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Analysis of Scientific Literacy of Senior High School Students on Fluid Dynamics

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ABSTRACT

The research aims to analyze the scientific literacy of senior high school students on fluid dynamics. Research was implemented at SMA Negeri 3 Nganjuk. The population in this research were senior high school students. The sampling technique in this research was random cluster sampling. The sample in this research amounted to 36 students. Three instruments are used in the data collection technique, interviews, scientific literacy tests, and questionnaires. The data analysis used in this research is the percentage of students' scientific literacy achievement in the competency domain. This research shows that students' literacy ability is relatively low. The percentages obtained for each competency are the competence to explain scientific phenomena by 44% in the low category, evaluate and design scientific investigations by 47% in the low category, and interpret scientific data and evidence by 56% in the low category. This research concludes that the scientific literacy of senior high school students on fluid dynamics is in a low category. One of the causes is that the student's ability is only memorizing and not relating various science topics or applying complex concepts to solve problems in their everyday lives. The research implications can provide information related to scientific literacy skills in senior high school students on fluid dynamics according to the competencies that have been presented.

INTRODUCTION

In this era, there are several changes in various fields, including education. The use of information and communication technology is now being used in all aspects of life. It was caused by the development of information and communication technology in providing convenience for society. It also has an impact on competence and changes in qualifications. The 21st century is also known as the century of knowledge, where there is a development of technology and information can be spread easily. The indications in the 21st century are a strong connection between the world and science which indicates that the challenges of education are getting tougher. One of the roles in education is to obtain human resources who have the ability to face challenges in life. At this time, education should focus on activities that can be used as provisions by students in facing challenges in the era of globalization, environmental problems, advances in information technology, the convergence of science and technology, knowledge-based economy, and the influence and impact of science-based technology. It is in line with Godwin et al. (2015), which states that individuals must be able to follow the development of science and technology, including in the world of education in the 21st century.

In the 21st century, we need to be ready to face the current development by having the ability of science literacy (Suryani et al., 2017). According to OECD (2019), scientific literacy is defined as individual performance in applying their knowledge in identifying questions, building new knowledge, providing scientific explanations, making decisions based on scientific evidence, and building a reflective mindset. By doing so, they can solve the issues related to science. Griffin & Ramachandran (2014) define scientific literacy as a person's ability to apply their knowledge in identifying a problem and building conclusions based on scientific evidence in order to understand and make a conclusion related to nature and human relations with nature. Moreover, according to Gormally et al. (2012), scientific literacy can be defined as a perspective that emphasizes all learners' cognitive in utilizing their scientific knowledge in real situations. More specifically, scientific literacy is the ability to associate scientific processes with scientific information found in our daily lives (Ladachart & Yuenyong, 2015). It is in line with Syofyan & Amir (2019), which states that scientific literacy is the ability of an individual to implement their scientific knowledge in their everyday life. By mastering scientific literacy, students can prepare themselves to face the era of scientific development and the use of technology in the future (Mardhiyyah et al., 2016). According to Bagasta et al. (2018), mastery of scientific literacy is needed by students considering the important role of mastering scientific literacy in solving economic and social problems in society.

Scientific literacy is measured by the study of PISA (Programme for International Student Assessment) conducted by the OECD (Organization for Economic Co-operation and Development) every three years. The results of the OECD (2018) state that the ranking of scientific literacy in Indonesia in 2000, 2003, 2006, 2009, 2012, 2015, and 2018 respectively, is 393, 395, 393, 383, 403, 396 with an average score for all participating countries of 500 based on PISA. In 2018, the PISA results were given to the Minister of Education and Culture (Mendikbud) at the Kemendikbud Building, Jakarta. Indonesia ranks 70 out of 78 participating countries (Kompas, 2019). In these 20 years, based on the data from PISA, Indonesia has always been at the bottom of the list compared with other countries. This shows that students' scientific literacy in Indonesia is still in the low category. According to Setiadi (2014), the low scientific literacy of students in Indonesia indicates that the quality of science learning in Indonesia is far behind that of OECD countries. It is supported by research by Huryah et al. (2017), which states that the ability of Indonesian students is on average. Their ability is stuck in remembering and recognizing, and they are unable to relate various science topics, apply complex concepts in solving problems in everyday life. In addition, according to Kurnia et al. (2014), the low scientific literacy of students is caused by the curriculum and education system, the selection of learning methods, and learning models provided by teachers to students.

