p-ISSN 1693-1246
e-ISSN 2355-3812
January 2017

Jurnal Pendidikan Fisika Indonesia 13 (1) (2017) 19-24
DOI: 10.15294/jpfi.v13i1.8391

http://journal.unnes.ac.id/nju/index.php/jpfi

SCIENCE LITERACY INDICATORS IN OPTICAL INSTRUMENTS OF HIGHSCHOOL PHYSICS TEXTBOOKS CHAPTER

A. Rokhmah*, W. Sunarno, M. Masykuri

Fakultas Pendidikan, Pascasarjana,
Universitas Sebelas Maret (UNS), Surakarta, Indonesia

Received: 2 September 2016. Accepted: 11 October 2016. Published: January 2017

ABSTRACT

The direction of current science is emphasized on the importance of science literacy skill as a preparation for students returning to community after finishing school. Science literacy skill is believed can help the individuals to solve the problem scientifically and accountable. Science textbooks are instructional tools that help students learning science. The purpose of this research is to analyse the textbooks of Physics for high school grade X about Optical Instruments topic based on science literacy indicator. The study conducted in four senior highschools. There were two textbooks used in those schools, Book A and Book B. The results showed that on average the emergence of science literacy indicator of science nomenclature was 17.5%, intellectual process skills was 45.5%, the rules of scientific evidence was 8.5%, postulate of science was 19%, and scientific disposition was 9.5%. Book A contained of more research activities than Book B, but Book B linked the second indicator more comprehensive. The advantages and disadvantages of each analyzed textbooks can be used as a further background study for developing the good quality teaching material of physics-based scientific literacy.

ABSTRAK

Arah dalam pembelajaran sains saat ini menekankan pentingnya kemampuan literasi sains sebagai persiapan untuk terjun ke dalam masyarakat setelah menyelesaikan studi. Kemampuan literasi sains diyakini dapat membantu individu untuk menyelesaikan masalah yang dihadapi secara ilmiah dan bisa dipertanggungjawabkan. Buku ajar merupakan suatu alat pengajaran yang membantu siswa dalam memahami sains. Tujuan penelitian ini adalah menganalisis buku teks fisika SMA/MA Kelas X materi alat optik berdasarkan indikator literasi sains. Penelitian dilakukan di empat sekolah menengah atas. Terdapat dua buku yang digunakan di sekolah tersebut, Buku A dan Buku B. Hasil penelitian menunjukkan bahwa rata-rata kemunculan indikator literasi sains penamaan ilmiah 17,5%, kemampuan eksperimen dan observasional dasar 45,5%, kaidah bukti saintifik 8,5%, postulat sains 19%, dan disposisi ilmiah 9,5%. Buku A mengandung kegiatan penyelidikan lebih banyak dibandingkan Buku B, namun Buku B mengaitkan indikator literasi sains yang kedua lebih komprehensif. Kelebihan dan kekurangan dari masing-masing buku dapat dijadikan dasar penelitian lebih lanjut untuk meningkatkan kualitas pembelajaran berbasis literasi sains.

Keywords: optical instruments; science literacy; textbooks

INTRODUCTION

The main purpose of current Physics learning is to prepare the students for their better future in 21st century (Karelina, A. & Etkina, E., 2007). In order to fulfill the purpose, Physics learning should be able to help the students to develop the abilities to struggle for their bright future (Etkina et al., 2006). The students are demanded to be able to solve complex problems using media, technology, information, and communication for their life and future career. They are also expected to use the logical and

***Correspondence Address:**
Jl. Ir. Sutami No. 36A, Jebres, Surakarta, 57126, Indonesia
E-mail: ainur.rokh@gmail.com

accountable scientific reasoning in their daily life.

Comprehension and application of science for society needs in solving the problem is the definition of science literacy (Hurd, 1997; Holbrook & Rannikmae, 2009; Gormally, Brickman, & Lutz, 2012). Development of science framework revealed that having science attitudes as students behavior is the main purpose of science learning. The students are trained to have abilities in applying the competences of science which they learned from school to become well behavior persons in society and vice versa they can utilize the society and environment as a learning source to become more wise people in making decision of their life.

