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Analysis of the Science Literacy Competency Profile of High School Students on Sound Wave Material

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ABSTRAK. The learning process in the 21st century requires students to have scientific literacy skills. However, in fact, the scientific literacy skills of Indonesian students are relatively low and tend to decline every year. The purpose of this study was to describe the scientific literacy profile of high school students for the competency aspect in the material of sound waves. This study uses a quantitative approach with a descriptive analysis method. The study was conducted in May 2024 at one of the State High Schools in Nganjuk Regency. The population in this study was 72 students. The research instrument used was a scientific literacy test that had been declared valid with an average Percentage of Agreement (PoA) of 96.43. The data analysis technique used quantitative descriptive analysis from the results of calculating the level of scientific literacy of students. The results of the study obtained a profile of scientific literacy competencies of students of 3% very low, 51% low, 33% sufficient, and 13% high. The percentage for each indicator of scientific literacy competency obtained by students is 43% for the competency of explaining phenomena scientifically, 33% for the competency of evaluating and designing scientific investigations, and 23.6% for the competency of interpreting data and evidence scientifically.

1. Introduction

The development of the 21st century is marked by the increasing linkage between science and technology, which has a very large influence on the field of education (Rohmah & Jauhariyah, 2020; Rohmawati et al., 2018). In the 21st century learning process, students are required to have skills, one of which is scientific literacy (Wardi & Jauhariyah, 2023). This ability is very important to help students face the progress of the times (Agustya & Jauhariyah, 2023). Students with scientific literacy will have critical and creative thinking as well as in-depth knowledge and understanding to care about and respond to problems in society (Rosana *et al.*, 2020).

Scientific literacy is defined as the ability to engage in problems related to science and be willing to engage in scientific problems and be able to put forward scientific ideas so as to become a reflective society (OECD, 2019). In Indonesia, students' scientific literacy skills are included in the low category and tend to decline. This was conveyed by the Organization for Economic Co-operation and Development (OECD) after conducting research on students' scientific literacy skills on an international scale through the Programme for International Student Assessment (PISA). The results of the study revealed that students' scientific literacy skills in Indonesia in 2022 rose 5-6 positions compared to the 2018 PISA results at 70th place with an average score of 396. However, these results cannot be said to be good, considering that Indonesia's score is still far from the target of the 2024 National Medium-Term Development Plan (RPJMN) with a score of 402. The results of the study conducted by PISA to determine the scientific literacy skills of Indonesian students from 2012 to 2022 can be seen in **Table 1**.

Table 1. PISA study results for students' scientific literacy skills in Indonesia

Year	Average Score Indonesia	Average Score PISA	Indonesia Ranking	Number of Participating Countries
2012	375	494	64	65
2015	403	490	63	70
2018	396	489	70	78
2022	383	476	65	81

(Adapted from Sutrisna, 2021 & Kemendikbudristek, 2023)

The low level of scientific literacy of students is influenced by several factors, including students' tendency to memorize, variations in learning methods that do not direct students to read, and limited learning media that support the learning process (Istiqomah & Hariyono, 2019). Suciati et al., (2014) said that the low scientific literacy skills of Indonesian students were caused by the application of learning methods that did not explore natural phenomena and the investigation process, but rather tended towards conventional knowledge transfer that was oriented towards teachers. Non-contextual learning also has an impact on students' ability to solve scientific literacy-based problems (Sari et al., 2022).

Contextual learning is learning that connects information from everyday life with the scientific concepts being studied. By using contextual learning, students will more easily understand the information conveyed by the teacher, including the test questions given. Based on the needs analysis that has been carried out, it was obtained that 61.4% of students in one of the State Senior High Schools in Nganjuk Regency have not been able to carry out physics learning related to scientific literacy competencies. This is because the physics learning that is carried out is only focused on textbooks and teacher's notebooks, without involving phenomena in everyday life. In one of the topics in physics, namely sound waves, there is a logical, contextual meaning that causes the concept of the material to be related to its application. Applications of the concept of sound waves can be found in everyday life, such as guitar strings, ultrasound, and sonar technology (sound navigation and

ranging). In addition, one part of the regional culture that can be used to visualize sound wave material is Javanese Gamelan. In gamelan instruments there is potential that can be explored for use in the learning process.

Science literacy learning emphasizes the use of physics knowledge to explain scientific phenomena, evaluate and design scientific investigations, and interpret data and evidence scientifically (Mijaya et al., 2019). The three PISA 2018 science literacy competencies are explained in **Table 2**.

