

THE ANALYSIS OF PRE-SERVICE PHYSICS TEACHERS IN SCIENTIFIC LITERACY: FOCUS ON THE COMPETENCE AND KNOWLEDGE ASPECTS

by Agus Pahrudin

Submission date: 16-Mar-2019 05:42PM (UTC+0700)

Submission ID: 1094298090

File name: FIX_REVISI_5_MARET.pdf (414.2K)

Word count: 6647

Character count: 37672



THE ANALYSIS OF PRE-SERVICE PHYSICS TEACHERS IN SCIENTIFIC LITERACY: FOCUS ON THE COMPETENCE AND KNOWLEDGE ASPECTS

A. Pahrudin^{1*}, Irwandani², E. Triyana³, Y. Oktarisa⁴, C. Anwar⁵^{1,2,3,5}Faculty of Education and Teacher Training, Universitas Islam Negeri Raden Intan Lampung, Indonesia⁴Department of Science Education, University of Copenhagen, Denmark

DOI:

Accepted: Approved: Published:

ABSTRACT

The role of scientific and technological knowledge is needed to compete in the era of industrial revolution 4.0. One of the roles of scientific knowledge is by analyzing the scientific literacy ability of pre-service physics teachers. This research aims to find out how far the achievement of scientific literacy possesses by current pre-service physics teachers. The measurement of scientific literacy encompasses two aspects, namely competence and knowledge aspects. The subjects of this research were thirty (30) pre-service physics teachers from Universitas Islam Negeri Raden Intan Lampung (State Islamic University Raden Intan Lampung) selected by using purposive sampling. The research instrument used in this research was a test of scientific literacy ability. The data analysis techniques used consisted of data reduction, data display, and verification. The result of the study indicated that some indicators of scientific literacy skills need to be improved. The results showed that there were differences in the achievement of literacy skills in each indicator. In the aspect of competence, the indicator of Indicating Scientific Issues aspects of competence covers identifying issues scientifically (poor), explaining phenomena scientifically (good), using scientific evidence (poor). The aspects of knowledge: content knowledge (good), procedural knowledge (poor), epistemic knowledge (moderate). Overall the scientific literacy ability of the pre-service physics teachers has not shown satisfying results. It can be concluded that pre-service physics teachers' literacy ability should be improved. A special strategy is needed that can improve the scientific literacy skills of prospective physics teachers so that the students who will teach in the future also could have good scientific literacy skills.

© 2019 Science Education Study Program FMIPA UNNES Semarang

Keywords: pre-service teachers, physics, scientific literacy

INTRODUCTION

Currently, we are facing we have entered an era of digitalization known as the industrial revolution 4.0 (Aldianto, Mirzanti, Sushandoyo, & Dewi, 2018; Anwar, Saregar, & Widayanti, 2018; Matsun, Ramadhani, & Lestari, 2018; Subekti, Taufiq, Susilo, Ibrohim, & Suwono, 2018). An era in which humans move the nation's economic development has been slowly displaced by mechanical automation and technology digitalization (Buer, Strandhagen, & Chan, 2018; Liao, Deschamps, Loures, & Ramos, 2017; Suwardana, 2017). In order to remain in the global competition, each person is required to have superior competencies and skills (Jatmiko et al., 2018; Yani, Widodo, & Nurohman, 2018). The role of scientific and technological knowledge is needed in this global era in order to improve the competitiveness and

prosperity of a nation in the international environment (Matsun et al., 2018; Ratnasari, Sukarmin, Suparmi, & Harjunowibowo, 2018) because science is the key to the development of Science and Technology (Choerunnisa, Wardani, & Sumarti, 2017).

The development of science and technology has a major influence on the field of education, especially in Indonesia (Bahriah, 2015; Irwandani, Latifah, Asyhari, Muzannur, & Widayanti, 2017; Wulandari & Sholihin, 2016), to balance the rate of development of science and technology, the quality improvement in science learning is one of the challenges that must be faced in the world of education (Subekti et al., 2018). Good education must be able to bring about capable students and pre-service physics teachers, possess the ability to think logically, creatively, able to solve problems, master the

*Correspondence Address

E-mail: agus.pahrudin@radenintan.ac.id

technology, adaptive to the times, and to be literate in science (Abdurrahman, Saregar, & Umam, 2018; Choerunnisa et al., 2017; Isdaryanti, Rachman, Sukestiyarno, Florentinus, & Widodo, 2018; Sulistiyowati, Abdurrahman, & Jalmo, 2018).

To be literate in science is also known as scientific literacy (Bahriah, 2015). One program that measures scientific literacy in the world is the Program for International Student Assessment (PISA). The PISA defines scientific literacy as an individual's capacity to use scientific knowledge, identify questions scientifically, and draw conclusions based on available evidence (Chi, Liu, Wang, & Won Ha, 2018; Diana, 2016; Winata, Cacik, & W., 2016), in order to be able to make decisions about nature and human interaction with nature itself (Nisa', Sudarmin, & Samini, 2015; Nurfaidah, 2017).

Scientific literacy is the main objective of science education (Senturk & Sari, 2018) and is used as an indicator to see the quality of education and

human resources in a country (Winata et al., 2016). Scientific literacy is not only the ability to read and understand science (Griffin & Ramachandran, 2014), but also the ability to understand and apply basic principles of science (Holden, 2015; Nahdiah, Mahdian, & Hamid, 2017). Therefore, scientific literacy ability is important for citizens at various levels of education.

China and South Korea have made scientific literacy as a state program to boost the strengths and skills of science (Gao, He, & Zhang, 2016; Mun et al., 2015; Wu, Zhang, & Zhuang, 2018; Yao & Guo, 2018; Zhu, 2017). When compared with other Asian countries, the literacy ability of Indonesian students is classified as below average (Ariyani, Nayana, Saregar, Yuberti, & Pricilia, 2018; Rosidah & Sunarti, 2017). The average score of scientific literacy of Indonesian students in the PISA study conducted every three years can be seen in the following Table 1.

