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An Analysis of Students' Scientific Literacy Ability on Vibration and Wave Materials

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Abstract
This study aims to describe students' scientific literacy skills on vibration and wave material at SMP Negeri 14 Pontianak and examine differences in abilities in each aspect of scientific literacy. The research method used is described with a quantitative approach. The research instrument was used in the form of test questions in the form of essays consisting of 15 questions based on scientific literacy. The sample in this study was class IX students at SMP Negeri 14 Pontianak, totalling 174 people. The measured scientific literacy includes aspects of science content, scientific processes, and the context of science. The results of data analysis showed that the scientific literacy ability of students of vibration and wave material was 33.70% for the science content aspect, 44.60% for the science process aspect, and 42.00% for the science context aspect. Based on the Kruskall-Wallis test, the results of the analysis showed that there were differences in the abilities of students in every aspect of scientific literacy. It is hoped that other researchers can apply science learning that focuses on aspects of science content.
Keywords: Science Learning; Scientific Literacy; Vibration and Wave

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INTRODUCTION

Education is currently in the 21st century, also known as the era of the industrial revolution 4.0, characterized by rapid advances in science and technology. The Ministry of Education and Culture requires Indonesians to master six basic literacy skills, including scientific literacy (Sani, 2021; Sutiani, 2021).

Education in Indonesia accommodates scientific literacy in the education curriculum, starting from the KTSP curriculum, the 2013 curriculum, and the prototype curriculum. The expected abilities in learning that are applied to each curriculum are in line with the existing aspects of scientific literacy.

The Program for International Student Assessment (OECD, 2016) defines scientific literacy as a reflective citizen's ability to engage with science-related issues and ideas. The ability to recognize scientific problems, explain scientific phenomena, analyze data, and use scientific evidence are necessary to participate in reasoned discourse about science and technology.

Scientific literacy comprises three interconnected components: science content, science processes, and the context of science in its application (Chen et al., 2021; Sinaga et al., 2017; Yuyu, 2017). One of the reasons why scientific literacy is so important for students is that it relates to how they understand environmental, health, and economic issues, as well as other aspects of modern society that are heavily reliant on technology and scientific advances (Dewantara et al., 2019; Hartini et al., 2019; Lestrari et al., 2021; Mahtari et al., 2019; Nugraheni, 2017).

Countries such as America and Australia recognize the significance of students' scientific literacy (McFarlane, 2013).This demonstrates that America already has a unique standard, the Benchmark for Science Literacy. According to the Australian Curriculum Assessment and Reporting Authority, the Benchmark for Science Literacy is a specific standard regarding scientific literacy skills that students must have at each grade level (Fatmawati, 2016). Several prominent science educators in the United States have written about the importance of science literacy in the literature as a school science curriculum goal (Osborne, 2007).

Assessment of scientific literacy is required to determine students' scientific literacy abilities so that Indonesia can compete with other countries to improve science education. The PISA study results in support the low scientific literacy of Indonesian students. According to the PISA survey results from 2000 to 2018, Indonesia is one of the countries with low scientific competence (Hewi & Shaleh, 2020; Sholikah & Pertiwi, 2021). Indonesia's low PISA ranking reflects that science learning in Indonesia has not been able to empower students' scientific literacy abilities.

It is critical to understand how far students' abilities toward scientific literacy have progressed. As a result, students require scientific literacy tools. Instruments for evaluating scientific literacy already exist and can be adopted from PISA, but the results of scientific literacy of Indonesian students in international studies apply in general. Instruments for scientific literacy are required for test-type students in a limited scope.

According to the description provided above, this study will examine scientific literacy abilities at the junior high school level because children aged 15 (nearing the end of compulsory education) are deemed to have adequate scientific literacy skills, both of which will be used to determine whether or not they continue their studies in science. This is consistent with Pertiwi et al.'s (2018) research, which concluded that scientific literacy is effective in creating science learning in 21st-century junior high schools. Thus it can be used as a guideline for developing science learning.