Table 2. Explanation of scientific literacy competencies

Science Literacy Competence	Explanation
Explaining scientific phenomena	This competency requires students to remember the information they have obtained and use it to interpret interesting phenomena. This competency also includes the ability to describe phenomena and anticipate changes that may occur.
Evaluate and design scientific investigations	This competency requires students to be able to collect accurate and precise data, evaluate research results and reports critically, and use knowledge related to the basics of scientific research.
Interpreting data and evidence scientifically	This competency requires students to be able to convey the meaning of scientific evidence, use appropriate diagrams or data presentations, analyze data, and use standard methods to change data into other representations.

Assessment of scientific literacy is very necessary to determine students' scientific literacy competencies. (Permatasari, 2022). Since 2021, Indonesia has implemented the National Assessment which includes the Minimum Competency Assessment (AKM), character survey, and learning environment survey. The minimum competency assessment aims to measure students' competencies in literacy and numeracy. The implementation of similar assessments needs to be carried out through the development of test instruments by teachers that involve aspects of science literacy. Thus, teachers can find science learning methods that can improve students' learning outcomes and science literacy skills.

Several studies have been conducted to determine students' scientific literacy abilities, especially in the field of physics. Wardi & Jauhariyah (2023), onducting research on the profile of high school students' scientific literacy competencies on the subject of atomic nuclei and radioactivity. Likewise, Agustya & Jauhariyah (2023), conducted similar research on the material of energy sources. Mukharomah et al., (2021), also conducted similar research on the material of linear motion kinematics. Andriani et al., (2018). in his research on the physics science literacy skills of junior high school grade VIII in three schools using the PISA framework in South Sumatra. However, these studies are also limited by the materials used so that further research is needed on other physics materials. Therefore, research was conducted with the aim of describing the profile of science literacy competencies of high school students on sound wave material. The competency indicators analyzed refer to PISA 2018, namely (a) explaining phenomena scientifically, (b) evaluating and designing investigations scientifically, and (c) interpreting data and evidence scientifically.

2. Research Method

This research is a research that uses a quantitative approach with a descriptive analysis method. The research was conducted in May 2024 in the Even Semester of the 2023/2024 Academic Year at one of the State Senior High Schools in Nganjuk Regency. The population in this study were 2 classes, namely XI-F and XI-G as many as 72 students. The research instrument used was a science literacy test. Students' science literacy abilities were measured using pre-test and post-test sheets from the development of cognitive assessment instruments on sound wave material with six questions in the form of descriptions that had been tested for validity. Based on the test, the six questions used were declared valid with an average Percentage of Agreement (PoA) of

96.43%. The data analysis technique used quantitative descriptive analysis with the calculation of students' science literacy levels using equation (1) with categories as in **Table 3.**

$$Literacy\ Level = \frac{Total\ score}{Highest\ Total\ Score} x100 \quad (1)$$

Table 3. Categories of students' scientific literacy abilities

Literacy Level	Categories
30-39	Very Low
40-55	Low
56-65	Enough
66-79	High
80-100	Very High

(Arikunto, 2015)

Then the data obtained from the results of the students' science literacy test were analyzed based on the science literacy competencies tested in the questions.

3. Result and Discussion

The scientific literacy test used three indicators in the scientific literacy competency aspect by PISA 2018, namely (a) explaining phenomena scientifically, (b) evaluating and designing investigations scientifically, and (c) interpreting data and evidence scientifically. Of the six questions, there are two questions with the first indicator, two questions with the second indicator, and two questions with the third indicator. The following are the results of the scientific literacy test of students that have been carried out.