Table 1. The PISA Score of Indonesian Scientific Literacy in 2000-2015

Year	2000	2003	2006	2009	2012	2015
Score	393	395	393	383	382	403
Ranked	38/41	38/40	50/57	60/65	64/65	62/70

(Ardiansyah, Irwandi, & Murniati, 2016; OECD, 2018)

Based on the scientific literacy scores of students in Indonesia in Table 1, the scores obtained are still very low, and there is no significant increase. Many factors certainly influence the low level of scientific literacy ability of these students. Without prejudice to other factors, the teacher is an essential factor in determining the quality of education as well as being a determinant in the success of scientific literacy abilities of students (Hordatt Gentles, 2018; Rohman, Rusilowati, & Sulhadi, 2017; Titu, Ring-Whalen, Brown, & Hrig, 2018).

Teacher's scientific literacy ability and the emergence of scientific literacy in learning in Indonesia are needed to develop students' literacy ability (Afandi, Junanto, & Afriani, 2016; Asyari & Asyari, 2017). Much like Japan which strongly emphasizes the quality of teachers' competencies to achieve literacy achievements in Trends in the International Mathematics and Science Study (TIMSS) (Diana, 2016).

The quality of science teachers cannot be separated from the process of preparing pre-service science teachers (Fernández, 2018). Pre-service science teachers are expected to have good scientific literacy in order to be able to produce students with scientific literacy insight (Rachmatullah, Roshayanti, Shin, Lee, & Ha, 2018). Therefore, improving the competence of pre-service science teachers, including pre-service physics teachers in scientific literacy ability is important (Rosidah & Sunarti, 2017; Zainab, Wati, & Miriam, 2017).

Preparing pre-service physics teachers who are knowledgeable about scientific literacy is a big

task for higher education in Indonesia (Putra, Widodo, & Jatmiko, 2016). This is in line with the goal of nations in the face of the industrial revolution 4.0, which is to prepare qualified science graduates who can compete globally (Subekti et al., 2018). For this reason, higher education plays an important role in preparing pre-service science teachers including pre-service physics teacher. Based on the argument, assessing the extent of the scientific literacy abilities of current pre-service physics teacher is important.

Previously there were many scientific studies that discussed scientific literacy, including scientific literacy studies at the primary education level (Nurfaidah, 2017), junior high school level (Novili, Utari, Saepuzaman, & Karim, 2017; Wulandari & Sholihin, 2016; Yani et al., 2018), and high school level (Ardiansyah et al., 2016; Rohman et al., 2017). In addition, there are also scientific studies discussed the scientific literacy at the level of higher education, including discussing the initial abilities of students' scientific literacy (Winata et al., 2016), scientific literacy ability for pre-service chemistry teachers (Bahriah, 2015), to the application of learning methods in scientific literacy ability (Gherardini, 2016).

The difference between this research and the previous studies is that this research focuses on scientific literacy ability which covers two aspects of scientific literacy, namely aspects of competency and knowledge for pre-service physics teachers. Both of these aspects are important to determine the scientific literacy skills of pre-service physics teachers. Also, the researchers also analyze the scientific literacy abilities

27 of pre-service physics teachers and present the right steps to obtain appropriate information related to the scientific literacy ability possessed by the pre-service physics teachers. The results of this study can later be used as recommendations for improving the learning process that can improve the scientific literacy skills of pre-service physics teachers especially to face the industrial revolution 4.0 era.

RESEARCH METHODOLOGY

Research Design

This research employed a qualitative descriptive method which aimed at describing the scientific literacy ability of pre-service physics teachers based on the aspects of competence and knowledge.

Research Subjects

The population in this research were all 4th-semester students of Physics Education Department, Faculty of Education and Teacher Training, Universitas Islam Negeri Raden 15 an Lampung in the academic year 2017/2018. Purposive sampling was used to determine the sample that consisted of 30

students. After the data were obtained and analyzed, interviews were then conducted to the students with low, medium, and high abilities. This was done to strengthen the results of previous research.

Research Instrument

The instrument used to determine the scientific literacy ability of pre-service physics teacher on the aspects of competence and knowledge was in the form of scientific literacy ability test. The instrument used in this study was in the form of a description and was the result of the adaptation of existing scientific literacy instruments. From the existing instruments, the researchers then re-develop it by constructing 20 items in accordance with the indicators to be achieved. The instrument was then validated in terms of content and language by involving the help of 3 experts (expert judgment). From the results of the second validation, the expert stated that 15 questions were declared valid in terms of content and language so that they were fit to be used for research. The item distribution of the test is presented in Table 2.

Table 2. Distribution of Science Literacy Questions

Aspects of Scientific Literacy	Indicator	Number of Questions
Competency	Identifying issues scientifically	1, 2, 8, 10, 11, 13
	Explaining phenomenon scientifically	3, 4, 6, 9, 14
	Using scientific evidence	5, 7, 12, 15
Knowledge	Content Knowledge	1, 2, 9, 13, 14
	Procedural Knowledge	4, 8, 10, 11
	Epistemic Knowledge	3, 5, 6, 7, 12, 15

Table 2 is the distribution of scientific literacy questions based on predetermined scientific literacy indicators. Each question contains indicators on aspects of competence and knowledge. The problems given were in the form of an essay question that covered the sound waves material.

The following is an example of the scientific literacy instrument used in this study. The instrument of this research has been translated from the original language, Indonesian.

Read the following article and answer questions No. 3 & 4

Bats and Elephants




Figure 2. A group of elephants (left) and bats at night (right)

Although they have different life habits, elephants and bats are similar in which they have the ability to emit and detect sounds that humans cannot hear. Sound waves that elephants can detect between 1 to 20 Hz where the air and soil act as medium. Elephants possess extraordinary hearing abilities and can emit specific sounds called infrasonic that can be heard by other elephants within a radius of 10 km. This sound is a notification of danger, greetings, location of food, excitement, fear, and more. This sound can also help males find the location of females especially during the mating season.