The measurement of science literacy skill has been done in many countries. One of the routine programme of measurement of science literacy skill which is done once in 3 years is Program for International Student Assessment (PISA). From the report of PISA 2015, the average score of science literacy of Indonesian students was 403 and in the rank of 62 from 70 countries of test participants. Research from Arief & Utari (2015) has reported the same result. They used levels of inquiry approach in students' learning program of grade VII to improve students' science literacy. The result of the research revealed that by applying inquiry approach, the competence of explaining scientific phenomenon and the competence of interpreting data were significantly increase. However, the competence of evaluating and designing scientific investigation were still poor. Nevertheless, actually there is a potensial showed by the students to become increase those competence by special training which is accordance that can be done in future study.

Two main factors that influenced students' science literacy are the learning resources (e.g. book) and the learning program that support them to have science literacy skills (Rusilowati, Susilowati, & Nugroho, 2016). The fact showed that students have more time to interact with the textbook than with the teacher. Having this flexibility, there is a chance to train them to have science literacy skill by optimizing the textbook function. But of course there is a requirement for the textbook to bridge the students to have good science literacy skill by enriching the textbook with research activities to develop students scientific abilities. Therefore, the content of textbook for students should be the main consideration.

Many researches about science literacy skill development were done. One of the developments is in the used of indicator of science literacy. Nature of Scientific Literacy Test (NOSLiT) is an instrument measuring the students' comprehension of authentic science to reach the success of science literacy (Wenning, 2006). NOSLiT is developed especially to measure the science literacy of senior high school students. Thus, the indicators of science literacy skill used by NOSLiT are suitable with the thinking abiliy of senior high school students. The indicators are science nomenclature, intellectual process skills, rules of scientific evidence, postulate of science, scientific disposition, and major misconceptions about science.

The research procedures that will be done are adapted from science literacy indicators stated by Wenning (2006). The first adaptation is the use of five from six science literacy indicators, diminution of one indicator is about the major misconceptions about science. The second adaptation is diminution of the third criteria of indicator, the rules of scientific evidence. From 12 criterias there will be only 4 criterias which will be used. This is chosen because the consideration about the discussion of science misconceptions consists of complexity and needs a separated discussion. Then, the reason to not use the other 9 criterias in the indicators of the rule of scientific evidence is because it consists of complexity which can not be seen directly from the textbook.

To get the prelimenary data about misconception on optical instruments topic which hold by the students, interview session were done with some students in Pacet subdistrict. Based on interview results, optical instruments was difficult to be learned because it was delivered using mathematic equations. Since, they did not understand the concepts behind the mathematic equations, it results misconception among them. Other researches also reported difficulies in understanding the topic. Suniati et al. (2013) explained that the students had a misconception in defining properties and magnification of images on the magnifying glass. Agnes et al. (2015) stated that most of students in her research samples had misconception in analyzing the formation of image on the mirror and optics devices. From the premilinary data and other researchers report, it can be concluded that there is a need to do a crucial effort in revising and correcting the misconception in optical instruments topic. Thefore, the purpose of this research is to describe the contribution of the textbook in developing students science

literacy skills by analysing the Physics textbook for high school grade X on Optical Instruments topic based on the indicators of science literacy in Pacet subdistrict.

METHOD

This research was used descriptive method and conducted in all high schools in Pacet subdistrict, Mojokerto district in the odd semester in academic year 2016/2017. There are SMA N 1 Pacet, SMA 45 Pacet, MA Pacet, and MBI Amanatul Ummah as participants of this research.

The research subject was the Physics textbooks for grade X of Optical Instruments topic used by those four schools. There were two textbooks used, Book A and Book B. The analysis was done by using the indicator of science literacy skill setted by Wenning (2006). The analysis has been done based on the indicator of learning material arranged by the researchers. The indicators are adjusted with the rules of Optical Instruments on Curriculum 2013.

The data collection was used check-list technique on the analysis paper. The first step was analysed the indicator of science literacy, in every indicator of the optical instruments material from Book A. After giving the check-list, descriptions of the indicators that appears also need to be written. This part was repeated until five indicators of science literacy on arranged learning indicator had been analyzed.

The second step was analysed the science literacy indicators on every learning indicators of Optical Instrument material from Book B. After finished all books, the analysis result of science literacy was calculated it percentage by counting the number of indicators that appears and divide them with the total number of indicator then multiplied the result by one hundred percent. From the calculation, the emergence of science literacy of the books can be described.

