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Analysis of the Preliminary Ability of Scientific Literacy on Temperature and Heat

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Abstract: The purpose of this study to describe the preliminary ability of scientific literacy in the domain of competence. PISA 2015 establishes three aspects of the competency/science process domain in the process of evaluating scientific literacy, namely (1) the ability to explain phenomena scientifically, (2) the ability to design and evaluate scientific inquiry, and (3) the ability to interpret scientific data and facts. This research includes descriptive research. The data analysis technique uses a quantitative descriptive analysis. The test of the preliminary ability of scientific literacy analyzed is scientific literacy skills before the implementation of learning strategies that can improve the ability of scientific literacy. The results of the analysis show that the preliminary ability of scientific literacy in the three aspects are still below 50%. On the aspect of the ability to explain phenomena scientifically shows a percentage of 42.38%, the ability to design and evaluate scientific investigation of 47.32%, and the ability to interpret data and facts scientifically by 42.96%. This shows that the ability of scientific literacy by following per under reports from the results of 2006, 2009, 2012 and 2015 PISA studies is still relatively low.

Keywords: *the preliminary ability, scientific literacy, the domain of competence*

INTRODUCTION

Science and Technology (SCIENCE TECH) experienced very rapid development. The rapid development of science and technology requires an increase in the quality of human resources and good quality education. In the current era of globalization, the key to the glory of a nation located on the quality of human resources of science and technology. For this reason, it is necessary to prepare a quality human resource that is strong and able to bring change in a positive direction through good and quality education. Increased human resources and the quality of education will affect the economic level of a country, as we know that countries that have good achievements in PISA evaluation on average have advanced economies and technologies. This is relevant to the statement of Fuertes-Camacho, Graell-Martín, Fuentes-Loss, & Balaguer-Fàbregas (2019) which states that education has a very important role to build a sustainable world to produce quality human resources in which there are actions educative and didactic.

Science education as part of education is generally responsible and plays an important role in producing and forming students who have can think critically, creatively, innovatively and globally competitive (Abidin, Mulyati, & Yunansa, 2018). An understanding of science and technology allows students to participate fully in societies where science and technology play an important role in living in modern society. This is what will later bring change to a more positive and advanced direction, namely through education so that the school needs the right learning strategy so that later it can improve the quality of education.

Winata, Cacik, & Widiyanti (2018) said that "The quality of education and human resources of a country can be measured, one of which is through scientific literacy skills". Science literacy ability is defined as a person's ability to distinguish scientific facts from a variety of information, recognize and analyze the use of scientific inquiry methods and the ability to organize, analyze, interpret quantitative data and scientific information (Rizkita, Suwono, & Susilo, 2016). Science literacy according to PISA is the ability to use science, to identify problems and draw conclusions based on evidence to understand and make decisions about nature and changes made to nature through human activities (OECD, 2000). Knowledge and understanding of concepts and scientific processes needed in making personal decisions, contributing to cultural and social activities and economic productivity (NCES, 2012). In line with Laugksch (2000) that the importance of scientific literacy is because it contributes to the social, economic life of the community and in the decision making the process. Based on some of these definitions it can be concluded that scientific literacy is someone who can solve problems using scientific knowledge. From the results of a survey conducted by the OECD through PISA, it was stated that in 2000 Indonesia was still ranked 38th out of 41 countries that participated in PISA, in 2003 it ranked 38 out of 40 countries, in 2006 ranked 50th out of 57 countries, in 2009 ranked 60th from 65 countries, in 2012 ranked 64 out of 65 countries, 2015 ranked 62 out of 70 countries. Some of the causal factors that occur due to low scientific literacy include teachers, students, facilities and learning processes.

In building students' scientific literacy, a learning activity must be able to shape certain skills from the facts of science that exist and solve each problem in the context of the real world. By following per under the statement of Ogunkola (2013) that an increase in the ability of scientific literacy in science learning is by connecting a science concept to a topic that is developing and interesting in real life. PISA 2015 describes the scientific literacy framework into 4 domains, namely context, competence, knowledge, and attitude. However, the measurement of scientific literacy is not to measure context but rather measures competency, knowledge, and attitudes in that context (PISA, 2015). Odja & Payu (2014) Evaluation of scientific literacy is done to give attention to the cognitive and affective aspects of students.