Unlike elephants, bats are animals that can fly in the dark. They do not use eyes to see in the dark but by using high-frequency sound called ultrasonic. When flying, the bat emits sound waves to determine how far the body is from objects, which is why they will not hit the wall or objects before them even in the dark. The bat's ultrasonic sound is illustrated by the picture above. The frequency limit that can be heard by bats is 3,000 Hz up to 120,000 Hz. That frequency is far above the audiosonic sound frequency that can be heard by humans which is between 20 Hz up to 20,000 Hz.

The principle of distance measurement by bats has been used in measurements of ocean depth using ultrasonic waves emitted by a transmitter and receiver (Fathometer). By knowing the sound velocity in seawater, and the time of receiving waves by a Fathometer, the depth of the sea can be calculated.

3. Explain the method of measuring distance using sound waves by bats!

4. The principle of measuring the depth of the sea with a Fathometer is illustrated by the following figure.



Explain the procedure for measuring the depth of the sea based on the image and complete with the equation or calculation!

Figure 1. Example of a Science Literacy Instrument Used

In addition to the question of the instruments, researchers made interview instruments that contained questions to express students' scientific literacy skills after solving the problem. Interviews were carried out structurally to reveal the extent of students' scientific literacy skills. Before being used, the interview instrument was first validated by the expert.

Research Procedure

This research was conducted by giving a test of scientific literacy ability to pre-service physics teachers. Fifteen questions were given and must be finished within 2 x 45 minutes.

Data Analysis

The data analysis used in this research was the model provided by Milles and Huberman. The flow of data analysis is shown in Figure 1.

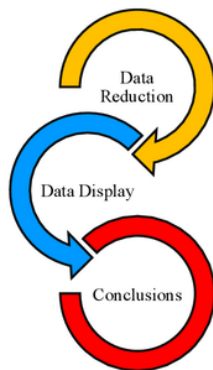


Figure 2. Chart of Qualitative Data Analysis Model by Milles and Huberman

Figure 1 is a qualitative data analysis chart of the Milles and Huberman model used in this research which includes data reduction, data presentation, and conclusion drawing (Rohman et al., 2017; Sugiyono, 2014). The model proposed by Milles and Huberman can help to facilitate the researchers in analyzing research data. In this study, this model reduces the data and the presentation into a quantitative form. In order that quantitative can be more meaningful, it is turned into qualitative in analyzing the data and presenting the data. The data obtained were analyzed by calculating the percentage of achievement of the scientific literacy ability of pre-service physics teachers on the aspects of competence and knowledge.

The percentage of scientific literacy ability achievement was interpreted descriptively based on the criteria of scientific literacy abilities shown in Table 3.

Table 3. Criteria of Scientific Literacy Ability

Persentase (%)	Kriteria
$80 < \% \leq 100$	Very Good
$66 < \% \leq 79$	Good
$56 < \% \leq 65$	Moderate
$40 < \% \leq 55$	Poor
$0 < \% \leq 39$	Very Poor

(Novili et al., 2017)

Criteria of scientific literacy ability in Table 3 were used to see the achievement of scientific literacy of the pre-service physics teachers. The percentage of scientific literacy abilities was then interpreted descriptively based on the criteria of scientific literacy abilities. The data obtained was analyzed by every aspect of scientific literacy and discussed in depth so that a conclusion can be obtained.

RESULTS AND DISCUSSION

After the test, the score (x) obtained was then compared to the average score (\bar{x}) and standard deviation (S). These values are then grouped into three categories of scientific literacy abilities with the criteria as in Table 4.

Table 4. Categories of Scientific Literacy Ability

Categories	Description
High	$x \geq \bar{x} + S$
Moderate	$\bar{x} - S \leq x \leq \bar{x} + S$
Low	$x \leq \bar{x} - S$

Based on the categorization in Table 4, the scientific literacy ability of the pre-service physics teachers of Universitas Islam Negeri Raden Intan Lampung can be mapped in Table 5.

Table 5. Distribution of Scientific Literacy Ability of the Pre-service Physics Teachers

Categories	N	%
High	6	20.00 %
Moderate	19	63.33 %
Low	5	16.67 %
Total	30	100 %

In this study, the data analysis used was qualitative descriptive. In order to make it easier for the researchers to retrieve data, the strategy by Milles and Huberman's was used (Figure 1). According to Milles and Huberman, data analysis activities in qualitative research were conducted interactively in each stage of the research (Rohman et al., 2017).

The first stage carried out in analyzing the data of scientific literacy skills of pre-service physics teacher was data reduction. The complex and not meaningful data on the results of tests on scientific literacy ability was reduced based on the research objectives to be achieved. In this case, the researcher

analyzed the answers of each physics teacher candidate based on the existing assessment rubric 4, so that more meaningful data could be produced in the form of the score of scientific literacy ability test results. The following is an analysis of two

scientific literacy ability questions of the high category student (represented by Subject 1), moderate (represented by Subject 2) and low (represented by Subject 3).

Table 6. Analysis of Pre-service Physics Teacher Answers Based on the Categories of Scientific Literacy Ability

No	Item Description	The Analysis of the Answer of Subject 1 (High Category)	The Analysis of the Answer of Subject 2 (Moderate Category)	The Analysis of the Answer of Subject 3 (Low Category)
3	In 13 question, the students were expected to be able to explain scientific phenomena related to sound wave propagation (Maximum Score 4).	Based on the answer given, Subject 1 got 2 points. Subject 1 was able to answer the question correctly, but he did not provide a detailed answer and the arguments given were not explained scientifically based on the existing phenomena.	Based on the answer given, Subject 2 only got 1 point. This was because Subject 2 was not able to provide answers in detail and the arguments given were not explained scientifically based on existing phenomena.	Based on the answer given, Subject 3 only got 1 point. Based on the analysis of answers, Subject 3 was unable to provide detailed answers and could not explain the existing phenomena scientifically.
4	In 13 question, the students were expected to be able to analyze the measurement procedure on a fathometer (Maximum Score 8).	Based on the answer, Subject 1 scored 3 out of 8 because of Subject 1. Couldn't explain the measurement procedure on a fathometer in detail. Subject 1 did not analyze the answer scientifically; Subject 1 was unable to identify the calculation variables in the measurement using the fathometer as instructed.	Based on the answer given, only subject 2 obtained 2 points. This was because Subject 2 was unable to explain the measurement procedure on the fathometer in detail. Subject 2 did not analyze the answers scientifically, and he did not identify the calculation variables in the measurement of the fathometer as expected in the problem.	Based on the answers, Subject 3 obtained 0 points. Subject 3 did not fill in at all the question number 4. So it can be concluded that Subject 3 was not able to identify the calculation variables in the measurement using a fathometer.