RESULTS AND DISCUSSION

Based on the analysis, the content of both of the books on the Optical Intruments material had similar learning indicators. In this chapter, the materials discussed from Book A and Book B were Human Eyes, Visual Impairment, Magnifying Glass, Microscope, Telescope, and Camera. These materials were delivered in text and images forms. On Book A there were additional rubric in form of links about the related information concepts taught. Students were expected to access the link independently or by group to get additional knowledge more than the content from the text Book A and also to train the students' skill in collecting data and information. Both of the books were also equipped by the example of problems and answers which can help students to understand the applied concept

The first analysis result from the research process is the analysis of science literacy indicators on every learning indicator. Not all of the learning indicators on the book which are analyzed contain of the science literacy indicators. Below are the results of the analysis.

Table 1. The analysis results of science literacy indicator in every learning indicator

Learning Indicators	The Emergence of Science Literacy Indicator	
	Book A	Book B
Identify parts of eye	1	1
Analyze the formation of images in the eyes	1	0
Identify optical instruments for visual impairment	0	0
Analyze image formation in eyes with impaired vision	1	1
Analyze formation of images on the magnifying glass	1	1
Identify microscope parts	2	1
Analyze formation of images on the microscope	5	1
Identify telescope parts	1	1
Analyze formation of images on the telescope	5	5
Analyze system of the eye and the camera	0	1
Analyse formation of images on the camera	0	0
Analyze the use of focal length and exposure time	0	0
Total	17	12

On Book A, the learning indicators 7 and 9 contain the most science literacy indicators. There are some analysis activities about microscope and telescope which can be done by the students to improve their scientific attitu-

des, understanding of concepts, and skills. That activities will integratively train the five science literacy indicators at once, such as science nomenclature, the intellectual process skills, rules of scientific evidence, postulate of science, and scientific disposition. Indicator 1, 2, 4, 5, and 8 only contain one indicator of science literacy because those indicators only show the intellectual process skills. That indicator appears in form of observing the picture from the textbook. Generally, the picture provides the students activity to observe the formation of images on some optic instruments. Indicator 6 shows two indicators of science literacy, there are science nomenclature and the intellectual process skills. The activity for students is to find the literature through the link provided and observe the parts of microscope and the formation of images in microscope through picture and link it with what they get from the website.

On Book B, the learning indicator 9 contain the most science literacy indicators. In this indicator there are research activity about telescope done by the students which is integratively train all five indicators of scientific literacy at once. The Indicator 1, 4, 5, 6, 7, 8, and 10 only contain of one indicator of science literacy. Those seven indicators only show the intellectual process skills. As in the Book A, the indicator is shown in form picture observation from the textbook.

Based on the analysis results above, it can be concluded that the emergence of scientific literacy indicator is mostly shown on the indicator 9, which is analyzing the form of images on the telescope. Both of the books have five scientific literacy indicators which are analyzed. The completeness of scientific literacy indicators in that learning indicator is packaged in exploratory activities. Book A used the exploratory activity to make a simple Galileo telescope meanwhile Book B used the exploratory activity through literature study about the space telescope, radio telescope, and simply measurement of the diameter of the moon.

The disappearancee of complete science literacy indicator on the other learning indicator is because the material is presented in text form. Students are often exposed that science is a collection of concepts to be memorized rather than processes for information-seeking and evaluation (Zimmerman, 2007; Kuhn, 2010; Minner, Levy, & Century, 2010; Morris, Masnick, Baker, & Junglen, 2015). The books give the explanation directly related to the material without providing an opportunity for students to engage in activities that construct their understanding. Most of the indicators in optical instruments material are taught by reading and writing only.

The second result of the analysis from the research is the analysis of science literacy indicator from both of the books. Table 2 is the data of the analysis results from the science literacy indicators on Book A and Book B. Based on the analysis data in Table 2, both of Book A and Book B have contained five science literacy indicators. On average, the highest percentage of science literacy indicator is the second indicator, it is 45.5%. Both of the books show the same result that the most dominant science literacy indicator is the second indicator which use the picture as a media to provide the students activity to do observation to get the learning concept. Another media which can be used for teaching the concepts are natural phenomenon, graph, or the environmental investigation.