According to PISA, there are four domains that can be used to measure students' scientific literacy. The four domains are 1) Context domain, which is an assessment of the knowledge and competence of students in certain contexts (personal, local/national, and global); 2) The competence domain, this domain consists of the ability to explain scientific phenomena, evaluate and design scientific investigations, and interpret scientific data and evidence; 3) Knowledge domain, this domain includes content, procedural, and epistemic knowledge; 4) attitude domain, this domain shows students' interest in science, the support of scientific investigations, and motivation to act responsibly towards the environment and natural resources (OECD, 2015).

The scientific literacy ability measured by PISA also includes the field of Physics. Physics is a branch of science that can be analyzed related to scientific literacy (Nurwulandari, 2018). The measurement of scientific literacy in physics is needed because the development of physics is one of the factors that increase the ability of students to adapt to the development of technology (Indrawati & Sunarti, 2018). One of the materials in physics that can be analyzed for scientific literacy is fluid dynamics material. The basic competencies of fluid dynamics are in accordance with scientific literacy competencies, namely explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting scientific data and evidence. We may encounter many applications of fluid dynamics in our everyday life, for example, watering plants using a hose, spraying perfume on clothes, the process of a flying airplane to the air, and many more. Based on the description above, this research aims to analyze the scientific literacy of senior high school students on fluid dynamics.

RESEARCH METHOD

This research is descriptive research where the researcher does not give special treatment to the research sample so that the researcher does not need a control class or an experimental class (Sukmadinata, 2012). This research was implemented at State Senior High School 3 Nganjuk. In this research, the research population was senior high school students of class XII MIPA at State Senior High School 3 Nganjuk. The sampling technique in this research is using random cluster sampling. The sample in this research amounted to 36 students of class XII MIPA 1.

Instrument and Procedures

Three types of instruments are used in data collection techniques: interviews, scientific literacy tests, and questionnaires given to students. The interviews were conducted with a physics teacher at State Senior High School 3 Nganjuk. This interview was conducted in order to determine the development of the teaching and learning process that has been applied in the senior high school. In another interview with physics teachers, scientific literacy tests carried out the data collection technique. The test is in the form of scientific literacy test questions on fluid dynamics material. This scientific literacy test is in the form of essay questions containing the domain of scientific literacy competence, namely, explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting scientific data and evidence (OECD, 2015). As stated by Rusilowati et al. (2016), that one way to measure students' scientific literacy can be done by analyzing students' mastery of concepts in the domains contained in scientific literacy. The last instrument for collecting the data is through a questionnaire in order to strengthen the results of the research conducted.

There are three stages in this research procedure, the first is preparation for the implementation, and the last stage is to process the data. In the preparation stage, the researcher chooses the school, takes a look at the condition of the school and the students, formulates the problem, and lastly, manages the administration to use the place as the research place. In the implementation stage, the researcher interviewed the physics teacher at State Senior High School 3 Nganjuk to find out the progress of the teaching and learning process that had been carried out. The other thing that the researcher did was give scientific literacy test questions to students in the form of essays on fluid dynamics material. The students were given limited time to answer the

question. In the next stage, to strengthen the data, the researcher gives the questionnaire to the students. For the last stage, the researcher processes the data and analyzes the data to form a conclusion from the research. As for the research, the scheme can be described in Figure 1.

