Gender difference and scientific literacy level of secondary student: a study on global warming theme

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Abstract. A study was conducted to measure scientific literacy of lower secondary students in the learning theme of global warming. This survey research involved 112 fifteen-year students who attend the science course at three secondary schools in Bandung. Sampling was done by random sampling method. The scientific literacy of students was measured by using a developed test of science literacy. The test was constructed under PISA framework 2015 and validly used to measure scientific literacy between high and low-achieving students. The finding showed that no significant differences among three competencies of scientific literacy. The average score of each competency was in moderate category. It also revealed that there is no significantly different between male and female students.

1. Introduction

Scientific literacy is a term in science education that becomes an important issue in recent years, though its definition is constantly changing [1]. Paul de Hurt was a person who proposes the term of scientific literacy, defined scientific literacy as how people understand science and apply it directly for his needs in social life [2]. That definition implies that scientific literacy is very important to be mastered by students from an early age, so that students do not only learn science to get the high score at school, but also master the knowledge and skills in facing the real-life problem. Keefe and Copeland [3] said that scientifically literate students will capable to solve problems in their daily social life by applying science content they learned.

The PISA (Program for International Student Assessment) is an international study developed by several countries in the world incorporated in the Organization for Economic Cooperation and Development (OECD). The PISA was developed to assess and compare the ability of 15-year-old students in literacy such as literacy, math literacy, and science literacy in participating countries. Indonesia participated in the international study of PISA since 2000. The OECD countries consider PISA as an important study to get a depiction of scientific literacy of students, as well as the weaknesses and strengths of the students so as to adopt policies for improving the quality of education [4]. It needs to be implemented because the quality of human resources education is the quality of reading literacy, mathematical literacy, and scientific literacy is one of the factors of economic development, a country's development [5].
In fact, the profile of student’s scientific literacy in Indonesia is very apprehensive. This can be seen from the results obtained by Indonesia in the PISA study from year to year. The score of scientific literacy of Indonesian students from 2000, 2003, 2006, 2009 and 2012 respectively are 393, 395, 393, 383, and 382, whilst the average of international literacy score is set at 500 with standard deviation 100. Trend of scientific literacy of Indonesian students' has not shown a significant increase, from 2000 to 2009 obtained by 0.35; 0.35; 0.34; 0.34 [4]. The results of the PISA 2012 show the Indonesian education system is still very far from expectations. Of the 65 participating member States of PISA, Indonesia's education is ranked 64th. Also in the PISA 2015 results from 72 countries, Indonesia ranks 64th out of 72 participating countries. But in PISA 2015 Indonesia experienced a significant increase in student achievement of 22.1 points from the year 2012 that is 382 to 403 in 2015 [6].

These data indirectly provide a picture of students, who are part of human resources in Indonesia who will become the nation's future successor as well as agents of development and development of the state of Indonesia, still have a low quality compared with other countries. Scientific literacy is an important part in improving the quality of human resources so that students are expected to have high competitiveness in competence in this era of globalization and modern times. Therefore, the problem of the low scientific literacy of Indonesian students' cannot be ignored.

Several studies have been conducted related to scientific literacy. Lau [7] has conducted research related to STSE approach (Science, Technology, Society, Environment) which can develop scientific literacy of high school biology students. Seprianto [8] who examines the scientific literacy of high school students in Padang city in PISA-Chemistry reported that scientific literacy of high school students in Padang City is still low compared to the international benchmark, but higher than the national benchmark. Based on previous studies, it was observed that many studies were conducted at the senior high school level, whereas in the PISA study, it was determined that the students who measured their abilities were the first middle school students of 15 years of age [5]. Huang [9] has conducted research on how the effects of student gender, student interest in science learning and school characteristics on literacy skills of 15-year-old students in Canada, but in this study still use data of PISA 2006. Therefore researchers are interested to conduct a research to investigate the scientific literacy level of secondary students by taking the global warming as the learning theme.

2. Method
The method used in this research was a quantitative descriptive. Data was obtained by using the scientific literacy test which was developed previously by Hardinata [10] in the learning theme of global warming and has been adapted to the curriculum of Indonesia. The instrument was constructed to assess the domains of scientific literacy based on framework PISA 2015 and administered to 112 fifteen-year students of three secondary schools at the end of the semester in Bandung. Sampling was taken by using purposive sampling method with rationale that the schools are selected based on accreditation, as written in the PISA 2015 framework, which participating schools on each country is selected from the superior schools representing participating countries [5]. This research described the achievement of scientific literacy of secondary students in science learning of global warming theme by presenting the average score of student’s achievement on each science literacy domains of framework PISA 2015, namely competence, knowledge, and attitude toward science. The scientific literacy data was also analysed and presented based on the gender differences.

3. Result and Discussion
This section presents the achievement of students' scientific literacy obtained. Data shows the comparison of the average scores of student performance on each competence. This section also discussed how the difference between the mean score of students' science literacy based on gender issue.