The second literacy indicator that often arises is the science nomenclature by 17.5%. The science nomenclature is the general language used in science. The language is related with the experiment activity and the concept of epistemology. The textbooks that rich of science literacy uses the general scientific language that commonly used in science. The Book A has higher percentage of the science nomenclature indicator than Book B. Eventhough the material of Book A is lesser than Book B, but Book A is richer in the use of scientific language.

The third literacy indicator that often arises is postulate of science by 19%. In this indicator, Book A has higher percentage than Book B. Postulate of science is the assumption about science which is still used until now. There are 8 indicators of postulate of science analyzed in the book. Postulate of science will be understood if only students do the activity that actively construct their comprehension of concepts taught. This is because the assumptions about science is closely related to the investigation or experimental activities. The Book A contains two exploratory activities while the Book B contains only one exploratory activities.

The fourth indicator that often arises is a scientific disposition by 9.5%. Scientific disposition is the character or attitude that is expected from a scientist. Scientists are people who learn about science so the students are also expected to have a scientific disposition indicator. These characters include curiosity and skepticism, objective, and not dogmatic,

Table 2. Data from the analysis of scientific literacy indicators in both books

Science Literacy Indicator (Wenning, 2006)	The Physics Textbook				Average (%)
	Book A (16 pages)		Book B (20 pages)		
	∑ Statement	(%)	∑ Statement	(%)	
Science nomenclature	14	20	8	15	17.5
Intellectual process skills	26	37	28	54	45.5
Rules of scientific evidence	6	9	4	8	8,5
Postulate of science	16	23	8	15	19
Scientific disposition	8	11	4	8	9.5
Total	70	100	52	100	100

creative and logical, as well as honest and trustworthy. Book A and Book B was different only about 3% on this indicator. In general, the two books have given indicators of scientific disposition to the students.

The last indicator that appears with the lowest percentage is the rules of scientific evidence by 8.5%. The rules of scientific evidence is treating the problems faced by students. The problems in the textbooks can be either a case study or the problem in exploratory activities. There are four criterias in this indicator which were analyzed in both textbooks. Indicators rules of scientific evidence has the lowest percentage since the second book presents many descriptions science knowledge without involving students about how the knowledge is acquired.

Based on the analysis, the second science literacy indicator is the highest appearance on both of the book. The second science literacy indicator on Book A does not relate to a mathematical equation, but only the physical concepts. On Book B, the second science literacy indicator is related to physical concepts which is going to be learned then relate it to applicable mathematical equation. For example the indicator to analyze the formation of images on a magnifying glass, the Book B associates images as a media observation to introduce the logic of mathematical equations of the obtained magnification image. The Book A invites students to analyze about the light rays in the process of forming an image without defining how the magnification can be obtained.

Thus, it can be concluded that Book A has more science literacy indicators than Book B. However, the second indicator, intellectual process skills in Book B is more comprehensive. Through Book A, skill of science literacy can be trained more optimal, but linkages with the concept of mathematical equations will be more easily found in Book B.

The science textbook is a very important component in learning science in school (Chiappetta & Fillman, 2007). The students look the subject through the textbook that they read. Some Physics textbooks still give the mathematical equations without explaining it is obtained through the physical state of a scientific phenomenon. Therefore, the contents of physics teaching materials used need to be designed to improve students' perceptions and the logic of how a mathematical equation is applied and obtained.

One of the effort can be done is to engage students in exploratory activities. Exploratory activities will require students to track down a problem or issue of certain phenomena using complex skills, either using the mathematical and non mathematical approach. Exploratory activities will encourage students to be more critical and active, not just directly accept the concepts presented in textbooks. Through these activities, the learning processes invite students to observe, predict, investigate, analyze and conclude. The kind of activities that can be done such as experimental activities, observation, literature study, as well as role play.

Those points are suitable with the objective of science literacy by Holbrook & Rannikmae (2009) that the excellent scientific literacy is taught with the view that "teaching through science" not "science through teaching". Currently, the direction in learning science emphasizes on the importance of scientific literacy as the ability to be owned by the students after learning (Fives, Huebner, Birnbaum, & Nicolich, 2014). There are many researches on students' science literacy assessment which has been done (for example Bybee, 2008; Wenning, 2006, 2007; Fives et al, 2014). Therefore, the learning process in school should support the development of students science literacy

skills and it can be done optimally by providing good physics textbook to encourage student to do many kind of activities such as experimental activities, observation, literature study, as well as role play.