After the data on the results of the scientific literacy ability test were reduced, the next data analysis stage was data display. Data reduction was made by adjusting the criteria of the assessment of each item with the results of student literacy ability in solving the problem. The analysis of the result of the interview of the representative data was done to confirm the validity of the data generated. After

obtaining valid and consistent data, the research conclusions will be produced.

Data analysis of scientific literacy ability was compared with the results of interviews. This was done to test the validity of the data in this study. The following are the results of data triangulation that has been done on the research subject data

Table. 7 The Data Triangulation of Students' Literacy Ability

Research Subject	Results of the Scientific Literacy Ability Test	Result of Interview
Subject 1 (High Literacy Ability)	Subject 1 has the best scientific literacy ability compared to other subjects. The test results showed that Subject 1 was able to solve the questions given well. In general, subject 1 can solve questions correctly and be able to answer in detail according to his understanding.	Based on the results of the interview, researchers can confirm that Subject 1 did not encounter many difficulties in solving the problem of scientific literacy. Subject 1 argues that the problems he is working on are related to phenomena that often occur in life. So that in answering Subject 1 can associate with the understanding he has. Although it is admitted that there are many difficult questions to answer, Subject 1 still tries to solve them.
Subject 2 (Moderate)	Subject 2 has moderate scientific literacy. Based on the tests given, Subject 2 was quite	Based on the results of the interview, Subject 2 provided recognition in solving

Research Subject	Results of the Scientific Literacy Ability Test	Result of Interview
Literacy Ability)	able to solve the questions given even though there were still some questions was unable to be resolved. In solving the questions given, Subject 2 was quite capable of answering questions correctly and was able to answer in detail according to his understanding. However, some of the questions found were still not resolved properly.	the problem of scientific literacy. There were several questions that he was not able to complete properly. Subject 2 still found some difficult question. It might be caused by Subject 2 was less able to understand the theories that underlie these problems.
Subject 3 (Low Literacy Ability)	Subject 3 has low scientific literacy ability. From the scientific literacy tests given, subject 3 was not able to solve the questions correctly and in detail. Subject 3 was unable to do until they were finished. In fact, some other questions couldn't be answered at all by Subject 3.	Based on the results of the interview, the researchers found that Subject 3 experienced difficulties in solving the problem of scientific literacy given. It might be caused by subject 3 did not fully understand the concepts underlying the problem. In addition, Subject 3 admitted that he was still unfamiliar with the type of question given, so he encountered many difficulties in answering it.

Based on the score of the scientific literacy ability test, the achievement of scientific literacy ability of the pre-service physics teachers at

Universitas Islam Negeri Raden Intan Lampung can be seen in Table 8.

Table 8. The Percentage of Scientific Literacy Ability for each Indicator of Competence and Knowledge Aspects

Aspects of Science Literacy	Indicators of Scientific Literacy Aspects	Percentage (%)	Criteria
Competency aspect	Identifying issues scientifically	51	Poor
	Explaining phenomena scientifically	73	Good
	Using scientific evidence	54	Poor
Knowledge aspect	Content Knowledge	77	Good
	Procedural Knowledge	42	Poor
	Epistemic Knowledge	64	Moderate

After the data on scientific literacy skills are presented and obtained in the form of a percentage, the next stage of data analysis is to conclude from the data presented. Based on the percentage criteria in Table 3, it was found that the scientific literacy abilities of pre-service physics teachers at Universitas Islam Negeri Raden Intan Lampung on the aspect of competence is 59 % and the knowledge aspect is 61 % so that the abilities can be categorized as moderate.

Based on the results obtained in Table 8, it can be shown that the results of literacy abilities obtained are not very encouraging. There are three indicators belong to the poor category, one moderate category, and two indicators are in a good category. None of the indicators belongs to a very good category. The competency aspect of the pre-service physics teachers is in the good category in explaining phenomena scientifically while the scientific literacy ability in identifying issues scientifically and using scientific evidence is in the poor category.

In identifying scientific questions, the pre-service physics teachers are required to be able to recognize questions that might be scientifically investigated in a given situation, find information,

identify keywords, and recognize features of scientific inquiry, such as what things should be compared, what variables should be changed and controlled and what additional information is needed so that relevant data can be collected (Wulandari & Sholihin, 2016). In this indicator, pre-service physics teachers have not been able to investigate the question scientifically, so that they have not been able to provide relevant answers. This is why the scientific literacy ability of pre-service physics teachers on these indicators is still relatively poor. Identifying scientific issues is a basic thing that pre-service physics teachers must understand before identifying further literacy. This is in line with several studies (Nehru & Syarkowi, 2017; Rahayu, 2015).

The next scientific literacy ability indicator that belongs to the poor category is using scientific evidence. This aspect requires a student to be able to interpret scientific findings as evidence to make a conclusion and communicate the reasons behind the conclusion (Novili et al., 2017). In this indicator, the pre-service physics teachers were not able to provide scientific evidence for resolving problems in scientific literacy issues. This is proven by the analysis of the answers to the questions. Pre-service teachers generally answered with short and less

argumentative answers. The answers given were also not accompanied by corroborating concrete evidence. The ability to argue with scientific evidence is an indicator of a teacher's ability to teach in the classroom (Rahayu, 2015). Physics teachers who can explain with scientific evidence will be able to brighten up the atmosphere of the discussion (Alan Deta, 2017). However, this ability still needs to be improved because it is included in poor category.

On the indicator of explaining phenomena scientifically, the pre-service physics teachers were able to solve the problems based on existing scientific phenomena. In solving the problems, the pre-service physics teachers were able to connect scientific concepts and applications quite well. This is in line with the research of Noviliet al. which states that explaining phenomena scientifically will be easy to do because scientific phenomena are often found in everyday life (Novili et al., 2017). Therefore, pre-service physics teachers had no difficulty in solving problems on this indicator.