Previous studies related to this research (both to analyze scientific literacy ability profiles) have been conducted to describe scientific literacy skills in the aspect of scientific competence of class IX students in junior high school in several science materials. One of the studies is vibration and wave material for indicators of identifying scientific problems and explaining scientific phenomena are classified as moderate, while indicators using scientific evidence are classified as low (Harlina et al., 2020).

The distinction between this study and previous studies is in scientific literacy, particularly in the material of vibrations and waves. Since vibration and wave material has many applications, it is an important for junior high school science material to master and comprehend (Sutopo, 2016). PISA-based aspects of scientific literacy, namely content, process, and context, are used to assess scientific literacy in this study. This aspect of scientific literacy is extremely important in terms of science attitudes, which are related to processes, products, attitudes, and applications (technology) (Suciati et al., 2016). Furthermore, researchers examine scientific literacy skills in each aspect of scientific literacy and differences in scientific literacy abilities in each aspect of scientific literacy.

METHOD

The descriptive method with a quantitative approach was used in this study. This research aimed to describe the scientific literacy abilities of students at SMP Negeri 14 Pontianak.

The population in this study were grade IX students at SMP Negeri 14 Pontianak for the 2021/2022 school year who had taken science lessons on vibration and waves with 309 people. The Cluster Random Sampling technique was used in this study's sampling. This study's sample size was 174 people.

The test instrument in this study describes the three aspects of scientific literacy, with 15 questions adapted from the 2018 PISA science competency level.

The scientific literacy ability test grids in this study were modified from previous studies, as shown in Table 1.

Table 1 Science literacy questions grid

Question Number	Question Indicator	Aspects of Scientific Literacy
1	Calculate the period of the pendulum	Science Content
2	Draw conclusions regarding the influence of the length of the pendulum string on the period of vibration	Science Process
3	Write down how to overcome the slowing of the pendulum clock swing	Science Context
4	Use the doppler effect formula to find the listener's frequency in a particular situation	Science Content
5	Express opinions about sound frequencies based on illustrations	Science Process
6	Write down how to know the sound of an ambulance siren approaching or moving away without seeing the ambulance	Science Context
7	Describe the reflection of sound emitted by bats	Science Content
8	Infer changes in the frequency of sound received by the bat when the sound receiver moves away from the bat	Science Process
9	Write down how bats detect sound receptors moving away	Science Context
10	Calculate the frequency of each player based on the jump data in the table	Science Content
11	Summarize the effect of the number of jumps on the frequency of jumps	Science Process
12	Write down how to increase the frequency of jumps	Science Context
13	Infer what happened from the experimental steps provided exactly	Science Process
14	Sequence the propagation of sound waves in different mediums accurately	Science Content
15	Describe the propagation of sound heard under certain conditions	Science Context

Based on the calculation results of the instrument validation questions that the validator had carried out, an average of 3.64 was obtained. This showed the level of validity of the question instrument made by the researchers belongs to the very valid category. It is suitable for use as an instrument in this study.

Furthermore, the reliability test carried out in this study used the Alpha Cronbach formula because the type of instrument was an essay question. Based on the analysis data from the results of the research instrument trials, it was declared reliable with a Cronbach Alpha coefficient of 0.622, so the test items were declared reliable. Processing scientific literacy measurement data for students is based on the tests' results. The steps were as follows.

1. Assessment of test results
   a. Giving a score on each student's test results
   b. Changing the answer score into a value form
   c. Determining the average value score
   d. Defining the standard deviation
2. The students were then divided into three groups, namely high, medium, and low, based on Table 2's categorization, to establish their profile of scientific literacy skills (Sugiyono, 2019).

Table 2 Science literacy category

Score	Category
Score > $\overline{x}$ + SD	High
$\overline{X}$ – SD ≤ Score ≤ $\overline{X}$ + SD	Medium
Score < $\overline{x}$ – SD	Low

3. The data were analyzed using the SPSS to find differences in students' scientific literacy abilities in each aspect of scientific literacy, namely Kruskall Wallis test, because the data were not normally distributed. Furthermore, the *Mann-Whitney* test was carried out to see the differences in students' scientific literacy abilities in science content *vs* science process, science content *vs* science context, and process *vs* science context.