Someone who has scientific literacy must be involved in reasoning about science and technology that requires competence. PISA specifies three aspects of the competency/science process domain namely, (1) the ability to explain phenomena scientifically: reminding and applying appropriate scientific knowledge, identifying, producing, and using various models and clear representations, making and justifying predictions appropriately, explaining implications potential scientific knowledge for the community (2) the ability to design and evaluate scientific inquiry: identifying questions as a result of exploration of scientific research provided, distinguishing questions that can be scientifically investigated, proposing ways to explore questions given scientifically, evaluating how to explore questions given scientifically, explain and evaluate how the scientists ensure data reliability, objectivity and generalized explanations, and (3) the ability to interpret data and facts scientifically: change data from one type of presentation into other types of presentation, analyzing, interpreting and drawing the right conclusions, identifying assumptions, evidence and reasoning in science texts, distinguishing arguments based on scientific evidence and theory with those based on other considerations, evaluating arguments and scientific evidence from sources that different (eg newspapers, internet and journal (OECD, 2016b).

Temperature and heat is a lot of material to research applications in everyday life that will affect the ability to get new phenomena and problem solving, also affect students' scientific attitudes. One of the conclusions from Millers's research Hobson (2008) related to scientific

literacy states that global scientific literacy is very low. The low ability of students' scientific literacy is a reason that underlies the government to change the curriculum that was originally 2006 to the 2013 curriculum. As PISA 2015 has determined so that students engage in reasoning about science and technology, students must have (1) the ability to explain phenomena scientifically, (2) the ability to design and evaluate scientific inquiry, and (3) the ability to interpret data and facts scientifically.

METHOD

This research is a preliminary study that produces supporting data for the preliminary abilities of the scientific literacy of high school students in Blora. At this stage, the research was carried out in a quantitative descriptive manner on 35 students of class XI determined by cluster random sampling. The instrument used was the initial scientific literacy test instrument as many as 14 items about temperature and heat. Students' initial scientific literacy abilities are reviewed from the domain of competence. Data obtained to analyze the level of student literacy skills.

RESULTS AND DISCUSSION

This research was carried out in preparation for students 'scientific literacy initial ability tests on temperature and heat material and guidelines for categorizing the scientific literacy abilities of students based on PISA 2015. The 2015 PISA assessment, students' literacy skills must master three competencies, namely (1) the ability to explain phenomena scientifically, (2) the ability to design and evaluate scientific inquiry, and (3) the ability to interpret data and facts scientifically. Students are still unable to get grades above the KKM. Based on the results of the initial scientific literacy ability test, high school students showed that the competency value in the material temperature and heat averaged 44 was still below the KKM value of 70. This value was still very lacking, because students were still weak in understanding scientific issues, not too understanding the intent of the problem, not being able to distinguish the release and absorption of heat, not being careful in the calculation, there was a misunderstanding of the concept of expansion of water and still being weak in reading charts.

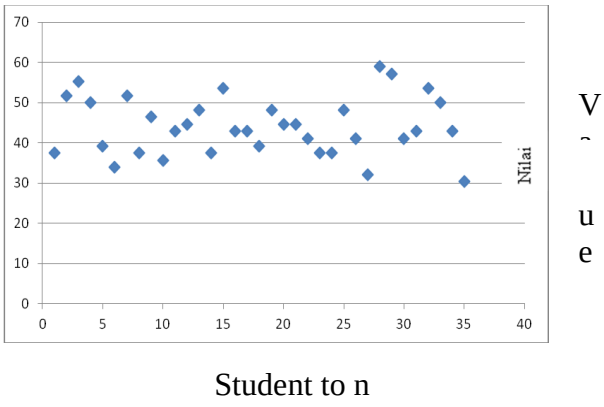


Figure 1. Percentage of students 'correct data answers to students' initial scientific literacy skills in temperature and heat

Students are still having difficulty understanding physics material. Based on the interviews conducted, 50% more students agreed that the physics material was difficult especially on the subject of temperature and heat. Students hope that the existence of physics learning can apply the concepts of physics in everyday life so that students' scientific literacy abilities increase.