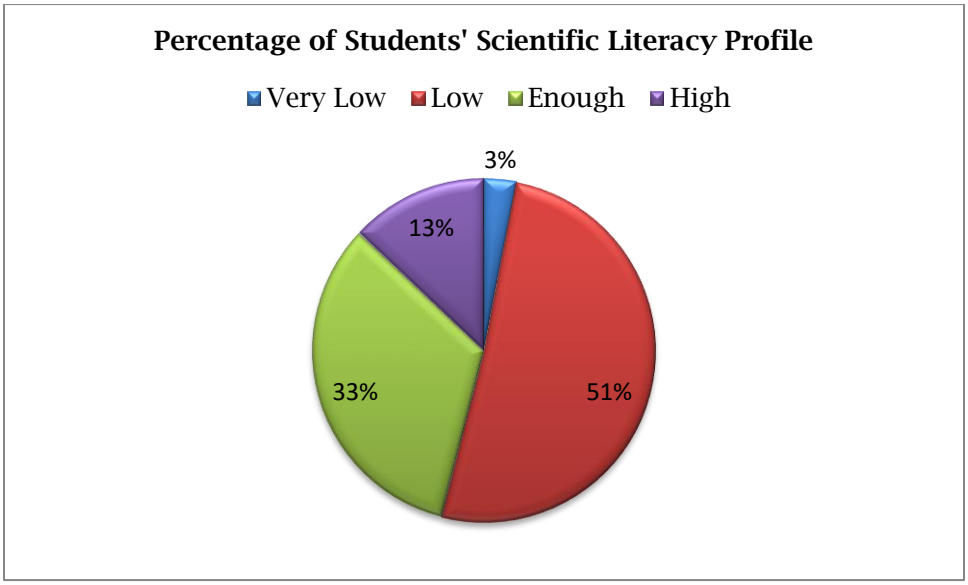

Figure 1. Percentage of students' scientific literacy profile

The results of the students' scientific literacy profile measured using a physics assessment instrument based on scientific literacy on the sound wave material presented in Figure 1 obtained a percentage of 3% of students having very low abilities, 51% of students having low abilities, 33% of students having sufficient abilities, and 13% of students having high abilities. There is a significant difference between students with low and high categories. Based on the diagram, it can also be seen that the largest percentage of students' abilities are in the low and sufficient categories. This means that students in this population tend to have different scientific literacy abilities. So it can be concluded that most students have low scientific literacy abilities. Students with low scientific literacy abilities tend to be less responsive in responding to problems that develop

in society (Nofiana & Julianto, 2018). The percentage of results of students' scientific literacy profiles based on scientific literacy competency indicators is presented in graphic data as in **Figure 2**.

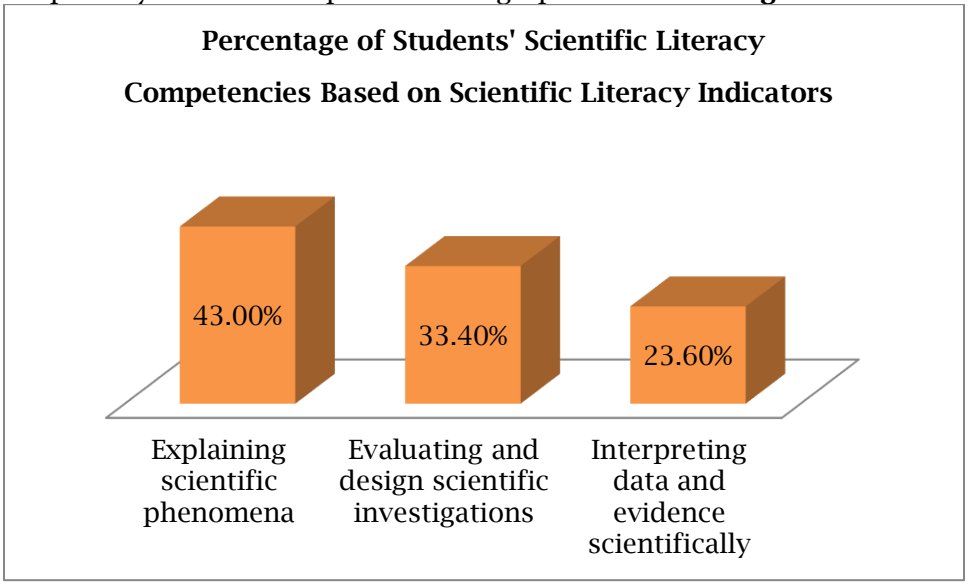

Figure 2. Percentage of students' scientific literacy competencies based on scientific literacy indicators

Figure 2 shows that the average percentage of students who have the competence to explain phenomena scientifically, the percentage obtained by students is 43%. Then for the competence to evaluate and design scientific investigations, the percentage obtained by students is 33.4%. For the competence to interpret data and evidence scientifically, the percentage obtained by students is 23.6%. Based on this, it can be concluded that students have the best ability in the competence to explain phenomena scientifically.

The competence of explaining phenomena scientifically has the highest average score because students are required to recognize and remember a scientific phenomenon. This is relatively easy considering that so far the learning carried out by students has mostly been focused on theory and memorization (Afina et al., 2021). Meanwhile, the second competency, namely evaluating and designing scientific investigations, has a lower average score compared to the first competency. This is due to the focus of science learning which tends to be on the content aspect, while 90% of science learning should consist of practicums (Diana et al., 2015). The third competency, namely interpreting data and evidence scientifically, is the competency with the lowest percentage. This is due to the lack of skill of students in making a conclusion from the data presented, whether in the form of tables, graphs, or analysis. This is in accordance with research conducted by Mawardini et al., (2015), where the low level of scientific literacy competency is influenced by the inability of students to interpret data and information provided in the form of tables or graphs.

