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Preliminary Research of Students' Science Literacy on Harmonic Vibration to Design Interactive Multimedia Based on Cognitive Conflict

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ABSTRACT

Science literacy is one of the skills developed in 21st century education. Physics and science literacy are closely related because physics can foster science competency which is one aspect of science literacy. Students must be able to evaluate and design scientific research, interpret scientific data and evidence, and explain events scientifically. All of these are components of science competency. However, Indonesia's science literacy is relatively low according to the results of PISA 2022. The purpose of this study was to evaluate students' initial science literacy on harmonic vibration material. To measure students' initial science literacy on harmonic vibration material, a study was conducted. This study is a preliminary study on the design of interactive multimedia as teaching materials to improve science literacy on harmonic vibration material. The study was conducted on 30 Phase F5 students who had studied the material. The instruments given were in the form of teacher questionnaires and student tests in the form of 10 multiple-choice questions of 2 levels. Based on the results of data analysis, the context aspect was obtained with an average of 47%, the competency aspect was obtained with an average of 47%, the content aspect was obtained with an average of 48%, and the science attitude aspect was obtained with an average of 50%. The indicators on the teacher questionnaire obtained a percentage for the Use of learning models on harmonic vibration material 54% with the category sometimes, identification of student science literacy 55% also categorized sometimes, the use of teaching materials and media on harmonic vibration material 55% categorized sometimes, the implementation of experiments on harmonic vibration material 40% categorized rarely, and the use of supporting facilities and equipment by 68% categorized often.

INTRODUCTION

Based on the development of innovative technology, children can develop scientific literacy, one of the 21st century skills. Scientific literacy develops attitudes, abilities, and understanding of science and technology in everyday life (Asyhari & Hartati, 2015) . The ability to understand and use science and technology in everyday life is known as scientific literacy (Sahyar, 2020) . Therefore, education is needed that is ready to face 21st century

learning in order to create a science-literate society (Ma, 2023) . One of the main goals of education today is to teach and guide individuals to apply scientific literacy in everyday life (Sutrisna, 2021) .

Physics is a branch of science related to natural phenomena and real-world contexts discussed in physics material. Physics studies natural phenomena through systematic scientific procedures based on scientific attitudes that produce concepts, laws, and theories (Nikat et al., 2021) . Physics is very close to everyday life because it explains natural events that occur based on human thoughts, experiences, and experiments (Hartini, 2024) . Today's students have a higher chance of memorizing and remembering physics subject matter. In addition, the information provided focuses more on formulas and calculations than on conceptualization and application of educational content (Wulandari, 2021) . In addition, learning resources can be used to prepare students for the 21st century. The 21st-century learning paradigm places great emphasis on students' critical thinking skills, their ability to apply science to real-world situations, their proficiency in using information and communication technology, and their capacity to work together in teams (Sartika, 2023) .

One source of knowledge for students in schools that is very helpful in the teaching and learning process is teaching materials. Students pay attention to and develop pre-existing realities in a dynamic inquiry-based learning environment driven by student-centered learning and the use of technology. In addition to information, it fosters social intelligence by fostering critical thinking, curiosity, empathy, and the search for answers to world problems (Elvisto, 2022) . To improve understanding of the students, a physics teacher can be used in everyday life, scientific literacy in physics is needed (Dhanil & Mufit, 2023) . A generation that can overcome problems and difficulties related to science and can be accounted for is also prepared, one of which is through scientific literacy (Narut & Supardi, 2019) .

The ability to understand and apply science to solve problems related to the surrounding environment is known as scientific literacy. OECD, (2013) defines scientific literacy as a person's scientific understanding and skills in recognizing scientific problems, knowledge from research results, scientific and technological literacy, and readiness to learn about scientific subjects. Scientific literacy includes the following dimensions: 1) individual, social, and global scientific contexts; 2) scientific competence, such as the capacity to recognize scientific issues, provide scientific explanations for events, assess and plan scientific research, and analyze scientific data and evidence; 3) scientific settings, such as biological systems, earth and space systems, technological systems, and physical systems; and 4) scientific mindsets, such as more research, self-confidence, curiosity, and environmental responsibility (OECD, 2019) . Understanding the nature of science, its application in everyday life, the process of scientific inquiry, and the interaction between science, technology, and society are components of scientific literacy (Yuliyanti & Rusilowati, 2014) . The basic concept of scientific literacy includes contextualization in line with current demands, cultural, societal, and national norms, 21st century educational standards, and collaborative and interactive approaches (Fananta et al., 2017) .