RESULT AND DISCUSSION

Profile of students' science literacy ability in SMP Negeri 14 Pontianak

Based on the recapitulation of the student's answers results, the students' average score is 40.09. It was found that most students had science literacy abilities in the moderate category, with a percentage of 73.0%.

Analysis of test data from the three aspects showed that the highest percentage for literacy aspects was in the Science Process aspect, which amounted to 44.6%. Meanwhile, the lowest percentage was on the science content aspect at 33.7% and on the science context aspect at 42.0%.

Differences in Science Literacy Ability in Each Aspect of Science Literacy

According to the Kruskall-Wallis test results, it was determined that students' levels of ability in each area of science literacy varied. The findings of the Kruskal-Wallis test using the SPSS 24 program are presented in Table 3.

Table 3 Kruskall-Wallis test results

Test Statistics[a,b]

	Score
Chi-Square	22.374
df	2
Asymp. Sig.	.000

a. Kruskal Wallis Test
b. Grouping of Variable: Aspects of Scientific Literacy

Moreover, the Mann-Whitney test compared students' science literacy abilities regarding science content, science process, science context, and process. Table 4 shows the findings of a Mann-Whitney test using SPSS 24 between aspects of science content and science process.

Table 4 Science content vs science process test results

Test Statistics

	Score
Mann-Whitney U	10737.500
Wilcoxon W	25962.500
Z	-4.701
Asymp. Sig. (2-tailed)	.000

a. Grouping of Variable: Aspects of Scientific Literacy

The results of the Mann-Whitney Test using SPSS 24 between aspects of the science process vs the science context are shown in Table 5.

Table 5 Science process vs science context test results

Test Statistics[a]	Score
Mann-Whitney U	14140.500
Wilcoxon W	29365.500
Z	-1.069
Asymp. Sig. (2-tailed)	.285

a. Grouping of Variable: Aspects of Scientific Literacy

Meanwhile, Table 6 shows the results of the Mann Whitney Tests conducted using SPSS 24 between aspects of science content and science context.

Table 6 Test results science content vs. science context

Test Statistics[a]	Score
Mann-Whitney U	12141.000
Wilcoxon W	27366.000
Z	-3.213
Asymp. Sig. (2-tailed)	.001

a. Grouping of Variable: Aspects of Scientific Literacy

Profile of students' science literacy ability at SMP Negeri 14 Pontianak

The first problem examined the profile of students' science literacy abilities at SMP Negeri 14 Pontianak. The results of the overall profile of students' science literacy abilities are presented in Figure 1 as follows.

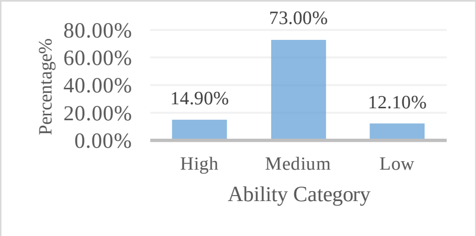

Figure 1 Percentage of science literacy ability

Based on Figure 1, it was found that of all the students who were the research sample, the category that students got was mostly moderate, which was 73.00% of the total research sample, for the high category as much as 14.90%, and for the low category as much as 12.10%. The following is the percentage of students' science literacy abilities in each aspect of science literacy shown in Figure 2.

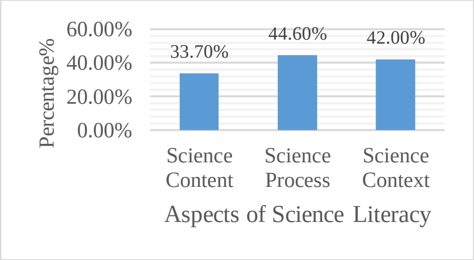

Figure 2 Percentage of ability in each aspect

The analysis of the three aspects of science literacy showed that the science process aspect had the highest percentage. This aspect measured the ability to process the information obtained to conclude vibrations and waves. While the lowest percentage was in the science content aspect. In this aspect, it measured students' understanding of vibrations and waves. The inability of students to use formulas when working on problems in this study was due to a lack of understanding of science concepts.

