$Persentage\ score = \frac{score\ each\ indicator}{total\ score\ each\ inndicator} \times 100\%$$

Then categorization is carried out for each aspect by grouping the scores obtained by students into very high, high, medium, low, and very low categories. Guidelines for categorizing

student scientific literacy competencies are presented in Table 2 below.

Table 2. Category of student scientific literacy competencies

Percentage score	Category
80 – 100	very high
66 – 79	high
56 – 65	medium
40 – 55	low
0 – 39	very low

Quantitative data in the form of percentages were analyzed descriptively. The analysis is intended to find out the complete description and information, so that conclusions can be taken to describe the profile of students' scientific literacy competencies.

RESULTS AND DISCUSSION

Research on student scientific literacy analysis refers to scientific literacy competence, which consists of explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically. Figure 1 is an example of a scientific literacy test instrument in explaining phenomena scientifically with indicators of correcting or justifying the predictions given. There is a description and representation are given in the stimulus that becomes a reference for students to respond whether the statements given are wrong or true. Students must provide explanations that show or imply that the movement of tectonic plates or faults is caused by a force or stress and that rocks move in different directions. Some students confirmed that the question was wrong but could not provide a scientific explanation of the relationship between stress and cesarean. Some students confirmed that the question is true that stress is formed by the movement of faults. Some other students confirmed the questions given by providing an appropriate explanation that the fault is caused by a force or stress.

Question 1. Stress is formed by the movement of the fault. Why can this happen? _____ _____ _____ _____ _____ _____	A geological fault or fault is a fracture area accompanied by a relative displacement of one block for another rock block. The displacement distance can be only a few millimetres to tens of kilometres, while the fault planes range from a few centimetres to tens of kilometres. Faults with large sizes occur due to tectonic forces caused when plate movements occur, such as a subduction zone at the meeting of two tectonic plates. In general, faults or faults can be formed due to the force on the rock (can be a pressing force, an attractive force, or a combination of both). So that the rock is no longer able to withstand the force, these events are called earthquakes. Areas with active faults are areas that are prone to earthquakes.

Figure 1. Examples of aspects of scientific literacy instruments explaining phenomena scientifically

Figure 2 is an example of a student's scientific literacy test instrument in interpreting data and evidence scientifically with indicators of data transformation from one representation to another. In this item, students are asked to transform data from image representations into verbal representations. Based on the wave image, the epicentre of the earthquake has a smaller wavelength than distant locations. So that the frequency of the waves at the epicentre of the earthquake is getting bigger while the areas that are far away are getting smaller. The energy is proportional to the frequency, so the smaller the earthquake energy felt at places far from the epicentre. All students provide uniform information that the farther from the epicentre, the smaller the impact. Only a small number of students can represent well in verbal form. Most of the students were only able to explain that the epicentre of the earthquake had a high frequency so that the earthquake felt bigger. Students have not been able to explain that frequency is proportional to energy. Energy from the earthquake propagates from the epicentre to the surrounding area with a decrease in energy, causing areas far from the epicentre to feel only a little of the earthquake's impact.

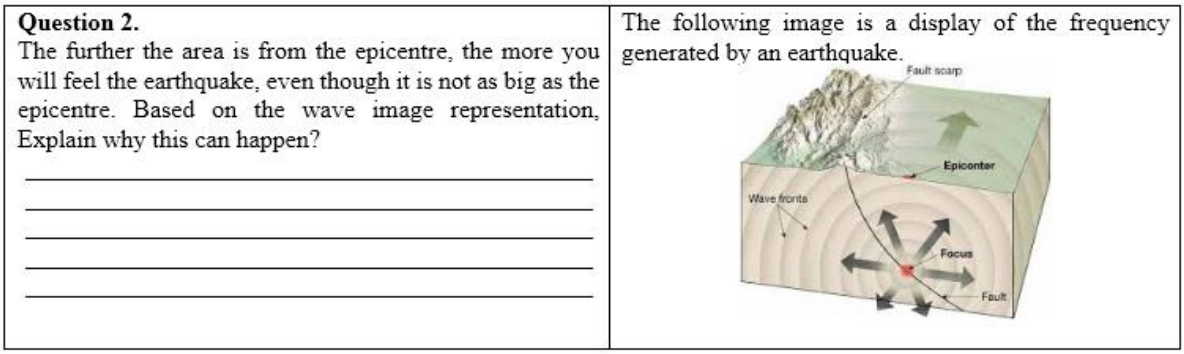

Figure 2. Examples of aspects of scientific literacy instruments interpreting data and evidence scientifically

Figure 3 is an example of a student's scientific literacy test instrument on evaluating and designing scientific investigations with indicators proposing questions to be explored scientifically. In this item, students are asked to choose from three options to demonstrate their understanding of the question being explored scientifically by the researcher. The researchers' responses who examined the effect of the amount of groundwater extraction on earthquake activity correctly identified the independent and dependent variables in the experiment. Most of the students can design an investigation and can distinguish the independent variable from the dependent variable. However, there are still a small number of students who are still upside down in answering these questions by answering the effect of earthquake activity on groundwater extraction activities. The mistake is caused because students have not been able to design scientific investigations properly and do not know the difference between independent and dependent variables properly.