Since 2000, Indonesia has consistently had a poor level of science literacy (Emilya & Mufit, 2023) . PISA 2022 data shows that, with a score of 383 (OECD, 2023) , the 2022 science literacy score is lower than the 2018 PISA score. This shows that science education in Indonesia has not provided the best results. This shows that science education in Indonesia is still below standard. There are several reasons why Indonesian students have poor scientific

literacy. The selection of learning resources used during the learning process is one of the factors that influences this (Hidayani et al., 2016) . Students' lack of understanding of the relationship between science subjects and real-world applications is another variable that causes inadequate scientific literacy (Morgacheva, 2023) . Students' scientific literacy levels are still relatively low in solving problems involving harmonic vibration material (Hidayani et al., 2016; Morgacheva, 2023) . According to (Masithah et al., 2022) Scientific literacy needs to be developed because: (1) understanding science provides pleasure and satisfaction after studying and understanding science; (2) everyone needs information and makes decisions in everyday life; (3) everyone must involve their abilities in discussing important issues related to science and technology in public forums; (4) the world of work requires high skills so that everyone must reason, think creatively, make decisions, and solve problems. Therefore, appropriate teaching materials are needed to support students' scientific literacy with the help of appropriate learning models.

Based on the above problems, the solution is to create teaching materials in the form of interactive multimedia containing images, animations, videos, and sounds with the help of animaker, ispring, and canva applications that allow students to interact and students are interested in learning. Interactive multimedia makes subjects more interesting and can be used as problem solving, training students' critical thinking skills and student activeness in the classroom (Koesnandar, 2019). The characteristics of interactive multimedia are interactive, varied, independent, easy to use, and students are required to interact during the learning process (Fatmawati et al., 2024). This interactive multimedia is designed to assist the learning process, therefore to support this interactive multimedia it is necessary to use the right learning model, one of which is a cognitive conflict-based learning model.

According to Mufit,(2018) Cognitive conflict-based learning models can be interpreted as learning activities carried out to prevent discrepancies between students' initial perceptions and actual knowledge. The cognitive conflict learning model consists of four syntaxes, namely (1) Activation of preconceptions and misconceptions, (2) Presentation of cognitive conflicts, (3) discovery of concepts and equations, (4) Reflection. Learning models using complete methods can achieve learning objectives that are adjusted to the syntax of the learning model used (Mufit, 2018) . The cognitive conflict learning model has a positive impact such as increasing concept understanding, correcting student misconceptions, increasing student enthusiasm for learning, and increasing student science literacy (Aini & Mufit, 2022). The cognitive conflict learning model encourages students to be active in finding conceptual errors and finding the real concept (Lestari et al., 2019). This cognitive conflict learning model has been applied by Emilya & Mufit, (2023); Mufit et al., (2023) on teaching materials with the result that the teaching materials developed have been valid and practical to use in the learning process.

Learning models to support 21st century education must help meet the demands of the times and the needs of students in utilizing technology and having competent skills in the current era (Dhanil & Mufit, 2023) . Teachers must be able to choose the right learning model that is in accordance with the goals to be achieved and the material being studied, so that the learning carried out is expected to help students understand complex problems in their environment from a broader perspective (Li, 2020) . The scientific approach that can be taken to encourage scientific literacy is the 5M activity, namely observing, asking, trying, associating, and communicating (Rosidah & Sunarti, 2017) . Therefore, along with the development of the current digital era, learning media has become very varied, such as

videos, animations, simulations, and interactive games, which can make it easier for students to understand physics concepts and motivate students to learn (Mufit et al., 2023) .

Research on students' mastery of scientific literacy needs to be studied because technological advances should have a positive impact on increasing mastery of scientific literacy if implemented properly. Because scientific literacy encourages the ability to explain, investigate, and interpret data from information in everyday life that can be obtained during effective learning. Initial analysis is needed to determine the level of students' mastery of scientific literacy, especially on harmonic vibration material. Through this initial analysis, initial information can be obtained to help improve the quality of education and find appropriate solutions to solve problems. Therefore, this study aims to analyze students' scientific literacy on harmonic vibration material.