CONCLUSION

The emerging of science literacy indicators from the two textbooks sequentially are the intellectual process skill of 45.5%, postulate of science by 19%, science nomenclature of 17.5%, scientific disposition by 9%, and rules of scientific evidence 8.5%.

The science literacy indicators from Book A appears more often than Book B. Book A contains more activities of investigation than Book B, but Book B is linking the second indicator, the intellectual process skills with the more comprehensive concepts and mathematical equations.

The results of this study can be used by teachers of physics community to consider the textbook to be used. The textbooks used must contain with indicators of scientific literacy and have clear thinking groove in teaching physics concept. The advantages and disadvantages of each analyzed textbooks can be used as a further background study for developing the good quality teaching material of physics-based scientific literacy.

REFERENCES

Agnes, D., Kaniawati, I., & Danawan, A. (2015). Analisis Deskriptif Tes Tiga Tingkat Materi Optika Geometri dan Alat Optik. *Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains 2015*. Bandung: Prodi Magister Pengajaran Fisika, FMIPA, ITB.

Arief, M. K., Utari, S. (2015). Implementation of Levels of Inquiry on Science Learning to Improve Junior High School Student's Scientific Literacy. *Jurnal Pendidikan Fisika Indonesia,* 11 (2), 117-125.

Bybee, R. W. (2008). Scientific literacy, environmental issues, and PISA 2006: The 2008 Paul F-Brandwein lecture. *Journal of Science Education and Technology*, 17, 566-585.

Chiappetta, E. L., Fillman, D. A. (2007). Analysis of Five High School Biology Textbooks Used in Uneted States for Inclusion of the Nature of Sciences. *International Journal of Science Education*, 29 (15), 1847-1868.

Etkina, E., Heuvelen, A. V., White-Brahmia, S., Brookes, D. T., Gentile, M., Murthy, S., Rosengrant, D., Warren, A. (2006). Scientific Abilities and Their Assessment. *Physics Education Research*, 2, 020103.

Fives, H., Huebner, W., Birnbaum, A., Nicolich, M. (2014). Developing a Measure of Scientific Literacy for Middle School Students. Science Education, 98(4), 549-580.

Gormally, C., Brickman, P., Lutz, M. (2012). Developing a Test of Scientific Literacy Skills (TOSLS): Measuring Undergraduates' Evaluation of Scientific Information and Arguments. *CBE-Life Sciences Education*, 11, 364-377.

Holbrook, J. & Rannikmae, M. (2009). The Meaning of Scientific Literacy. *International Journal of Environmental and Science Education,* 4(3), 275-288.

Hurd, P. D. (1997). Scientific Literacy: New Minds for a Changing World. *Science Education*, 82, 407-416.

Karelina, A. & Etkina, E. (2007). Acting like a physicist: Student approach study to experimental design. *Physics Education Research*, 3, 020106.

Kuhn, D. (2010). Teaching and learning science as argument. *Science Education*, 94(5), 810 –824.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, 47(4), 474 –496.

Morris, B. J., Masnick, A. M., Baker, K., Junglen, A. (2015). An Analysis of Data Activities and Instructional Supports in Middle School Science Textbooks. *International Journal of Science Education*, 37 (16), 2708-2720.

Organisation for Economic Cooperation and Develepment. (2016). PISA 2015 Results in Focus. Retrieved from https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf

Rusilowati, A., Nugroho, S. E., Susilowati, S. M. E. (2016). Development of Science TextBook Based on Scientific Literacy For Secondary School. *Jurnal Pendidikan Fisika Indonesia*, 12 (2), 98-105.

Suniati, N. M. S., Sadia, W., Suhandana, A. (2013). Pengaruh Implementasi Pembelajaran Kontekstual Berbantuan Multimedia Interaktif Terhadap Penurunan Miskonsepsi. *e-Journal Program Pascasarjana Universitas Pendidikan Ganesha,* 4.

Wenning, C. J. (2006). A framework for teaching the nature of science. *Journal of Physics Teacher Education*, 3(3).

Wenning, C. J. (2007). Assessing Inquiry Skills as Component of Scientific Literacy. *Journal of Physics Teacher Education*, 4(2), 21-24.

Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. *Developmental Review,* 27(2), 172 –223.