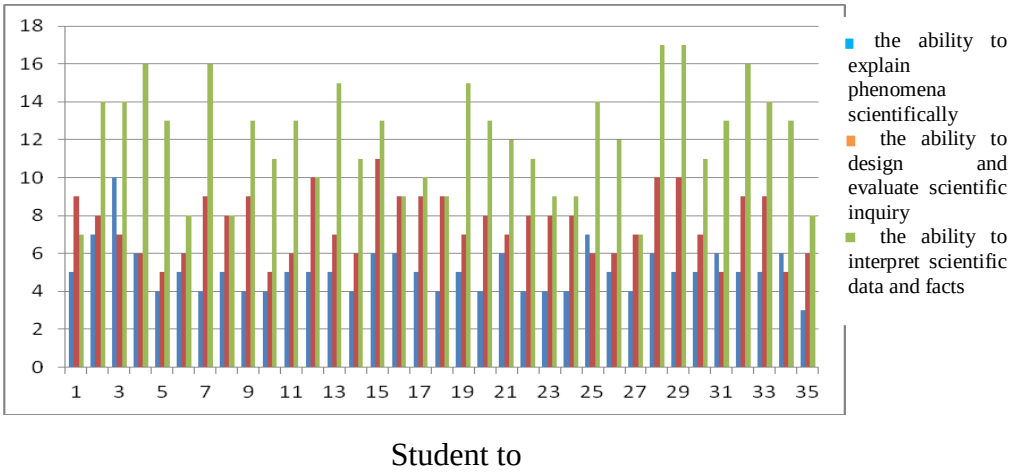


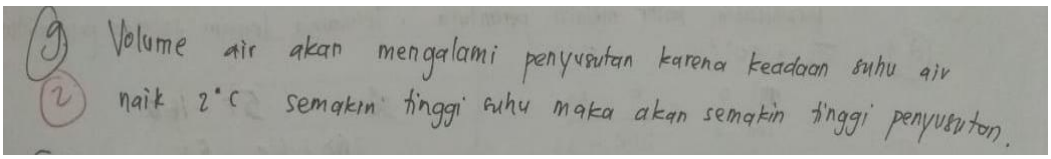
Figure 2. Graph of answers for each student in the material science and temperature literacy test

From the results of tests on the three aspects of scientific literacy in the domain of competency, it shows that most students are still weak in all three aspects, especially in terms of explaining scientific phenomena. This is because students still have difficulty understanding the concept, identifying, predicting and applying appropriate scientific knowledge. There are still errors in the concept of heat absorption and release. The results of the questions and answers from several student difficulties can be seen in the analysis below.

Table 1. The concept of liquid expansion and student answers

Question Number 9	Conception	The percentage answers
Roni measured the water temperature and he found the temperature was 2°C. Is the volume of water he is measuring smaller now than when the temperature is 0°C? Explain!	**Correct conception** The result of temperature increases is expansion. However, water has a peculiarity of nature (water anomaly) the water will shrink if heated at 0°C - 4°C. When the water temperature is 2°C, the water shrinks and the volume is smaller than when the water temperature is 0°C	The percentage answers correctly 37,14%
	Incorrect conception The volume of water will experience shrinkage due to expansion, the higher the temperature the water will shrink.	The percentage answers incorrectly 62,86 %

From table 1, most of the students as much as 62.86% there was a misunderstanding about the concept of water anomalies, that almost all students did not answer according to the concept of physics. Then the analysis of student answers can be seen in Figure 3.



"The volume of water will experience shrinkage because the water temperature rises to 2°C, the higher the temperature, the higher the shrinkage"

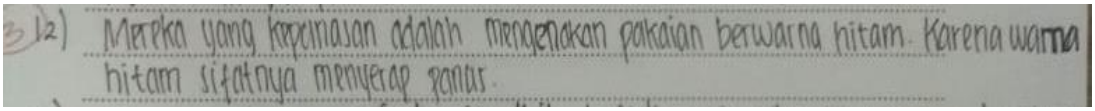
Figure 3. Description of students' answers to the concept of water expansion

Figure 3, students assume that the higher the water temperature, the volume of water will experience shrinkage even though it only occurs when the temperature is 0°C - 4°C, while the rest above this temperature will experience an increase in water volume or expansion according to the temperature of the water when boiling. The irregular nature of the expansion of water is called a water anomaly (Serway & Jewet, 2010).

Table 2. The concept of heat transfer of radiation based on student answers

Question Number 11	Conception	The percentage answers
 Martial arts groups and "sedulur sikep" of the Samin community while following the ceremonies of the proclamation on Blora Square Based on the color of the clothes they wear, who feels hot? Why?	**Correct conception** Those who feel hot are Samin people because they wear black clothes that absorb heat while the white color reflects heat (heat)	The percentage answers correctly 52,86 %
	Incorrect conception Those who feel hot are those who wear black clothes because they absorb heat.	The percentage answers incorrectly 47,14 %

In table 2, most of the students as much as 52.86% almost answered correctly, by following the concept of physics but students did not understand the purpose of the problem.