METHODS

This type of research is a survey with a quantitative descriptive approach. This study aims to analyze initial knowledge about scientific literacy and the implementation of learning to support the improvement of students' scientific literacy in the Harmonic Vibration material. This study used a sample consisting of 30 students at SMAN 8 Padang. Students were given a two-level multiple-choice science literacy test. Teachers were given a questionnaire to fill out in order to better understand how learning is carried out. Two physics teachers of SMA Negeri 8 Padang were given a questionnaire. The questionnaire sheet contains teacher learning activities using Harmonic Vibration material. The purpose of distributing the questionnaire was to find out more about learning models, learning activities that improve scientific literacy, and the use of IT-based learning resources. The following is the formula used to process teacher and student questionnaires.

$$Value = \frac{score\ obtained}{maximum\ score} x100 \qquad (1)$$

Table 1. Questionnaire Assessment Categories

Evaluation	Answer Categories
1	Never
2	Seldom
3	Sometimes
4	Often
5	Always

Source: (Retnawati, 2016)

Next, a test was given in the form of 10 questions on the harmonic vibration material. Providing questions based on scientific literacy can be one way to measure students' mastery of each indicator of scientific literacy (Mukharomah et al., 2021) . This study uses indicators of scientific literacy competency aspects, such as Identifying Scientific Problems, providing scientific explanations for phenomena, assessing and planning scientific investigations, and interpreting scientific data and evidence (OECD, 2019) .

Data analysis was carried out by measuring the percentage of achievement of science literacy skills on competency aspect indicators. Data analysis from science literacy test questions, the initial score obtained can be obtained in percentage form using the following equation.

$$Value = \frac{Number\ of\ correct\ answers\ from\ each\ category}{Number\ of\ students} x\ 100 \qquad (2)$$

All data were analyzed based on aspects of scientific literacy, the next step was to group the results of students' mastery of scientific literacy and conclude according to the specified criteria. The following are the score interpretation categories.

Table 3. Score Data Interpretation Category

Category	Hose
Very high	86-100
Tall	76-85
At the moment	60-75
Low	55-59
Very Low	<54

Source: (Purwanto, 2009)

RESULTS AND DISCUSSION

Results

A preliminary study conducted at SMA 8 Padang revealed the problem of low literacy. The science literacy questions given to students consist of 10 graded multiple-choice questions that are relevant to everyday problems. These questions are presented in the form of illustrations accompanied by questions that must be answered based on the students' understanding of the illustrations provided.

Analysis of students' scientific literacy aims to measure students' ability to understand scientific concepts and apply knowledge in real-life contexts. After being given test questions, it was found that students' scientific literacy was still relatively low. This can be seen in their ability to actively participate in scientific discussions and draw conclusions based on scientific evidence. According to the OECD (2016) , the assessment of scientific literacy skills involves 4 aspects of scientific literacy such as the scientific context aspect, the scientific competence aspect, the scientific content aspect, and the scientific attitude aspect.

The context aspect helps students understand life situations related to global and national issues involving science and technology. Students are expected to be aware of the importance of science in improving the quality of life. The following are the results of the context aspect of the science literacy test in Table 3.

Table 3. Results of the Contextual Aspects of Students' Scientific Literacy

Indicator	Question	Percentage (%)
Personal	2,3,8,9	50
Social	1,4,7	52
Global	5,6,10	39
Average		**47**

Based on Table 3, it is obtained that the indicators of the context aspect obtain a percentage ranging from 39% to 50% with a very low category. So the average obtained is 47% with a very low category. This result shows that students have difficulty linking science literacy to the context of students' lives, whether personal, social or global. To overcome this, learning that is more relevant to everyday life, diverse question exercises, and discussion or project activities involving social and global issues are needed. These efforts are expected to help students improve their understanding of science literacy in various contexts.

The competency aspect helps students understand the right actions in solving scientific problems. In this aspect, students are required to be able to explain phenomena

scientifically, evaluate and design scientific investigations, and interpret scientific data and evidence well. The following is the achievement of aspects of students' scientific literacy competencies in Table 4.