The competency of the pre-service physics teachers' scientific literacy ability has been discussed, so what about their scientific literacy knowledge? In Table 26 it is found that the aspect of scientific literacy knowledge of the pre-service physics teachers belongs to the good category, whereas the epistemic knowledge indicator belongs to the moderate category. The indicators of procedural knowledge obtained the lowest percentage which belongs to the poor category. The three indicators of scientific literacy knowledge are in different categories because the level of knowledge difficulty is different.

The content knowledge emphasizes real life (Novili et al., 2017). In this indicator, the pre-service physics teachers already have good content knowledge. This is evidenced by the good process of resolving the questions related to scientific concepts in real life. This is in line with the research of Novili et al., that claim a person has good content knowledge when he is able to uncover investigations related to cases given in accordance with real life (Novili et al., 2017).

The aspect of procedural knowledge is related to the ability to explore knowledge mainly in terms of identifying experimental variables. Scientific literacy ability of the pre-service physics teachers on this indicator belongs to the very poor category. The lack of scientific literacy ability on this indicator is caused by the inability to identify experimental variables and explore their knowledge. This can be seen through the lack of their ability on this indicator. This result is similar to the research by Winata et al., that the lack of someone's scientific literacy ability is caused by the inability to communicate the results of the experiment in writing (Winata et al., 2016).

The aspect of epistemic knowledge is related to the identification of scientific aspects, justifying data, and providing arguments scientifically. Scientific literacy ability of the pre-service physics teachers on this indicator is already good. This is

because pre-service physics teachers were able to provide good scientific arguments when solving problems.

Based on the results discussed in this research, several aspects of science must be increased by pre-service physics teachers so that their achievement of scientific literacy abilities could be eased. One of the things that can be done by the pre-service physics teachers is to get used to solving physics problems in the matter of scientific literacy so that they are accustomed to solving physical problems in the matter of scientific literacy. The increase on the teachers' scientific literacy ability could provide opportunities to improve students' scientific literacy.

In addition, the scientific literacy skills improvement of the pre-service physics teachers will certainly support them in facing the 4.0 industrial revolution, because the 4.0 industrial revolution is a development of the integration of science and technology. So, the scientific literacy skills are very important to be improved so that the pre-service physics teachers can be ready to compete when they graduate later.

Increasing scientific literacy skills of pre-service physics teachers will certainly support them in facing the industrial revolution 4.0 because this is a development of the integration of science and technology (Ibda, 2018). Such integration can have positive or negative impacts. To reduce the negative impacts (Crnjac, Veža, & Banduka, 2017; Liao, Loures, Deschamps, Brezinski, & Venâncio, 2018; Reuters & DinarStandard, 2014; Saregar et al., 2018), each Education Institution needs to implement three pillars of literacy, reading, writing, and archiving. The three pillars of literacy can be applied through data literacy, technology literacy, and human resource literacy. Data literacy can provide valid information (Subekti et al., 2018), technology literacy can publish information correctly, and literacy of human resources can produce generations who are literate in data literacy and technology. Literacy will be able to answer the challenges of industrial revolution 4.0 (Ahmad, 2018), especially in science learning that always interacts with everyday life (Subekti et al., 2018). So, science literacy skills are very important to be improved so that pre-service physics teachers can be ready to compete when they graduate later.

10 CONCLUSIONS AND SUGGESTIONS

Based on the results of data analysis and discussion, it can be concluded that, overall, the scientific literacy ability of the pre-service physics teachers at Raden Intan State Islamic University Lampung both on the aspects of competence and the aspects of knowledge. The aspects of competence cover identifying issues scientifically (poor), explaining phenomena scientifically (good), using scientific evidence (poor) and the aspects of knowledge which cover the content Knowledge (good), procedural knowledge (poor), epistemic knowledge (moderate).

The competency aspects of the scientific literacy abilities need to be improved especially on the indicators of problem-solving and using scientific evidence. The indicators of procedural knowledge of the knowledge aspects also need to be improved. The obtained scientific literacy scores indicate that the scientific literacy ability of the pre-service physics teacher is dissatisfactory. Therefore, pre-service physics teachers must increase their scientific literacy ability to be able to become competent science educators and able to compete in the industrial revolution era 4.0.