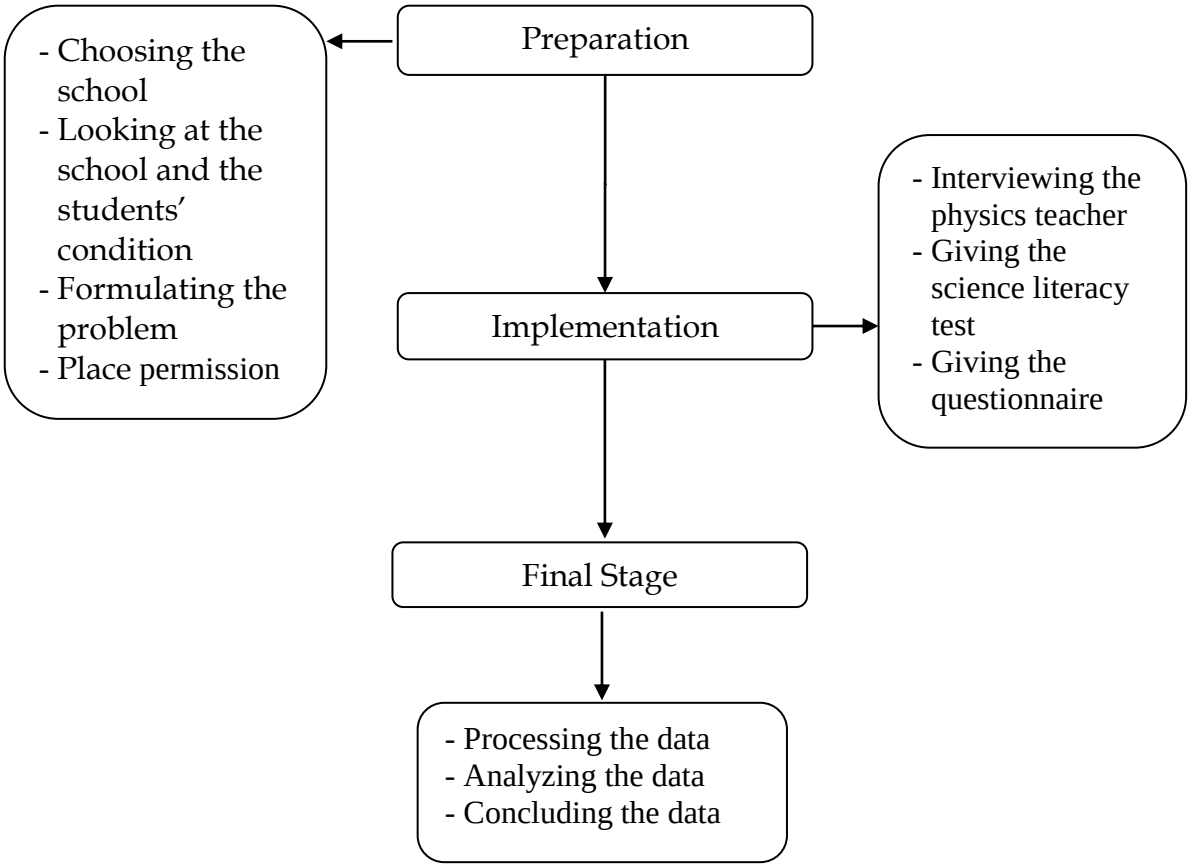

Figure 1. Research scheme.

Data Analysis

In this research, the researcher led the interview session. In guided interviews, the researcher gives a pre-arranged question for evaluation (Arikunto, 2013). As for the questionnaire given to students, it is a direct type of questionnaire. The students immediately fill out the questionnaire that has been given by the researcher and will be directly collected after the student has answered it. The function of this questionnaire is to find out the response of students to scientific literacy.

The students' scientific literacy ability scores in the domain competence can be calculated using the following formula in the scientific literacy test questions.

$$S = \frac{R}{N} \times 100\% \quad (1)$$

Information:
S = Value of students' scientific literacy ability
R = Number of scores answered correctly by students
N = Maximum test score

Furthermore, students' scores on their literacy science can be categorized in the form of percentages in Table 1.

Tabel 1. Category percentage of students' scientific literacy achievement.

Category	Score Interval (%)
Very good	86 - 100
Good	72 - 85
Enough	58 - 71
Low	43 - 57
Very Low	≤ 43

(Erniwati et al., 2020)

RESULTS AND DISCUSSION

Based on the research implemented in State Senior High School 3 Nganjuk, it can be concluded that the students' ability is low. The following are the results of students' scientific literacy skills at State Senior High School 3 Nganjuk, which are presented in Table 2.

Table 2. Results of students' scientific literacy skills.

Score Interval (%)	Frequency	Category
86 – 100	0	-
72 – 85	0	-
58 – 71	4	Enough
43 – 57	25	Low
≤ 43	7	Very Low
Total	**36**	-

From Table 2 can be seen that from 36 samples in this research, four students got the score interval in enough category (58-71%), 25 students are in a low category (43–57%), and seven students are in very low category (score ≤ 43%). It can be concluded that the scientific literacy ability of students is still relatively low. It is in line with research by Huryah et al. (2017), which states that the ability of students in Indonesia is only remembering and recognizing, and they are unable to relate, apply, or solve complex science concepts in daily life.

In this research, to measure students' science literacy, the researcher analyzes the concept of students' domain competence. The domain competencies include explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting scientific data and evidence. This is in line with Rusilowati et al. (2016) research, which states that analyzing students' mastery in the concepts of domains competence is one way to measure students' scientific literacy. After testing 36 students in the form of an essay with fluid dynamics material, the results can be seen in Figure 2. From Figure 2, it can be seen that students' ability to explain scientific phenomena is low (44 %), the other category is the competence to evaluate and design science investigations is also in the low category (47 %), and the ability to interpret scientific data and evidence is also in the low category (56 %). The category is based on Table 1. In the competence to explain scientific phenomena with the indicator implemented the proper scientific knowledge, the students are given some questions related to Bernoulli's law, which is related to the process of the airplane flying in the air. However, the students were unable to link various science topics with the concept or phenomena.