"Those who are hot are wearing black clothes. Because the black color absorbs heat "

Figure 4. Description of students' answers to the concept of heat transfer of radiation

Figure 4, students already understand the heat transfer material by radiation, but students do not understand the meaning of the problem. Students do not know the environment around them, which is mostly temperature and heat material that can be applied conceptually. Students have not been able to associate the application of physics to the environment around them. Because one increase in scientific literacy can be done by introducing the applications of physics concepts in their immediate environment. In table 3 is the percentage of scientific literacy capabilities of the three aspects of the overall domain of competence.

Table 3. Table a percentage of students' initial scientific literacy abilities in the competency domain

Competency	Percentage
Able to explain phenomena scientifically	42,38%
The ability to design and evaluate scientific inquiry	47,32 %
The ability to interpret data and facts scientifically	42,95 %

The results of the percentage of the three aspects of the domain of competence indicate that 35 students who have been studied as many as 42.38% of students are in the aspect of being able to explain the phenomenon scientifically, 47.32% of students are in the aspect of being able

to design and evaluate scientific investigation, and 42.95% students are on aspects able to interpret data and facts scientifically.

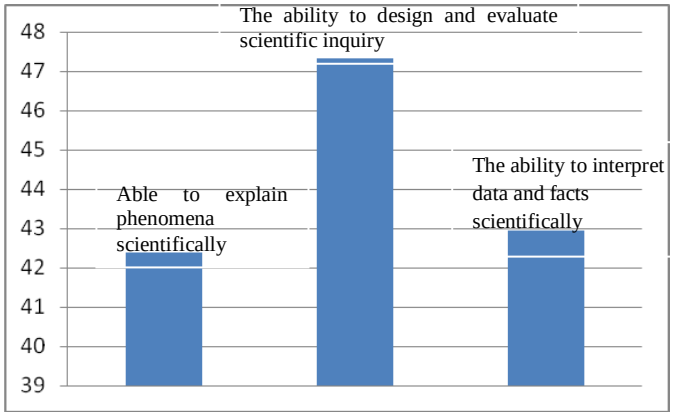


Figure 5. Graph of science literacy skills of high school students

The results of the analysis of the tests of early scientific literacy skills show that the science literacy of high school students in the school is still relatively low. This is because the inability of students in scientific literacy skills proves that students have not been able to solve problems in daily life scientifically and communicate the results of experiments conducted in writing (Winata et al., 2018).

Based on the results of the analysis of students 'initial scientific literacy abilities, it is necessary to have a learning strategy that can improve students' literacy skills so that science process skills of students can be trained and accustomed to doing things related to science literacy activities in accordance with PISA 2015 namely (1) ability to explain scientific phenomena, (2) the ability to design and evaluate scientific inquiry, and (3) the ability to interpret data and facts scientifically. (Sari, Rusilowati, & Nuswowati, 2017). Module-assisted project learning has a good influence on the ability of scientific literacy in aspects of the ability to explain phenomena scientifically. Science literacy skills can be improved through project-based learning strategies from the results of the study stating that almost all students are happy with STEM PjBL learning, students feel happy because they have gained a very impressive experience while following the stages of learning, giving rise to motivation and interest in learning (Afriana, Permanasari, & Fitriani, 2016). Increasing the ability of scientific literacy can be done to emphasize more on student-centered with a process approach that is more dominant in experimental activities, Integrated science learning with shared can improve scientific literacy skills both aspects of content, process and attitude of science because the type of learning strategies implemented can train literacy aspects of scientific literacy that are student-centered based on a process approach with more emphasis on the process of experimental learning and discussion (Ardianto & Rubini, 2016). In line with that, so that students are interested in scientific issues, it is necessary to have a contextual learning model that can improve scientific literacy in the aspects of competence. Wulandari & Sholihin (2015) By implementing the Problem Based Learning (PBL) learning model, it can improve scientific literacy skills in aspects of attitudes significantly, from the results of the study that the N-gain value is obtained by the Sig. (1-tailed) 0.011 <0.050 which means that H0 is rejected and H1 is accepted, then PBL contributes very well to students' scientific literacy. Students are more interested in scientific issues, increasing scientific inquiry and encouraging students' sense of responsibility towards their surrounding environment. Students are encouraged to try to solve problems related to science and care and be responsible for the surrounding environment.