REFERENCES

- Abdurrahman, A., Saregar, A., & Umam, R. (2018). The Effect of Feedback as Soft Scaffolding on Ongoing Assessment Toward the Quantum Physics Concept Mastery of the Prospective Physics Teachers. *Jurnal Pendidikan IPA Indonesia*, 7(1), 34–40. <https://doi.org/10.15294/jpii.v6i2.7239>
- Afandi, Junanto, T., & Afriani, R. (2016). Implementasi Digital-Age Literacy dalam Pendidikan Abad 21 Di Indonesia. *Seminar Nasional Pendidikan Sains*, 113–120.
- Ahmad, I. (2018). Proses Pembelajaran Digital dalam Era Revolusi Industri 4.0 Era Disrupsi Teknologi. *Kementerian Riset, Teknologi, Dan Pendidikan Tinggi*, 1–13.
- Alan Deta, U. (2017). Peningkatan Pemahaman Materi Kuantisasi Besaran Fisis Pada Calon Guru Fisika Menggunakan Metode Diskusi Kelas dan Scaffolding. *Jurnal Ilmiah Pendidikan Fisika Al BiRuNi*, 06(2), 201–207. <https://doi.org/10.24042/jipfalbiruni.v6i2.1801>
- Aldianto, L., Mirzanti, I. R., Sushandoyo, D., & Dewi, E. F. (2018). Pengembangan Science dan Technopark dalam Menghadapi Era Industri 4.0. *Jurnal Manajemen Indonesia*, 18(1), 68–76.
- Anwar, C., Saregar, A., & Widayanti. (2018). The Effectiveness of Islamic Religious Education in the Universities: The Effects on the Students' Characters in the Era of Industry 4.0. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 3(1), 77–87. <https://doi.org/10.24042/tadris.v3i1.2162>
- Ardiansyah, A. A. I., Irwandi, D., & Murniati, D. (2016). Analisis Literasi Sains Siswa Kelas XI IPA dada Materi Hukum Dasar Kimia di Jakarta Selatan. *EduChemia (Jurnal Kimia Dan Pendidikan)*, 1(2).
- Ariyani, F., Nayana, T., Saregar, A., Yuberti, Y., & Pricilia, A. (2018). Development of Photonovela with Character Education: As an Alternative of Physics Learning Media. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 7(2), 227. <https://doi.org/10.24042/jipfalbiruni.v7i2.3072>
- Asyhari, A., & Asyhari, A. (2017). Literasi Sains Berbasis Nilai-Nilai Islam dan Budaya Indonesia. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(1), 137. <https://doi.org/10.24042/jipfalbiruni.v6i1.1584>
- Bahriah, E. S. (2015). Peningkatan Literasi Sains Calon Guru Kimia Pada Aspek Konteks Aplikasi dan Proses Sains. *Edusains*, 7(1).
- Buer, S. V., Strandhagen, J. O., & Chan, F. T. S. (2018). The link between Industry 4.0 and lean manufacturing: mapping current research and establishing a research agenda. *International Journal of Production Research*, 56(8), 2924–2940. <https://doi.org/10.1080/00207543.2018.1442945>
- Chi, S., Liu, X., Wang, Z., & Won Han, S. (2018). Moderation of the effects of scientific inquiry activities on low SES students' PISA 2015 science achievement by school teacher support and disciplinary climate in science classroom across gender. *International Journal of Science Education*, 1–21. <https://doi.org/10.1080/09500693.2018.1476742>
- Choerunnisa, R., Wardani, S., & Sumarti, S. S. (2017). Keefektifan Pendekatan Contextual Teaching Learning dengan Model Pembelajaran Inkuiri terhadap Literasi Sains. *Jurnal Inovasi Pendidikan Kimia*, 11(2).
- Crnjac, M., Veža, I., & Banduka, N. (2017). From Concept to the Introduction of Industry 4.0. *International Journal of Industrial Engineering and Management*, 8(1), 21–30.
- Diana, S. (2016). Pengaruh Penerapan Strategi Peer Assisted Learning (PAL) Terhadap Kemampuan Literasi Sains Mahasiswa dalam Perkuliahan Morfologi Tumbuhan. *Jurnal Pengajaran MIPA*, 21(1), 82–91.
- Fernández, M. B. (2018). Framing Teacher Education: Conceptions of Teaching, Teacher Education, and Justice in Chilean National Policies. *Education Policy Analysis Archives*, 26(34), 1–37. Retrieved from <http://epaa.asu.edu/ojs/>
- Gao, H., He, W., & Zhang, C. (2016). Building scientific literacy in China : achievements and prospects. *Science Bulletin*, 61(11), 871–874. <https://doi.org/10.1007/s11434-016-1076-0>
- Gherardini, M. (2016). Pengaruh Metode Pembelajaran dan Kemampuan Berpikir Kritis terhadap Kemampuan Literasi Sains. *Jurnal Pendidikan Dasar*, 7(2).
- Griffin, K. L., & Ramachandran, H. (2014). Science Education and Information Literacy : A Grass-Roots Effort to Support Science Literacy in Schools. *Science and Technology Libraries*, (October 2014), 37–41. <https://doi.org/10.1080/0194262X.2010.522945>
- Holden, I. I. (2015). Science Literacy and Lifelong Learning in the Classroom : A Measure of Attitudes among University Students. *Journal of Library Administration*, 37–41. <https://doi.org/10.1080/01930821003635002>
- Hordatt Gentles, C. (2018). Reorienting Jamaican