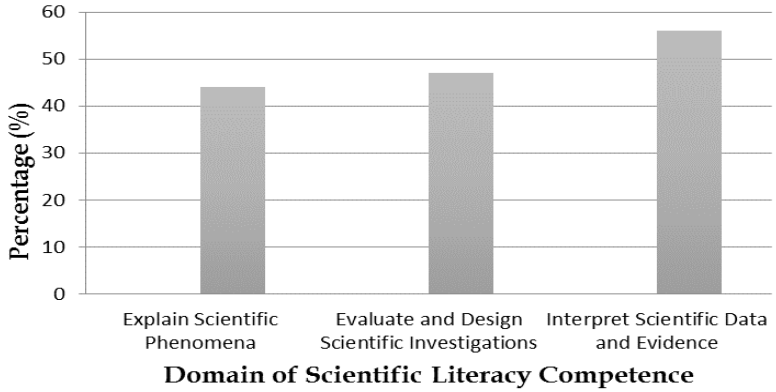

Figure 2. The percentage of students' scientific literacy in each competency domain.

As Huryah et al. (2017) state that the students are just able to memorize and recognize the knowledge without knowing how to link various science topics or even implement the complex concept in their daily life. According to Ning et al. (2020), the low ability of students to explain phenomena scientifically is because they are not able to predict the phenomena around them. Moreover, they cannot predict the changes that occur as a result of this phenomenon. In addition, Anggraini (2014) also stated that the teaching process in the classroom cannot encourage the students to analyze the cause of phenomena and is also one of the causes of the low ability of scientific literacy to explain scientific phenomena.

In the competence of evaluating and designing scientific investigations, the students are given two kinds of questions. The first question is about designing science investigations; the students are asked to create an experimental design related to Toricelli's experiment to analyze the effect of the depth (h) measured from the surface of the container on the distance of the jet of water (x). In this case, the students could not design the experiment; mostly, they just wrote down the tools and the materials related to Torricelli's experiment. It shows that the students; ability in designing experiments is still low. The cause of students' low ability in designing the experiment is because they tend to memorize rather than understand the point in science literacy. So that they just write down the tools and the materials in Torricelli's in line with the experiment, experiment of Rusilowati (2014), which states that the students tend to memorize the material rather than comprehend. The students tend to have the better ability at memorizing than thinking. Another factor is that the teaching and learning process emphasizes more on cognitive aspects, rather than how to develop students' thinking skills (Irwan et al., 2019). It is reinforced by research by Mardhiyyah et al. (2016), which states that education in Indonesia prioritizes abstract conceptualization rather than active experimentation, even though active experimentation may allow the students to conduct their own investigations and find answers to the problems they are facing.

The second question with scientific literacy indicators is to determine the variables of scientific experiments. In this question, students are given a table of experimental data related to Toricelli's law which aims to analyze the effect of depth (h) on the distance of the jet of water (x). In solving this problem, mostly the students write the wrong answer in a testing variable. The low ability of students in determining experimental variables is because students are still confused with the terms in the experiment. They also find it is difficult to distinguish between the intent of the manipulation variable, the control variable, and the response variable. It is in line with Rusilowati et al. (2016), which

states that the cause of the low ability of students in making experimental designs and determining experimental variables is because students rarely conduct the experimental activities. So, the students are still unfamiliar with some of the terms used in experiments. The results can see it of the questionnaire given to students, which shows that in the physics classroom, the experiments are only carried out on certain materials.