A variety of variables could impact science literacy abilities. a lack of ability to read and interpret a text, a limited ability to read and interpret a text, misconceptions about the primarily memorized materials a teacher teaches, science teaching methods focusing less on basic concepts and science centered on environmental issues, a limited ability to use (the state of school infrastructure, school human resources, type of organization, and school management), (Fuadi et al., 2020).

Another aspect of students' poor scientific literacy is their inexperience with practice questions, such as those found on PISA exams (Rohmah & Hidayati, 2021). Three categories of science literacy abilities were identified in this research:

a. Science Content

The assessment of the science content aspect measured students' understanding of the concepts of vibration and waves. The findings in this study showed the lowest aspect of science literacy. The findings in this study showed that the science content aspect was the least important aspect of science literacy. This is in line with research conducted by Nofiana (2017); the results of his research show that the science literacy abilities of junior high school students in Purwokerto City in the science content aspect are still relatively low at 53.80%.

Based on the results of the student's answers, it was found that the highest indicator of questions on the science content aspect could be answered by students, namely calculating the vibration period of the pendulum, with an average percentage of 61.4% contained in question number 1. Learners were expected to be able to calculate the vibration period based on the data in the table provided. On average, learners could remember the concept of the vibration period to apply the formula when working on the problem.

The lowest indicator of questions successfully answered by students was to sort the speed of propagation of sound waves in solid, liquid, and gas mediums, with an average percentage of 11.3%. Problem number 14: It was expected that students would be able to sort the propagation of sound waves in different mediums appropriately. However, some students had not mastered the material on the sound propagation medium. The students assumed that sound could not propagate in solids or liquids but would be reflected if it hit a solid or liquid. This is in line with research (Ibrahim & Aspar, 2011), which states that science concepts that cannot be fully mastered and understood will cause misconceptions. In addition, many students were wrong in their answers and did not answer this question due to limited time. This is in accordance with the research of Priyoko et al., which states that several variables cause students to make mistakes when working on problems because they rush to do calculations or work on problems because they feel pressed for time.

The lowest average percentage was in the science content aspect. This finding showed that students had difficulty working on problems in the science content aspect. This is in line with research (Azizah et al., 1977); in her research, she stated that there were 26% difficulties in understanding ideas and formulas, 18% difficulty in applying equations or formulas to problems, 17% difficulty in assessing graphs and visuals, and 7% difficulty in concluding the material studied.

b. Science Process

This aspect measures the ability to process the information obtained to conclude the vibration and wave occurrence concept. The findings showed that the average percentage of students' science literacy abilities in the science process aspect was 44.60% or in the medium category.

The indicator on the highest science process aspect could be answered correctly by students on the science content aspect, namely expressing opinions about the frequency of sound based on illustrations, with an average percentage of 76.0% in question number 5. In this question, students were expected to express opinions about the frequency heard by listeners based on the illustrations provided. On average, students could write their opinion about the frequency of the siren sound that can be heard by the listener when the ambulance moves closer or further away. The event presented in question number 5 was very familiar with the environment, so learners could draw the correct conclusion.

Based on the analysis of the student's answers, it was found that the students did not understand the questions in the problem well, so they could not answer correctly. This is in line with Suno et al. (2018), who state that various problems cause students to experience errors in solving physics problems, one of which is a misunderstanding in problem analysis. Errors in problem analysis include errors in determining the information contained in the problem.

