The profile of high school students’ scientific literacy on fluid dynamics

Parno*, L Yuliati and N Munfaridah
Physics Department, Universitas Negeri Malang, Malang, Indonesia

*Corresponding author’s e-mail: parno.fmipa@um.ac.id

Abstract. This study aims to describe the profile of scientific literacy of high school students on Fluid Dynamics materials. Scientific literacy is one of the ability to solve daily problems in accordance with the context of materials related to science and technology. The study was conducted on 90 high school students in Sumbawa using survey design. Data were collected using an instrument of scientific literacy for high school students on dynamic fluid materials. Data analysis was conducted descriptively to determine the students' profile of scientific literacy. The results showed that high school students' scientific literacy on Fluid Dynamics materials was in the low category. The highest average is obtained on indicators of scientific literacy i.e. the ability to interpret data and scientific evidence. The ability of scientific literacy is related to the mastery of concepts and learning experienced by students, therefore it is necessary to use learning that can trace this ability such as Science, Technology, Engineering, and Mathematics (STEM).

1. Introduction

The rapid development of science and technology has caused for a need of a development of scientific literacy in education. Scientific literacy is required for science education [1] for both basic and higher levels [2]. The scientific literacy is not only concerned with science Education but also covering a broader area of problem-solving in a study [3]. Literacy of science is the ability to engage oneself in daily issues related to science and technology. Scientific literacy has several competencies, such as explaining the phenomenon scientifically, evaluating and designing scientific inquiry, and interpreting data and scientific evidence [4]. Components required in scientific literacy include the understanding of natural phenomena and how to build scientific facts [5], understanding of what science is about, and what it means to establish scientific facts to generate discussion related to science itself [6].

The scientific literacy impacts not only on learning, but also in students’ ability to apply knowledge on the issues of everyday life. It serves to increase the students' knowledge in the sphere of knowledge of the life system, the earth system and outer space, and the technology system. Students’ knowledge of the three systems can help students understand the linkages between nature and technology better, therefore allowing them to solve the problems they encounter more easily. The learning process with the presence of scientific literacy results in a more stimulating experience and significant benefit for both students and teachers [7]. This exhibited role of scientific literacy shows that it’s an important skill for high school students to have. In addition, scientific literacy is also needed in industrial sector [8,9] in order for it to be developed better [10]. The development of scientific literacy can be achieved by engaging in the activity of reading and writing about science [11].
The results of the National Center for Education Statistics (NCES) survey in the form of the Program for International Student Assessment (PISA) in 2012 show that Indonesia is one of the countries with low level of scientific literacy. These results indicate that scientific literacy has not been optimally utilized at the school level in Indonesia. In this condition, most Indonesian students have only a limited scientific knowledge to apply in everyday life, which is indicated by the ability to present a scientific explanation from facts that are given clearly and explicitly. Only a few of the students managed to have a sufficient scientific knowledge to draw conclusions from simple observations, which is indicated by the ability to provide the reasons directly and interpret the data scientifically. The government has announced the integration of the curriculum 2013 (K13) with Science, Technology, Engineering, Mathematics (STEM). This plan is in line with the results of a National Science Foundation study which stated that 80% of employment will require the competence in science, technology, engineering, and mathematics in the next 10 years. In addition, the process of reviewing K13 would be better if the government, especially the education department, tried to apply STEM in the education system in Indonesia [12]. It is expected that this integration can help develop students' literacy skills in Indonesia.

Development of scientific literacy in Indonesia can be done by knowing the mapping of literacy ability of science students first. This mapping can be done on the subject of physics. One of the topics that can be used is dynamic fluid. This topic is a fairly difficult topic of physics [13]. In addition, dynamic fluid is a topic that is widely applied in everyday life, such as fertilizer sprayers used by farmers, mosquito repellent sprays, aircraft and others. Therefore, this topic can be one of the topics to map students' literacy skills. The results of this study are expected to be used to construct STEM-based learning activity steps.

2. Methods
This research is an early part of research on development of STEM-based learning model. This study uses a survey design that describes the tendency of attitudes, opinions, behaviors, or characteristics that occur in a particular population, which classifies this as a non-experimental quantitative type [14]. This research focuses in a high school student's scientific literacy profile on dynamic fluid materials. The subjects were 90 high school students in a city on the island of Sumbawawa who had experienced dynamic fluid material learning.

The instrument of this research is Scientific Literacy Test of Fluid Dynamics with Cronbach alpha reliability of 0.749. The test consists of 5 discourses, in which each has 2-4 items of description questions. In total, there are 13 items of description. The students’ score will be categorized in four scoring rubric. Score 0 indicates that the student doesn’t provide any answer. Score 1 indicates that the student’s answer doesn’t show an accordance to the problem, doesn’t show a deep understanding of the concept, or is unrelated to the problem at all. Score 2 indicates that the student’s answer is in accordance with the concept of the problem in the discourse. Score 3 indicates that the student’s answer is in accordance with the concept, shows a deep understanding of the concept, and is related to the problem. The students' scientific literacy profile was obtained by percentage analysis and description of the test result data and reinforced by the analysis of student variation.