In the competence of interpreting scientific data and evidence, the students are given the question related to creating the proper conclusion of the experiment. In this question, the students are given a graph of the relationship between the depth (h) measured from the surface of the container, and the distance of water scattering (x) is presented. Mostly, the students are still confused in reading the graph, which makes it difficult to conclude the graph. It can be seen from Figure 2, which shows that the students are in a low category (56 %) for interpreting scientific data and evidence. The reason for students' low ability is because the students tend to memorize the material without training to develop their critical thinking skills in facing the questions given by the teacher. As stated by Rusilowati (2014), mostly the students just memorize the material rather than practice the science process. Furthermore, Rahayu (2015) argues that the students are unable to read the graph because they tend to read the table provided by their teacher, so that their interpretation ability is limited. In addition, Merta et al. (2020) state that if the student was unable to analyze and make a conclusion of data, it would decrease their science literacy in interpreting scientific data and evidence. Based on the three scientific literacy competencies described above, it shows that the scientific literacy skills of students at State Senior High School 3 Nganjuk on fluid dynamics materials are in a low category. Several factors influence the low ability of scientific literacy in students; one of the factors is that the students are not accustomed to solving physics problems, especially in fluid dynamics materials based on scientific literacy. This is reinforced by the results of interviews with physics teachers who stated that at State Senior High School 3 Nganjuk that scientific literacy was still not implemented. At this school, scientific literacy is still in the socialization stage and is not optimal. This is in line with research (Irwan et al., 2019), which states that students' low scientific literacy ability is caused by the lack of guidance and services provided by teachers to students in working on questions related to scientific literacy.

The cause of students' low scientific literacy is because they tend to memorize the theory, law, and physics concepts in order to get a better score (Arisman & Permanasari, 2015). Moreover, students rarely did the experiment, so that they didn't know what to do during the experiment. Furthermore, the lack of students' cognitive skills in science and technology is also the cause of the low scientific literacy of these students (Rusilowati et al., 2017). Sulsilah et al. (2019) argue that the scientific approach can improve students' scientific literacy skills. Gucluer & Kesercioglu (2012) states that implementing science in the learning process is one of the ways to improve students' scientific literacy; science learning is inquiry learning (Wallace & Kang, 2014). The advantage of inquiry learning is that the students can build their cognitive skills in order to solve the problem in inquiry-based learning. By doing so, it will help the student to increase their critical thinking and increase their understanding of a science concept (Majid, 2013). One model of inquiry learning is guided inquiry. Guided inquiry is a learning model with scientific activity. For example, the students can propose an opinion before the teacher explains the topic, find the solution to a problem in the form of a symptom or phenomenon, and can explain and compare the data with scientific

theory (Solihin et al., 2018). In inquiry learning, the teachers give the minimum instruction about the topic to be learned. For example, the teacher will give the students questions, and the students can look for the information in order to solve their problems individually. Chodijah et al. (2012) stated that the guided inquiry might give the students an experience to be a scientist by letting them be active in designing and analyzing a problem.

The guided inquiry learning, when applied in physics learning, will give the students a chance to increase their higher-order thinking skills, be scientific, and solve the problem on their own self. According to OECD (2013), guided-inquiry learning is in line with the domain competence of scientific literacy. The students can explain scientific phenomena, evaluate and design scientific investigations, and interpret scientific data and evidence. In the implementation of guided-inquiry learning, the main point is that the students are actively involved during the teaching and learning process. It will require the emergence of students' trust in the investigation results in the inquiry process. Okada (2013) argues that guided inquiry is one of the learning models which bring many benefits in the learning process, especially in scientific literacy. Inquiry learning can improve students' achievement and improve students' scientific literacy. In the implementation of this learning model, the students can implement the knowledge they have learned in their daily life. Nurfadhilah & Admoko (2016) also states that inquiry learning can increase the number of students who master the question of scientific literacy. It can be proved from students' pretest and posttest scores. In addition, Ngertini et al. (2013) state that implementing the inquiry learning model, which focuses on constructive understanding, is the most suitable learning model, especially to achieve students' scientific literacy.

CONCLUSION

Based on the research conducted and analyzed, it can be concluded that the student's scientific literacy in fluid dynamics is in a low category. The low results of scientific literacy cover the three domains of scientific literacy competence, namely the competence to explain scientific phenomena, evaluate and design scientific investigations, and interpret scientific data and evidence. One of the reasons for students' low ability in their scientific literacy is that they are stuck on memorizing the material. The students are unable to link various science topic or implement the complex concept of science to s the problem in their daily life. The main implication of this research is to give the information related to scientific literacy skills in senior high school students on fluid dynamics according to the competencies that have researched the use of the limited time in doing the research, and the researcher just did the research on students' scientific literacy on domain competence. Thus, the next researcher can conduct research with more complete data. They can add the context domain, knowledge domain, and attitude domain to students' scientific literacy. In addition, future researcher can conduct research using the guided-inquiry learning model in order to enhance students' scientific literacy. The guided-inquiry learning model leads to students' ability to apply what they have learned in their everyday lives rather than memorizing the concepts. In addition, this guided inquiry focuses on constructivist understanding, which researchers are able for learning alternatives in improving students' scientific literacy.

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