- Teacher Education to Address Sustainability. *Caribbean Quarterly*, 64(1), 149–166. <https://doi.org/10.1080/00086495.2018.1435346>
- Ibda, H. (2018). Penguatan Literasi Baru pada Guru Madrasah Ibtidaiyah dalam Menjawab Tantangan Era Revolusi Industri 4.0. *JRTIE: Journal of Research and Thought of Islamic Education*, 1(1), 1–21.
- Irwandani, Latifah, S., Asyhari, A., Muzannur, & Widayanti. (2017). Modul Digital Interaktif Berbasis Articulate Studio'13 : Pengembangan pada Materi Gerak Melingkar Kelas X. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 06(2), 221–231. <https://doi.org/10.24042/jipfalbiruni.v6i2.1862>
- Isdaryanti, B., Rachman, M., Sukestiyarno, Y. L., Florentinus, T. S., & Widodo, W. (2018). Teachers' performance in science learning management integrated with character education. *Jurnal Pendidikan IPA Indonesia*, 7(1), 9–15. <https://doi.org/10.15294/jpii.v7i1.12887>
- Jatmiko, A., Kartina, Y., Irwandani, I., Fakhri, J., Pricilia, A., & Rahayu, T. (2018). Reading Concept Map-Think Pair Share (Remap-TPS) Learning Model on Cognitive Ability and Scientific Attitude. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 3(2), 183–195. <https://doi.org/10.24042/tadris.v3i2.3184>
- Liao, Y., Deschamps, F., Loures, E. de F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research*, 55(12), 3609–3629. <https://doi.org/10.1080/00207543.2017.1308576>
- Liao, Y., Loures, E. R., Deschamps, F., Brezinski, G., & Venâncio, A. (2018). The Impact of the Fourth Industrial Revolution: a Cross-Country/Region Comparison. *Production*, 28, 1–18. <https://doi.org/10.1590/0103-6513.20180061>
- Matsun, Ramadhani, D., & Lestari, I. (2018). Perancangan Media Pembelajaran Listrik Magnet Berbasis Android di Program Studi Pendidikan Fisika IKIP Pontianak. *Jurnal Pendidikan Informatika Dan Sains*, 7(1), 107–117.
- Mun, K., Shin, N., Lee, H., Kim, S., Choi, K., Choi, S.-Y., & Krajcik, J. S. (2015). Korean Secondary Students' Perception of Scientific Literacy as Global Citizens: Using Global Scientific Literacy Questionnaire. *International Journal of Science Education*, 1–31. <https://doi.org/10.1080/09500693.2015.1045956>
- Nahdiah, L., Mahdian, & Hamid, A. (2017). Pengaruh Model Pembelajaran Peer Led Guided Belajar Siswa pada Materi Hidrolisis Garam Siswa Kelas XI PMIA SMAN 3 Banjarmasin. *Journal of Chemistry and Education*, 1(1).
- Nehru, & Syarkowi, A. (2017). Analisis desain pembelajaran untuk meningkatkan literasi sains berdasarkan profil penalaran ilmiah. *Jurnal Wahana Pendidikan Fisika*, 2(1), 20–24.
- Nisa', A., Sudarmin, & Samini. (2015). Efektivitas Penggunaan Modul Terintegrasi Etnosains dalam Pembelajaran Berbasis Masalah untuk Meningkatkan Literasi Sains Siswa. *Unnes Science Education Journal*, 4(3), 1049–1056.
- Novili, W. I., Utari, S., Saepuzaman, D., & Karim, S. (2017). Penerapan Scientific Approach dalam Upaya Melatihkan Literasi Saintifik dalam Domain Kompetensi dan Domain Pengetahuan Siswa SMP pada Topik Kalor. *Jurnal Penelitian Pembelajaran Fisika*, 8(1).
- Nurfaidah, S. S. (2017). Analisis Aspek Literasi Sains Pada Buku Teks Pelajaran IPA Kelas V SD. *Mimbar Sekolah Dasar*, 4(1), 56–66. <https://doi.org/10.23819/mimbar-sd.v4i1.5585>
- OECD. (2018). *Pisa 2015 Results in Focus*.
- Putra, M. I. S., Widodo, W., & Jatmiko, B. (2016). The Development of Guided Inquiry Science Learning Materials to Improve Science Literacy Skill of Prospective MI Teachers. *Jurnal Pendidikan IPA Indonesia*, 5(1), 83–93. <https://doi.org/10.15294/jpii.v5i1.5794>
- Rachmatullah, A., Roshayanti, F., Shin, S., Lee, J., & Ha, M. (2018). The Secondary-Student Science Learning Motivation in Korea and Indonesia The Science Learning Motivation and the Roles of Educational Level and Gender in its. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(7), 3123–3141.
- Rahayu, S. (2015). Meningkatkan Profesionalisme Guru Dalam Mewujudkan Literasi Sains Siswa Melalui Pembelajaran Kimia / Ipa Berkonteks Isu-Isu Sosiosaintifik. *Semnas Pendidikan Kimia & Sains Kimia Di Fakultas Pendidikan MIPA FKIP Universitas Negeri Cendana*, 1–16. Retrieved from <https://www.researchgate.net/publication/283568309%0AMENINGKATKAN>
- Ratnasari, D., Sukarmin, S., Suparmi, S., & Harjunowibowo, D. (2018). Analysis of science process skills of summative test items in physics of grade X in Surakarta. *Jurnal Pendidikan IPA Indonesia*, 7(1), 41–47. <https://doi.org/10.15294/jpii.v7i1.10439>
- Reuters, T., & DinarStandard. (2014). State of the Global Islamic Economy 2014-2015 Report. Dubai the Capital of Islamic Economy.
- Rohman, S., Rusilowati, A., & Sulhadi. (2017). Analisis Pembelajaran Fisika Kelas X SMA Negeri di Kota Cirebon Berdasarkan Literasi Sains. *Physics Communication*, 1(2).
- Rosidah, F. E., & Sunarti, T. (2017). Pengembangan Tes Literasi Sains pada Materi Kalor di SMA Negeri 5 Surabaya", *Jurnal Inovasi Pendidikan Fisika. Jurnal Inovasi Pendidikan Fisika*, 6(3).
- Saregar, A., Irwandani, Abdurrahman, Parmin,

- Septiana, S., Diani, R., ... Sagala, R. (2018). Temperature and Heat Learning Through SSCS Model with Scaffolding: Impact on Students' Critical Thinking Ability To cite this article: Saregar, A., Septiana, I., Septiana, A., Septiana, P., Septiana, S., Diani, R., & Sagala, R. (2018). *Journal for the Education of Gifted Young*, 6(September).
- Senturk, C., & Sari, H. (2018). Investigation of the Contribution of Differentiated Instruction into Science Literacy. *Hipatia Press*, 7(2), 197–237. <https://doi.org/10.17583/qre.2018.3383>
- Subekti, H., Taufiq, M., Susilo, H., Ibrohim, & Suwono, H. (2018). Mengembangkan Literasi Informasi Melalui Belajar Berbasis Kehidupan Terintegrasi STEM untuk Menyiapkan Calon Guru Sains dalam Menghadapi Era Revolusi Industri 4.0: Review Literatur. *Education and Human Development Journal*, 3(1), 81–90.
- Sugiyono. (2014). *Metode Penelitian Kuantitatif Kualitatif dan R & D*. Bandung: Alfabeta.
- Sulistiyowati, S., Abdurrahman, A., & Jalmo, T. (2018). The Effect of STEM-Based Worksheet on Students' Science Literacy. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 3(1), 89–96. <https://doi.org/10.24042/tadris.v3i1.2141>
- Suwardana, H. (2017). Revolusi Industri 4.0 Berbasis Revolusi Mental. *JATI UNIK*, 1(2), 102–110.
- Titu, P., Ring-Whalen, E. A., Brown, J. C., & Roehrig, G. H. (2018). Exploring Changes in Science Teachers' Attitudes Toward Culturally Diverse Students During an Equity-Focused Course. *Journal of Science Teacher Education*, 29(5), 1–19. <https://doi.org/10.1080/1046560X.2018.1461006>
- Winata, A., Cacik, S., & W., I. S. R. (2016). Analisis Kemampuan Awal Literasi Sains Mahasiswa pada Konsep IPA. *Education and Human Development Journal*, 01(01).
- Wu, S., Zhang, Y., & Zhuang, Z. (2018). A Systematic Initial Study of Civic Scientific Literacy in China: Cross-National Comparable Results from Scientific Cognition to Sustainable Literacy. *Sustainability*, 10, 2–26. <https://doi.org/10.3390/su10093129>
- Wulandari, N., & Sholihin, H. (2016). Analisis Kemampuan Literasi Sains pada Aspek Pengetahuan dan Kompetensi Sains Siswa SMP pada Materi Kalor. *Edusains*, 8(1), 66–73.
- Yani, L. A. F., Widodo, E., & Nurohman, S. (2018). Pemahaman Nature of Science (NOS) pada Siswa Kelas VIII di SMPN Kota Yogyakarta Ditinjau dari Tingkat Kefavoritan Sekolah. *Jurnal Pendidikan IPA*, 1–6.
- Yao, J., & Guo, Y. (2018). Core competences and scientific literacy: the recent reform of the school science curriculum in China. *International Journal of Science Education*, 1–21. <https://doi.org/10.1080/09500693.2018.1514544>
- Zainab, Wati, M., & Miriam, S. (2017). Pengembangan Instrumen Kognitif Literasi Sains pada Pokok Bahasan Tekanan di Kelas VIII SMP Kota Banjarmasin. *Jurnal Ilmiah Pendidikan Fisika*, 1(3), 114.
- Zhu, X. (2017). The 'Great Leap Forward' of Public Scientific Literacy in China. *Journal of Scientific Temper*, 5(1), 7–20.