3. Results and Discussion
The result of data analysis showed that students’ scientific literacy ability is as follows: average 16.78, SD 14.60, min 0 and max 64.44. These results indicate that students' answers have not yet led to the correct physics concept. The standard deviation value indicates that the students' ability varies. The maximum value indicates that the student's answer almost leads to the correct concept. Average distribution for each indicator of student scientific literacy can be seen in Figure 1.

The lowest ability possessed by students is the ability to evaluate and design scientific research. These results indicate that there is a need for learning that trains this ability so that it will have an impact on the scientific literacy of students. Unlike the ability to evaluate, the ability to interpret data and scientific evidence has the highest average. The average value is derived from the work of students on 13 scientific literacy questions. Each question has a measure of the extent of students' attachment to the
scientific literacy indicator. This measurement of scientific literacy uses 5 discourses in the matter (Table 1).

| Discourse | Topic | Item Number | Scientific Literacy Competence | % Score |
|-----------|-------|-------------|--------------------------------|---------|
| 1         | Seawater distillation | 1 | Explaining scientific phenomena | 50.00 |
|           |       | 2 | Interpreting data and scientific evidence | 43.33 |
| 2         | Home water tank systems | 3 | Interpreting data and scientific evidence | 64.44 |
|           |       | 4 | Explaining scientific phenomena | 68.89 |
|           |       | 5 | Evaluating and designing scientific inquiry | 90.00 |
| 3         | Descriptions of aircraft wings | 7 | Explaining scientific phenomena | 73.33 |
|           |       | 8 | Explaining scientific phenomena | 68.89 |
|           |       | 9 | Explaining scientific phenomena | 60.00 |
| 4         | Airflow around a moving train | 10 | Explaining scientific phenomena | 74.44 |
|           |       | 11 | Evaluating and designing scientific inquiry | 93.26 |
| 5         | Airflow on the chimney | 12 | Explaining scientific phenomena | 77.78 |
|           |       | 13 | Explaining scientific phenomena | 88.89 |

Table 1 shows the percentage of the four scoring rubric in each item number in 5 number of discourse. As indicated by the scoring rubric, the students with the score of 1 had certain difficulties in providing the correct answer. The item number and its difficulty are mapped in Table 2.
The results in Table 1 show that there are still many students who have difficulty working on scientific literacy matters. This is evident from the high percentage of students’ score who obtained a score of 0. The highest percentage of score 1 is obtained on the indicator of scientific literacy in the form of explaining scientific phenomena. The percentage score 2 is also obtained on the indicator explaining the scientific phenomena. The highest percentage of score 3 is obtained on the indicator to interpret data and scientific evidence. The use of discourse on the problem of scientific literacy is in accordance with the results of research stating that reading the science discourse can help the development of students’ scientific literacy [11].

| Discourse | Topic | Item Number | Conclusion of Item Number |
|-----------|-------|-------------|----------------------------|
| 1         | Seawater distillation | 1 | Students have not been able to explain the relationship between fluid speed and pipe cross section |
|           |       | 2 | Students have not been able to interpret data and scientific evidence from the presented images |
| 2         | Home water tank systems | 3 | A small number of students are able to interpret data and scientific evidence |
|           |       | 4 | Students have difficulty explaining the difference in water flow rates in the water flowing on different pipes |
|           |       | 5 | Students have not been able to evaluate and design scientific inquiry related to the relationship of water speed and pipe height |
|           |       | 6 | Students have not yet made a graph |
| 3         | Descriptions of aircraft wings | 7 | Students experience the difficulties to explain the scientific phenomenon of aerodynamics |
|           |       | 8 | Students have difficulty in explaining the effect of fluid flow velocity and pressure on the top and bottom of aircraft wings |
|           |       | 9 | Students can explain the scientific phenomenon of the crashed plane, but cannot predict the direction the plane will fall |
| 4         | Airflow around a moving train | 10 | Students have not yet able to explain the phenomenon of mutual train-pull of people due to differences in fluid flow velocity |
|           |       | 11 | Students have difficulty in evaluating and designing scientific inquiry into the application of Bernoulli law |
| 5         | Airflow on the chimney | 12 | Students have difficulty determining the size of an efficient chimney |
|           |       | 13 | Students have not been able to explain the relationship between the inner air rate and the chimney |

Fluid dynamics is also a material that is considered difficult by students. [15] Reveals that students still find it difficult to identify magnitudes that affect fluid flow discharge. Students can work on quantitative questions but have not been able to apply concepts in solving real problems. Students still struggle to formulate the relationship between variables in the equation [15,16,17]. Students are also
less precise when entering numbers into equations and students are still unable to explain real-world problems related to the Bernoulli principle [13,16]. This difficulty is caused by the Bernoulli equation which contains many variables. Students have difficulties in imagining dynamic fluid material [18] because of the informative learning which only emphasizes on mathematical formulas without presenting the dynamic fluid related phenomena.