The lack of students' ability to solve scientific literacy-based questions that require analysis and understanding of the questions causes the low level of students' scientific literacy competency. This is in accordance with research Sutrisna (2021), Students are not yet accustomed to working on science literacy questions because so far in daily tests, mid-semester assessment and final semester assessment teachers tend to give questions that only require memory of theories and formulas. According to Huryah et al., (2017); Susiati et al., (2018) The factors causing the low level of scientific literacy of students are that students are not yet accustomed to solving problems that require analytical skills and students' lack of interest in reading.

The following is an example of a student answer sheet for each scientific literacy competency indicator.

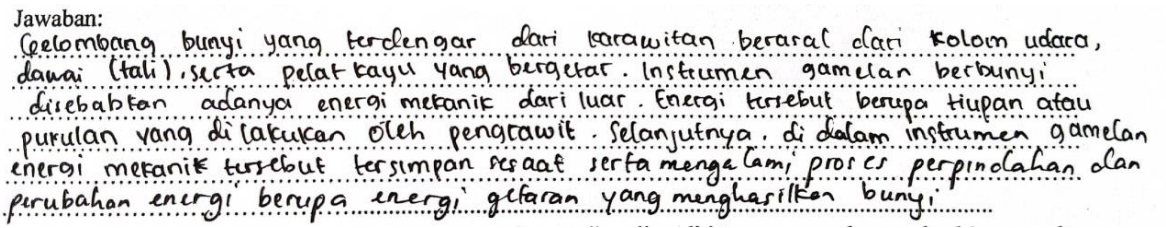
Jawaban:
Gelombang bunyi yang terdengar dari karawitan berasal dari kolom udara, dawai (tali), serta pelat kayu yang bergetar. Instrumen gamelan berbunyi disebabkan adanya energi mekanik dari luar. Energi tersebut berupa tiupan atau pukulan yang dilakukan oleh pengrawit. Selanjutnya, di dalam instrumen gamelan energi mekanik tersebut tersimpan sesaat serta mengalami proses perpindahan dan perubahan energi berupa energi getaran yang menghasilkan bunyi.

Figure 3. Results of student work for the competency of explaining phenomena scientifically (appropriate)

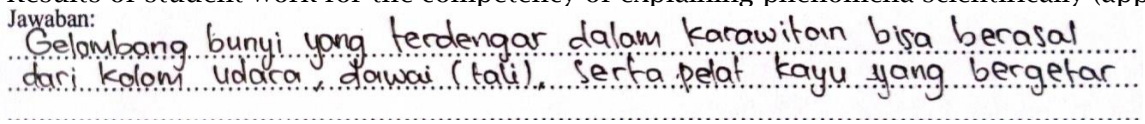
Jawaban:
Gelombang bunyi yang terdengar dalam karawitan bisa berasal dari kolom udara, dawai (tali), serta pelat kayu yang bergetar

Figure 4. Student work results for the competency of explaining phenomena scientifically (not appropriate)

Figure 3 and **Figure 4** present an example of one student's answer in completing a question with an indicator explaining phenomena scientifically. In the question, students are given initial information in the form of text or reading about the sound of gamelan instruments in a karawitan performance. Students are asked to explain how the process of sound in gamelan instruments occurs physically. Students will get the maximum score if they are able to explain that the sound sources in gamelan instruments vary, which are generally caused by the presence of mechanical energy from outside which is then stored for a moment and undergoes a process of transfer and change in energy in the form of vibration energy which ultimately produces sound.

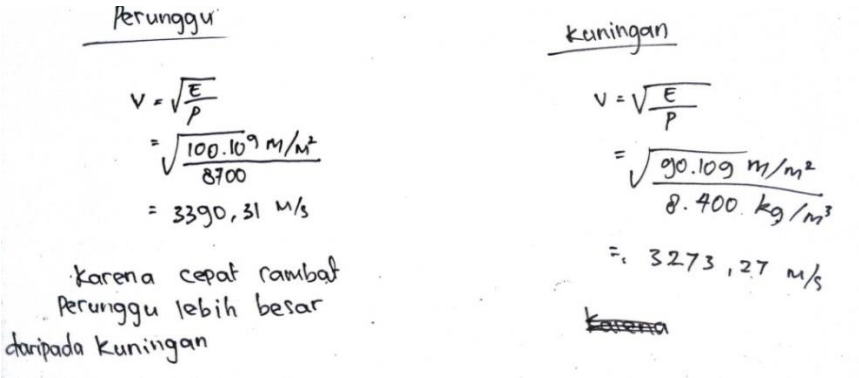

Figure 5. Results of student work for the competency of evaluating and designing scientific investigations (appropriate)