Table 4. Results of Students' Scientific Literacy Competency Aspects

Indicator	Question	Percentage (%)
Explaining phenomena scientifically	1, 2, 3, 4, 7, 9	50
Evaluating and designing scientific investigations	6, 9	40
Interpreting scientific data and evidence	5, 8, 10	50
Average		**47**

Based on Table 4, it is obtained that the percentage of students' scientific literacy competency aspects ranges from 40% to 50% with a very low category. So the average obtained is 47% with a very low category. The indicator of explaining phenomena scientifically found that students have not been able to apply, interpret, and make predictions related to the phenomena given. Likewise, the indicator of evaluating and designing scientific investigations such as identifying questions, designing experiments, and evaluating the stages of scientific experiments. Finally, in the indicator of interpreting data and scientific evidence, it is found that students have not been able to convert data into other forms, analyze the data obtained, and evaluate the results of experiments according to relevant sources.

The content aspect of science requires students to use relevant knowledge to understand real situations. Such as understanding natural phenomena and their changes, etc. The following are the results of the content aspects of students' scientific literacy on the harmonic vibration material in Table 5.

Table 5. Results of students' scientific literacy content aspects

Indicator	Question	Percentage (%)
Basic concept of harmonic vibrations	1, 4, 5	56
Factors that influence the period	2, 6, 7	34
Vibration patterns and amplitude	3, 9	45
Practical applications of harmonic vibrations	8, 10	57
Average		**48**

Based on Table 5, the percentage of scientific literacy content aspects ranges from 34% to 56% with very low and low categories. So that an average of 48% is obtained with a very low category. The content aspect of harmonic vibration material is found in the physical system in science literacy. Based on the table above, it can be stated that students are still unable to understand the basic concepts of harmonic vibrations, factors that affect the period, how the vibration pattern and amplitude in harmonic vibrations, and the application of harmonic vibrations in everyday life. So it takes practice in mastering science literacy skills that are applied during learning.

The science aspect requires students to be sensitive to scientific issues and apply scientific and technological knowledge. The following are the results of the aspects of students' scientific literacy attitudes in Table 6.

Table 6. Results of Students' Scientific Literacy Attitude Aspects

Indicator	Question	Percentage (%)
Support for scientific research	6, 8, 10	46

Interest in science	1, 2, 3, 7	50
Responsible for the environment	2, 8	55
Average		**50**

Based on Table 6, the percentage of science attitude aspects ranges from 46% to 55% with very low and low categories. So that an average of 50% is obtained with a very low category. It means that it can be concluded that students are still lacking in bringing up attitudes such as wanting to conduct scientific experiments, not being interested in scientific phenomena, and being responsible for the surrounding environment. Students' scientific attitudes can be trained through facilitating students to conduct experiments after learning the concept of harmonic vibrations. It is expected that after conducting experiments students begin to be trained in mastering their scientific attitudes.

Furthermore, a questionnaire was given to two physics teachers, and it was found that in the Harmonic Vibration material, the teachers had given concept questions and calculation questions, and had given questions containing scientific literacy. The following are the percentages of the 5 indicators of the educator questionnaire.

Table 7. Educator Questionnaire Analysis

Indicator	Percentage (%)
Utilization of learning models on harmonic vibration material	54
Identification of students' scientific literacy on harmonic vibration material	55
Utilization of teaching materials and learning media on harmonic vibration material	55
Implementation of Experiments on Harmonic Vibration Materials	40
Use of supporting facilities and equipment	68
Average	**54**

Based on Table 7, it can be seen that the percentage of indicators for the use of learning models on harmonic vibration material is 54%, identification of students' scientific literacy on harmonic vibration material is 55%, utilization of teaching materials and teaching media on harmonic vibration material is 55%, implementation of experiments on harmonic vibration material is 40%, and utilization of supporting facilities and equipment with a percentage of 68%. So that the total indicator is 57%. Teachers have implemented learning models according to the demands of the independent curriculum, but the models used have not specifically addressed students' literacy misconceptions on harmonic vibration material. Teachers have begun to hone students' scientific literacy but not yet as a whole, and teachers have not carried out learning according to students' prior knowledge. The use of teaching materials is only in the form of printed teaching materials and has not used animated digital teaching materials. The implementation of experiments is still rarely applied in learning materials. Teaching materials used in schools have not used cognitive conflict models to identify students' science literacy. teaching materials based on cognitive conflict models provide stages to remediate students' literacy misconceptions and improve students' science literacy.