3.1. Student’s Performance on Scientific Literacy
Based on the PISA framework, students are said to have the ability of science literacy when students are able to master the competence of scientific literacy, knowledge in scientific literacy and attitudes toward
science. The assessed competencies are explaining scientific phenomenon (K1), interpreting data and scientific evidence (K2), and evaluating and designing scientific research (K3). Domain of knowledge in scientific literacy includes content knowledge (P1), process knowledge (P2), and epistemic knowledge (P3), whilst attitudes domain includes interest in science, assessment of science findings, environmental care and others [5]. All of these domains are then packaged using the daily life contexts, in this case is global warming. The results of student’s performance can be seen in figure 1.

![Figure 1](image)

**Figure 1.** Student’s performance on each competence of scientific literacy

Figure 1 shows that the highest average score of competency domain is evaluate and design scientific research (K3), while the lowest is interpreting data and scientific evidence (K2). The average of each competency is 61 for the competence explaining scientific phenomena, 58 for the competence of interpreting data and scientific evidence and 67 for the competence of evaluating and designing scientific research. The total average of 112 secondary students is 62 of 100. The interpretation of the scientific literacy achievement is based on the category proposed by Purwanto as cited in [11] which can be seen in table 1.

| Percentage     | Category    |
|----------------|-------------|
| 86% – 100%     | Very good   |
| 76% – 85%      | Good        |
| 60% – 75%      | Fair        |
| 55% – 59%      | Enough      |
| ≤ 54%          | Poor        |

Based on the categories, the level of scientific literacy of secondary students can be categorized enough with an average gain of 62. The ability to explain scientific phenomenon and evaluate and design research scientific is in enough category, the ability to interpret data and scientific evidence is in the less category. Of the three competences of science literature framework PISA 2015, the average value obtained by students is highest in the third competence (evaluate and design scientific research) with an
average of 67. Competence of evaluating and designing scientific research is the ability of student to assess the critical of findings in emerging science or science. A science-literate student must be able to recognize the relationship between previous researches in conducting a scientific judgment [5].

The results of this study contradict the opinion of Soobard and Rannimae [12] who said that the level of scientific literacy of children in general is still at a functional level and few reach multidimensional levels. According to Bybee [13] individuals at this functional level have the ability to use scientific vocabulary, define true terms in specific activities or situations, memorize the scientific responses of textbooks. While the multidimensional level is where an individual understands the nature of science, the history of science and the role of science in personal, social, and global life, understand how to make connections in disciplines, between science, technology, and society. By definition, this multidimensional level is similar to the competence of scientific literacy evaluating and designing scientific research in which students are required to understand the history of knowledge and make connections between disciplines of knowledge. This finding is also inversely proportional to PISA 2012 data showing the percentage of students’ ability to understand science literacy is 49% at level 1 and 24.7% below level 1 (Fleischman, 2010 cited in [11]. This data shows that Indonesian students are still having difficulties in applying their knowledge and students have only general knowledge that can only be applied to ordinary situations.

This difference may be due to scientific literacy in each competency has a small number of problems and uneven distribution. So it has an effect on the calculation statistics. The problem that assesses K3 amounted to 6 items, K2 as much as 6 items and K1 as many as 18 items about. So the representation of each indicator competence of science literacy on the problem is still less and cause ambiguous on the results of science literacy profile.

3.2. Gender difference on student’s performance

Figure 3 shows that the average of science literacy achievement of male students is slightly higher than that of female students in competency of explaining scientific phenomenon and the competency of evaluating and designing scientific research, while the competence of interpreting data and scientific evidence of male students is lower. Overall scientific literacy of male students’ science is slightly higher than female students, in line with the results of the Ibe and Nwosu [14] studies which found that male students have higher rates than female students at all levels of scientific literacy (nominal, functional, structural and multidimensional level). But overall Ibe and Nwosu also found that the achievement of scientific literacy of male and female students was below the average.
OECD [15] said that differences in cognitive abilities of boys and girls at the same age range of 15 years in each country, male students excel in mathematics and female students excel in the field of reading. There is no significant difference in the ability of science by male and female students, but female students are younger than male students who choose science, technology, engineering, or mathematics (STEM) as a discipline while continuing education.

According to the researchers, the low achievement of scientific literacy is due to the fact that many teachers are not aware of scientific literacy, based on interviews by first author; there are still many teachers who do not know what scientific literacy is, although in fact their learning process has inculcated the competence and attitude of science literacy unconscious. The low achievement of Indonesian student scientific literacy is a blow for the Indonesian people, especially the academicians in Indonesia. It is expected that with the continuous development of education system and curriculum in Indonesia can continue to pump the competence of education owned by Indonesian students. The results of the 2015 PISA survey showed a significant increase in educational attainment in Indonesia by 22.1 points. These results put Indonesia fourth in terms of student achievement as compared to previous survey results in 2012, from 72 countries that took the PISA test. This can be optimism for the academic community in Indonesia to continuously improve the quality of education in Indonesia. But it cannot be denied that the average achievement of Indonesian education is still far below other countries OECD participants. If this average rate is maintained then in 2030 our achievement will be equal to the average OECD country.

4. Conclusion
The achievement of scientific literacy of secondary school students in science lesson of global warming theme is still in enough category, but based on result of PISA 2015 study, it is expected that science literacy competency of students shows improvement to be the beginning of the rise of the Indonesian state so that it can be equivalent to OECD countries. Similarly, the ability of male and female students showed results in adequate categories, and there was no significant difference from the acquisition of scientific literacy of male and female students.

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