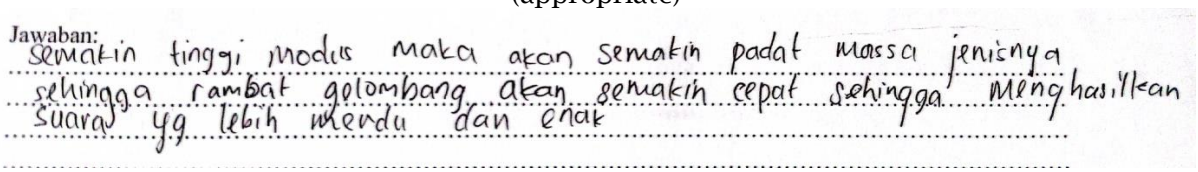
Jawaban:
Semakin tinggi modus maka akan semakin padat massa jenisnya sehingga rambat gelombang akan semakin cepat sehingga menghasilkan suara yg lebih merdu dan enak

Figure 6. Results of student work for the competency of evaluating and designing scientific investigations (not appropriate)

Figure 5 and **Figure 6** present an example of one of the students' answers in completing a question with the indicator of evaluating and designing scientific investigations. The question provides initial information in the form of text related to the differences in sound between gamelan instruments made of bronze and brass. In addition, information is also provided regarding the density and Young's modulus of bronze and brass. Students are asked to explain why gamelan instruments made of bronze are more pleasant to hear than gamelan instruments made of brass in terms of their propagation speed. Students will get the maximum score if they are able to explain that gamelan instruments made of bronze are more pleasant to hear because they have a greater propagation speed than brass.

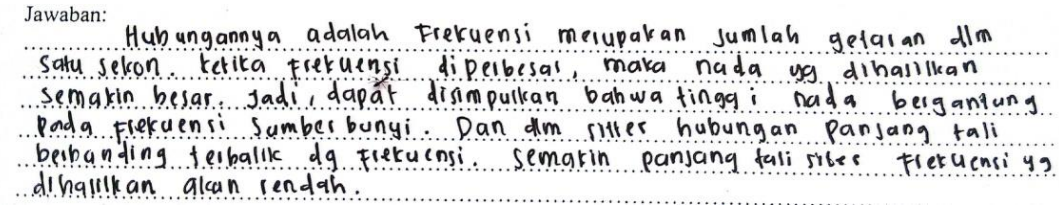

Figure 7 Results of student work for the competency of interpreting data and evidence scientifically (appropriate)

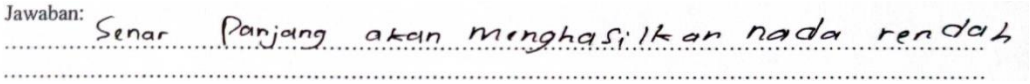

Figure 8. Student work results for the competency of interpreting data and evidence scientifically (not appropriate)

Figure 7 and **Figure 8** present an example of one student's answer in solving a question with the indicator of interpreting data and evidence scientifically. In the question, initial information is given in the form of text or reading related to the difference in sound frequency produced by zither strings of different sizes. Students are asked to determine the relationship between the length of the zither string and the frequency of the sound produced. Students will get the maximum score if they are able to answer that the relationship between the length of the zither string and the frequency of the sound produced is inversely proportional.

4. Conclusion

Based on the research that has been conducted, it was concluded that the results of the science literacy competency profile of students at one of the State Senior High Schools in Nganjuk Regency were 3% very low, 51% low, 33% sufficient, and 13% high. Meanwhile, the percentage of students' science literacy abilities for each science literacy competency indicator was 43% for the competency of explaining phenomena scientifically, 33% for the competency of evaluating and designing scientific investigations, and 23.6% for the competency of interpreting data and evidence scientifically. Thus, students have the highest competency in explaining phenomena scientifically and the lowest competency in interpreting data and evidence scientifically.

Thank You Note

Thank you to SMAN 3 Nganjuk for giving permission as a location for this research.

Author Involvement

NI: developed the assessment instrument, performed data acquisition and analysis, and wrote the manuscript, and MNRJ: review and editing of manuscript.

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