Discussion

Based on Table 3, it can be seen that students' ability to understand life situations, both on a national and global scale, is still very low. This is indicated by the percentage of results in the context aspect which ranges from 39% to 50%. This value shows that students have not been able to link science literacy with relevant problems in everyday life, both in personal,

social and global contexts. The overall average of only 47% also shows that students' understanding in this aspect still needs to be improved significantly. These results indicate the need for learning strategies that are more contextualized and focused on developing critical thinking skills and the application of science literacy in real life. The low results obtained by students indicate that learning has not been fully connected to everyday life. Teachers have not linked many science concepts with real situations that are close to students. As a result, students are less familiar with the context given, making it difficult to connect it with the subject matter. This makes students unable to apply science in everyday life, which can actually be a place where they understand and practice science concepts (Permatasari & Fitriza, 2019).

Based on Table 4, it is obtained that the percentage of students' scientific literacy competency aspects ranges from 40% to 50% with a very low category. So the average obtained is 47% with a very low category. This indicates that students are not yet able to relate the phenomena they discover to solving the problem through scientific investigation. Based on table 4, it can be seen that students have not been optimal in training their scientific literacy skills. Learning facilities, teaching materials, teacher teaching styles and practices, as well as the curriculum and education system, all have an impact on the low scientific literacy of Indonesian students. Because the evaluation questions given by teachers on daily tests, midterm exams, and final exams only ask students to recall the information they have learned, students are not used to working on questions that require understanding and analysis. Students must be accustomed to solving questions that require understanding and analysis and are relevant to real-world situations (Sutrisna, 2021) .

Based on Table 5, the percentage of scientific literacy content aspects ranges from 34% to 56% with very low and low categories. So that an average of 48% is obtained with a very low category. This proves that students have not mastered the knowledge they have, especially regarding harmonic vibration material. Science content contains the knowledge needed to understand and relate experiences in personal, social and global contexts. This knowledge covers the fields of biology, physics, chemistry, and earth and space science, organized according to criteria that support students' understanding of their surrounding environment (Noviana, M. & Julianto, 2017).

Based on Table 6, the percentage of science attitude aspects ranges from 46% to 55% with very low and low categories. So that an average of 50% is obtained with a very low category. This proves that students are less able in Support for scientific investigations, Interest in science, and Responsible for the environment. The improvement in students' attitudes occurs due to the use of a learning model that makes them more interested in scientific problems that can be solved through investigation. This helps students become more curious and aware of the problems around them. Learning activities that are directly related to real problems can support the development of attitudes in students' science literacy (Alatas & Fauziah, 2020).

Based on research by Dhanil & Mufit, (2023) that the results of students' mastery of scientific literacy in the context aspect were 35.5%, the content aspect 35.7%, and the competency aspect 35.3% and all were in the low category. These results indicate that students still have a lot of difficulty in understanding scientific concepts in everyday life. Furthermore, research by Putri & Mufit (2023) that scientific literacy in the material on work, energy, momentum, and impulse is also very low. An average of 35.4% was obtained in the context aspect, 35.6% in the content aspect, and 35.3% in the competency aspect. This means that overall, it is obtained that students' scientific literacy is still far from what is expected so that improvements and approaches to science learning in schools are needed.

The first indication in Table 7 shows that although teachers have adopted the learning paradigm recommended by the curriculum, scientific literacy has not been taught. The

learning model is a form of learning that is commonly presented by educators that is used from the beginning to the end of learning that contains approaches, methods, learning techniques, and syntax or work steps as guidelines in the learning process (Hayati & Mufit, 2023) . Based on the questionnaire, a percentage of 20% was obtained where teachers had not used a learning model that was specifically used to overcome student misconceptions in harmonic vibration material.

The science literacy identification indicator shows that teachers have used science literacy skills to students, but it is still not optimal. This is also in line with the teacher questionnaire which obtained a percentage of 40% to conduct initial concept tests to students, provide science phenomena to hone students' science literacy, and provide questions related to students' science literacy. Teachers tend to provide material presentation by providing calculation questions with a percentage of 60%.