CONCLUSIONS

From the results of research and analysis of the data obtained, it can be concluded that the scientific literacy ability of high school students in Blora on the aspect of competence, in general, is still low at under 50%. Of the three aspects of the science literacy competency domain, the ability to explain phenomena scientifically is 42.38%, the ability to design and evaluate scientific inquiry is 47.95%, and the ability to interpret data and facts scientifically is 42.95%.

RECOMMENDATION

However, the solution that can be offered is the need for a learning strategy so that scientific literacy skills are improved by module-assisted experimental learning methods, Project Based Learning learning strategies, shared types and Problem Based Learning (PBL) learning models.

REFERENCES

(NCES), N. C. for E. S. (2012). Highlights From TIMSS 2007:Mathematics and Science Achievement of U.S. Fourth and Eighth-Grade Students in an International Context. Washington DC: Department of Education.

Abidin, Y., Mulyati, T., & Yunansa, H. (2018). Pembelajaran Literasi (Strategi Meningkatkan Kemampuan Literasi Matematika, Sains, Membaca dan Menulis). Jakarta: Bumi Aksara.

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Penerapan Project Based Learning Terintegrasi STEM untuk Meningkatkan Literasi Sains Siswa Ditinjau dari Gender. Jurnal Inovasi Pendidikan IPA, 2(2), 202–212. Retrieved from https://journal.uny.ac.id/index.php/jipi/article/view/8561/9022

Ardianto, D., & Rubini, B. (2016). Lietrasi Sains Dan Aktivitas Siswa Pada Pembelajaran Ipa Terpadu Tipe Shared. Unnes Science Education Journal, 5(1), 1167–1174. https://doi.org/http://dx.doi.org/10.15294/usej.v3i2.3349

Hobson, A. (2008). The Surprising Effectiveness of College Scientific Literacy Courses. 46, 404–406.

Laugksch, R. C. (2000). Scientific literacy: A conceptual overview. Science Education, 84(1), 71–94.

Odja, A. H., & Payu, C. S. (2014). Analisis Kemampuan Awal Literasi Sains Siswa Pada Konsep IPA. Prosiding Seminar Nasional Kimia, 1(1), 40–47. https://doi.org/10.33086/ehdj.v1i1.291

OECD. (2000). Program from International Student Assessment: Sample Tasks from PISA 2000 Assessment of Reading, Mathematics and Scientific Literacy. Paris: OECD Publishing.

OECD. (2016a). Assessing Scientific, Reading and Mathematical Literacy A Framework for PISA 2015. Paris: OECD Publishing.

OECD. (2016b). Assessment and Analytical Framework Science, Reading and Financial Literacy. Kanada: OECD.

Ogunkola, B. J. (2013). Scientific Literacy: Conceptual Overview, Importance, and Strategies for Improvement. Journal of Educational and Social Research, 3(1), 265–270.

PISA. (2015). Assessment Framework Key Competencies in Reading, Mathematic,s and Science. OECD.

Rizkita, L., Suwono, H., & Susilo, H. (2016). Analisis Kemampuan Awal Literasi Sains Siswa SMA Kota Malang. Prosiding Seminar Nasional II, (1), 771–781.

Sari, D. N. A., Rusilowati, A., & Nuswowati, M. (2017). Pengaruh Pembelajaran Berbasis Proyek terhadap Kemampuan Literasi Sains Siswa. Pancasakti Science Education Journal, 2(2), 1–114.

Serway, R. A., & Jewet, J. J. W. (2010). Fisika untuk Sains dan Teknik Buku 2 (6th ed.; C. Sungkono, ed.). Jakarta: Salemba Teknika.

Winata, A., Cacik, S., & Widiyanti, I. S. R. (2018). Kemampuan Awal Literasi Sains Peserta Didik Kelas V Sdn Sidorejo I Tuban Pada Materi Daur Air. JTIEE, 2(1), 58–64.

Wulandari, N., & Sholihin, H. (2015). Peningkatan Aspek Sikap Literasi Sains Siswa Smp Melalui Penerapan Model Problem Based Learning Pada Pembelajaran Ipa Terpadu Untuk Meningkatkan Aspek Sikap Literasi Sains Siswa SMP. SNPS, 437–440.