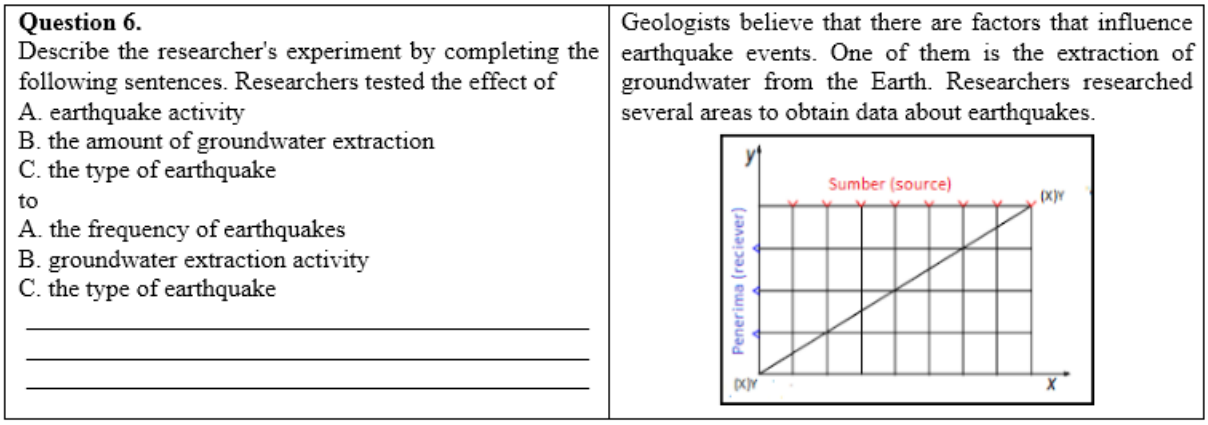

Figure 3. Examples of scientific literacy instruments for evaluation aspects and designing scientific investigations

The assessments are categorized based on each aspect. The score for the percentage of students' scientific literacy results is shown in Table 3.

Table 3. The score for the percentage of students' scientific literacy

Topic	Percentage			
	Explain phenomena scientifically	Evaluate and design scientific investigations	Interpret data and evidence scientifically	Average
Earthquake	57.5	42.5	48.5	49.5

Based on Table 3, each aspect has a percentage value in the low and medium categories, with the average percentage in the low category. The highest value is found in explaining

phenomena scientifically. While the lowest score in evaluating and designing an investigation. Based on the study results, it was found that students have sufficient understanding in scientifically explaining phenomena in everyday life. However, they still have difficulty in evaluating, designing investigations and interpreting data. When students are given a problem, they can understand the reason for the problem and explain it. However, it is still difficult to solve the problem in the form of an investigation.

The low level of scientific literacy in the physics education department is caused by some internal and external factors. Educational background before entering university is one of the factors for the diversity of students' scientific literacy. Several educational backgrounds consist of vocational schools with several majors and high schools (majoring in natural science and majoring in social). This difference causes different students' scientific abilities. Educational background, experience, and parental guidance will motivate students to develop better [9]. So, students whose educational background is from the science department will have excellent scientific literacy skills.

The development of technology and information is also a factor in the diversity of students' scientific literacy abilities. Students who have high motivation will try harder to solve some problems related to everyday life. There is a lot of information and easy to find will make it easier for students to solve some problems. Information and communication technology (ICT) can improve scientific literacy [10]. ICT is considered a key role in learning because ICT can provide instant access to any new knowledge around the world regardless of spatial and temporal constraints [11].

Students' perceptions that are not suitable are an inhibiting factor in learning science. Students' perceptions of learning activities in lectures held on campus positively influence learning achievement that students can achieve [12]. Holbrook's research shows that science learning is not relevant to student perceptions [13]. This is because the learning activities do not relate the material to everyday life. Emphasis on understanding the basic concepts and basic understanding of science is not associated with matters relating to everyday life. In contrast, Yager and Lutz state that science is relevant to processes and products in everyday life in society [14].

One of the other obstacles to learning science is the low ability to read. Students tend to seek and seek information if only given assignments or problems to solve. Based on PISA data for 2015, Indonesian people's reading literacy is low [15]. Indonesia is still far behind other countries, with an average reading literacy score of 493, while Indonesia is 397. The causes of low interest and the habit of reading include a lack of concern for the information obtained. The low reading interest of students can affect their scientific literacy skills. The lack of information they have makes it difficult for them to explain and carry out investigations into the problems encountered.

If it is based on the learning process, student scientific literacy is closely related to how a teacher presents the learning process. Therefore, as pre-service teachers, the teaching and learning process must be directed to equip them with scientific argumentation skills to support their scientific literacy. The constructivist learning model is needed to change learning from teacher centre to student centre so that students are more active to construct their knowledge. The most important reforms in education are in teaching, not in the curriculum, to promote appropriate learning, which is to emphasize "how" rather than "what" to the material being taught [14].

CONCLUSIONS

The results showed that each aspect of the student's scientific literacy competence was in different categories: low and medium. Low category for aspects of evaluating and designing investigations and interpreting data and evidence scientifically. Medium category for aspects of explaining phenomena scientifically. Based on these findings, students' scientific literacy skills need to be improved, and teaching practices should be directed at constructivist learning. It relates more about science learning with everyday life because science is very relevant to everyday processes and products.

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