Experimental indicators on harmonic vibration material are still rarely applied. Based on the questionnaire, it was found that 40% of high school physics kit experiments were used and virtual experiments using virtual laboratories were still rare with a percentage of 40%. The cause of low scientific literacy skills in students is because they rarely do practical activities, do not understand the terms in scientific investigations, and only focus on memorizing learning materials (Gunawan & Mufit, 2024) .

Indicators of the use of teaching materials and learning media still do not support students to practice science literacy. Teachers have used teaching materials in the form of textbooks, modules, handbooks, student worksheet. However, 20% of teachers reported not using learning resources, such as digital sources. One source of knowledge for students in schools that is very helpful in the teaching and learning process is teaching materials. All information, tools, and texts that are systematically arranged and show a list of abilities that students must have comprehensively are considered teaching materials. These materials are used in the learning process to plan and evaluate how learning is carried out (Ummah et al., 2018) . The current curriculum emphasizes student-centered learning and provides freedom and flexibility for students to fully realize their potential (Novita et al., 2024) . In addition, not all materials are used because school laboratories do not have adequate equipment and resources. Depending on the equipment and facilities in the laboratory, only certain materials are used for practical tasks. In addition to facilities and infrastructure, another obstacle in implementing practical work is the lack of time to prepare for practical activities. According to research (Muliani et al., 2022), the use of PhET simulation applications that can be accessed by all students and show the appearance of phenomena in real-world situations is one way to encourage and facilitate students in reasoning. Research (Ulfani et al., 2022) in 2022 stated that in order for the knowledge gained to be used in everyday life, students must be able to understand the concepts taught. Students' mastery of concepts can be improved by providing facilities and infrastructure that facilitate learning.

Traditional teaching methods that do not emphasize the importance of scientific reading and writing skills as crucial skills are the cause of low levels of students' scientific literacy. In addition, this method can be used to simply complete tables provided by teachers, which limits their ability to understand graphs and tables (Fuadi et al., 2020) . In contrast to the more focused vision of 21st-century learning , one of the learning paradigms is learning to think, which is focused on problem solving and independent living and is based on logical and rational understanding (Robbia & Fuadi, 2020) .

Three markers of mastery of scientific competence, namely explaining scientific phenomena, conducting scientific investigations, and using scientific evidence, are part of the scientific literacy competence that is learned. Students can gain knowledge by applying scientific learning to solve real-world problems in an organized manner (Asyhari & Hartati, 2015) . The problems learned are faced by students in everyday life. Students' scientific

literacy skills, such as recognizing scientific problems, can be developed through the challenges they face. Group activities that allow students to put forward ideas that can help in the problem-solving process demonstrate mastery of these skills. A number of useful information searches to obtain problem solving from the given phenomenon are then used to solve the problem being studied, students' scientific literacy skills, such as using scientific evidence, can be improved with the results of information gathering exercises.

Students then assess and reduce scientific data that has been collected from various reliable sources, which helps them solve problems. Students can also improve their scientific literacy skills in describing scientific events using scientific data and findings. Through teacher-facilitated class discussion activities, in which students share their thoughts both verbally and in writing about their group's research results, teachers can help students to further strengthen their abilities in using scientific evidence and explaining scientific phenomena.

CONCLUSION

Based on the data analysis, the results of students' scientific literacy in the context aspect were obtained with an average of 47%, the competency aspect was obtained with an average of 47%, the content aspect was obtained with an average of 48%, and the science attitude aspect was obtained with an average of 50%. Furthermore, the teacher questionnaire showed that the percentage of the use of learning models, identification of students' scientific literacy, and implementation of experiments was still low. This is also in line with the results of students' science literacy tests where students are still very low in evaluating and designing investigations, as well as interpreting the data they obtain. To ensure that students acquire science literacy skills, teachers must use science literacy-based learning resources during the learning process. It is recommended that teachers get students used to conducting experiments to train them in conducting investigations and communicating the results of the data collected. This will help students develop science literacy skills in developing and communicating data results. Given the still low science literacy of Indonesian students, it is hoped that more efforts will be made to create science literacy-based teaching materials.

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