The results also reveal that students still have difficulty explaining the relationship between variables in the equation that contains many variables. When students answer the question of the number 12, students have difficulty connecting the linkage between the pipe surface area and the fluid flow velocity, then connect the velocity with the amount of pressure produced, which then connects the pressure changes with the direction of fluid movement and fluid height change. This is in accordance with the results of the study [13,16]. The results of the study [19] also show that students have difficulty when asked to present mathematical equations into verbal forms. And one of the important results in the learning process is that students are able to express their understanding into the verbal form [20].

4. Conclusion
Based on the results of data analysis, it can be concluded that the students’ ability of scientific literacy in this study mostly reside in the ability to interpret data and scientific evidence. The ability of scientific literacy requires student’s mastery of an adequate concept. This will facilitate students in the learning process. In addition, the use of learning that refers to science and technology such as STEM (Science, Technology, Engineering, and Mathematics) is also needed so that students' scientific literacy can develop well.

5. References
[1] Eisenhart M, Finkel E and Marion S F 1996 Creating the conditions for scientific literacy: a reexamination American Educational Research Journal 33 2 261–95
[2] Amarulloh R R, Utari S and Feranie S 2017 The implementation of levels of inquiry with writing-to-learn assignment to improve vocational school student’s science literacy J. Phys.: Conf. Ser. 812 1 012049
[3] Laugksch R C 2000 Scientific literacy: a conceptual overview Sci. Ed. 84 1 71–94
[4] OECD 2012 PISA 2012 assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy (Paris: OECD)
[5] Raymo C 1998 Scientific literacy or scientific awareness? American Journal of Physics 66 9 752
[6] Yuenyong C 2013 Enhancing scientific literacy in thailand Global Studies of Childhood 3 1 86–98
[7] Moraes J V, Castellar S V, Castellar S V and Castellar S V 2010 Scientific literacy, problem based learning and citizenship: a suggestion for geography studies teaching Problems of Education in the 21st Century 19
[8] Hobson A 2003 Physics literacy, energy and the environment Phys. Educ. 38 2 109
[9] Hobson A 2008 The surprising effectiveness of college scientific literacy courses The Physics Teacher 46 7 404–6
[10] Hobson A 2006 Science literacy and backward priorities The Physics Teacher 44 8 488–9
[11] Glynn S M and Muth K D 1994 Reading and writing to learn science: achieving scientific literacy J. Res. Sci. Teach. 31 9 1057–73
[12] Sandra 2013 Re-Konstruksi Kurikulum STEM http://www.kompasiana.com
[13] Sabariasih D, Jamzuri and Rahmasari L 2015 Remidiasi pembelajaran fisika dengan model snowball throwing pada materi fluida dinamis kelas XI di SMA Negeri 6 Surakarta 6th Seminar Nasional Fisika dan Pendidikan Fisika 6 3
[14] Creswell J W 2002 Educational research: Planning, conducting, and evaluating quantitative and qualitative research The Journal of Educational Issues of Language Minority Students 15 810-881.
[15] Fathiah I K and Utari S 2015 Analisis didaktik pembelajaran yang dapat meningkatkan korelasi antara pemahaman konsep dan kemampuan pemecahan masalah siswa SMA pada materi fluida dinamis Jurnal Penelitian & Pengembangan Pendidikan Fisika 1 1 111–118
[16] Susanti 2013 Pengembangan perangkat pembelajaran fisika melalui pendekatan ctl untuk meminimalisir miskonsepsi fluida dinamis Jurnal Penelitian Pendidikan Sains 2 2 224–30
[17] Astuti R M, Djudin T and Hamdani 2017 Penerapan model nht berbantuan phet dalam remediasi miskonsepsi fluida dinamis sma 1 sungai raya Jurnal Pendidikan dan Pembelajaran 6 1 1–17
[18] Benigno I J V, Wirjawan D and Indrasusanto T 2015 Pengembangan media pembelajaran fisika bilingual ‘vocareli’ pada pokok bahasan fluida dinamis Jurnal Fisika Indonesia 55 XIX 49–53
[19] Bagno E, Eylon B S and Berger H 2009 how to promote the learning of physics from formulae? GIREP-EPEC & PHEC International Conference
[20] Eggen P and Kauchak D 2012 Strategi dan model pembelajaran mengajarkan konten dan keterampilan berpikir (Jakarta: Indeks)