The indicators of the questions on the aspects of the science process that participants least successfully achieved were processing information and drawing conclusions on question number 11. The students were expected to be able to conclude the effect of the number of jumps on the frequency of jumps based on the data obtained in question number 10. On average, students who did not remember the concept of vibration frequency (contained in question number 10) could not conclude the effect of the number of jumps on the frequency of jumps (in question number 11).

c. Science Context

This aspect measured the ability to apply vibration and wave concepts to solving everyday problems. The results of the research on the science literacy profile of class IX students at SMP Negeri 14 Pontianak, based on Table 4.3, showed that the average percentage of students' science literacy abilities in the scientific context aspect, was 42.00%, or in the medium category.

The highest indicator of questions that students could answer was Using the doppler effect to determine whether an ambulance was approaching or moving away. On average, students could determine whether an ambulance was moving closer or further away by hearing the siren.

Moreover, the lowest problem indicator that students could achieve was to determine the effect of the number of jumps on the frequency of jumps. Learners were expected to be able to use the relationship between frequency and the number of jumps to solve problems. Learners who could not answer the questions in question number 12 were students who could not answer questions in numbers 10 and 11. This was because the questions in Discourse 4 were interrelated with each other. This is in line with research (Ibrahim & Aspar, 2011) suggesting that aspects of science literacy are interconnected. If one aspect of science literacy was weak, it would impact other aspects of science literacy.

According to Okada in Subaidah et al. (2019), science literacy is the ability to read and understand an article and relate it to everyday life. In the 2013 curriculum, aspects of science context have been implemented in learning.

Differences in Science Literacy Abilities of Students at SMP Negeri 14 Pontianak in Each Aspect of Science Literacy

Since the data were not normally distributed and not homogeneous, the Kruskal-Wallis test was used to test whether there were differences in students' science literacy skills in each aspect of science literacy.

Furthermore, the Mann-Whitney test was conducted to see the differences in students' science literacy skills in science content vs science process, science content vs science context, and process vs science context. In this study, researchers found differences in students' science literacy skills between science content vs science process and aspects of science content vs science context. This is concluded based on the results of the Mann-Whitney test, which shows a significance value below 0.05.

The average percentage of student's ability in the science content aspect was lower than in the science process and context aspects. According to (Nofiana, 2017), the demand for teachers to complete teaching materials according to curriculum objectives forces students to accept science concepts they may not fully comprehend.

Therefore, many science concepts were memorized or misinterpreted (misconceptions), making them easy to forget.The low ability of students in this study to solve questions on aspects of science content was because they were unable to determine the formula used. After all, they did not understand the concept of calculation.

While the aspect of the science process had a percentage of 44.60%, it was found that its ability was greater than the aspect of science content, which had a percentage of 33.70%, and the context of science, which had a percentage of 42.00%. According to Pantiwati and Husamah (2016), the science process refers to the mental processes involved in answering a question. This includes knowing the types of questions that science could and could not answer, understanding the forms of evidence needed for scientific research, and understanding the conclusions drawn from data.

In this study, questions on aspects of the scientific process refer to phenomena in daily life. So that students could relate to their personal experiences when answering science process questions. In addition, to answer science process questions, students must carefully understand the discourse provided in the question to illustrate the intent of the question. Based on the analysis of student's answers, it was found that, on average, students who could answer questions on the science process aspect could also answer correctly on science context questions, even though they could not correctly answer questions on the science content aspect. So the results of the Mann-Whitney test found no difference in ability between the science process and the science context.

This study had some limitations that future researchers can consider when making decisions. One of the limitations is that the data was collected only from science literacy questions based on learners' answers. So the conclusions drawn were only based on what was found through students' answers, without additional interviews with respondents.

CONCLUSION

Based on data analysis and research results, it can be concluded that the science literacy abilities of students at SMP Negeri 14 Pontianak were in the medium category. The science literacy abilities of students in SMP Negeri, 14 Pontianak in the aspect of science content amounted to 33.70%, 44.60% in the aspect of science process, and 42.00% in the aspect of science context. The research findings showed differences in students' science literacy abilities in science content vs science process aspects and science content vs science context aspects.

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