THE ANALYSIS OF PRE-SERVICE PHYSICS TEACHERS IN SCIENTIFIC LITERACY: FOCUS ON THE COMPETENCE AND KNOWLEDGE ASPECTS

ORIGINALITY REPORT

12%

SIMILARITY INDEX

5%

INTERNET SOURCES

8%

PUBLICATIONS

2%

STUDENT PAPERS

PRIMARY SOURCES

1

S Diana. "Peer Assisted Learning Strategy for Improving Students' Physiologic Literacy", Journal of Physics: Conference Series, 2017

Publication

2%

2

mafiadoc.com

Internet Source

1%

3

Feral Ogan-Bekiroglu. "Effects of Model-Based Teaching on the Durability of Pre-Service Physics Teachers' Conceptions of Lunar Events", Contributions from Science Education Research, 2007

Publication

1%

4

media.neliti.com

Internet Source

1%

5

dergipark.gov.tr

Internet Source

1%

6

Sebnem, KANDIL INGEC. "Turkish pre-service physics teachers preferred learning styles",

1%

Educational Research and Reviews, 2015.

Publication

7	Encyclopedia of Science Education, 2015. Publication	1 %
8	Submitted to University of New England Student Paper	<1 %
9	Submitted to Universitas Negeri Jakarta Student Paper	<1 %
10	Submitted to Syiah Kuala University Student Paper	<1 %
11	Submitted to Universitas Pendidikan Indonesia Student Paper	<1 %
12	Wynne Harlen. "The Assessment of Scientific Literacy in the OECD/PISA Project", Research in Science Education - Past Present and Future, 2002 Publication	<1 %
13	Shih-Yeh Chen, Shiang-Yao Liu. "Reinforcement of Scientific Literacy through Effective Argumentation on an Energy-related Environmental Issue", Eurasia Journal of Mathematics, Science and Technology Education, 2018 Publication	<1 %
14	Submitted to Universitas Negeri Semarang Student Paper	<1 %

15

"Worldwide Commonalities and Challenges in Information Literacy Research and Practice", Springer Nature America, Inc, 2013

Publication

<1 %

16

ejournal.radenintan.ac.id

Internet Source

<1 %

17

endil Can. "Chapter 17 The Effects of Environment and Family Factors on Pre-Service Science Teachers' Attitudes Towards Educational Technologies (The Case of Muğla University-Turkey)", InTech, 2012

Publication

<1 %

18

jurnaliainpontianak.or.id

Internet Source

<1 %

19

www150.statcan.gc.ca

Internet Source

<1 %

20

Warni, Sunyono, Rosidin. "Measuring metacognitive ability based on science literacy in dynamic electricity topic", Journal of Physics: Conference Series, 2018

Publication

<1 %

21

Aloisius Harso, Jumilah Gago. "Profil Berpikir Kritis IPA Siswa Kelas VIII SMP Negeri di Kota Ende Berdasarkan Prespektif Gender", JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah), 2018

<1 %

22

researcharchive.vuw.ac.nz

Internet Source

<1 %

23

Rizki Zakwandi, Chaerul Rochman, Dindin Nasrudin, Endah Kurnia Yuningsih, Sandijal Putra. "Profil Literasi Fisika Siswa Madrasah Terhadap Mitigasi Bencana Erosi Batang Sinamar", BELAJEA: Jurnal Pendidikan Islam, 2018

Publication

<1 %

24

Haris Rosdianto. "Peningkatan Keterampilan Berpikir Kritis Siswa Melalui Penerapan Model Generative Learning pada Materi Hukum Newton", JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah), 2018

Publication

<1 %

25

www.neliti.com

Internet Source

<1 %

26

Ozcan, Ozgur, and Cem Gercek. "What are the Pre-service Physics Teachers' Opinions about Context Based Approach in Physics Lessons?", Procedia - Social and Behavioral Sciences, 2015.

Publication

<1 %

27

Saprudin Saprudin. "Analisis Kesiapan dan Strategi Monitoring Evaluasi Program

<1 %

Pengembangan Perkuliahan Gelombang dan Optik Berbasis Game", JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah), 2018

Publication

28

Samson Nashon. "Whatever happened to STS? Pre-service physics teachers and the history of quantum mechanics", Science & Education, 04/2008

Publication

<1%

29

Mäntylä, Terhi, and Ari Hämäläinen. "Obtaining Laws Through Quantifying Experiments: Justifications of Pre-service Physics Teachers in the Case of Electric Current, Voltage and Resistance", Science & Education, 2015.

Publication

<1%

Exclude quotes On

Exclude matches Off

Exclude bibliography On