Science Literacy: How do High School Students Solve PISA Test Items?

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Abstract. The Programme for International Students Assessment (PISA) does assess students’ science literacy in a real-life contexts and wide variety of situation. Therefore, the results do not provide adequate information for the teacher to excavate students’ science literacy because the range of materials taught at schools depends on the curriculum used. This study aims to investigate the way how junior high school students in Indonesia solve PISA test items. Data was collected by using PISA test items in greenhouse unit employed to 36 students of 9th grade. Students’ answer was analyzed qualitatively for each item based on competence tested in the problem. The way how students answer the problem exhibits their ability in particular competence which is influenced by a number of factors. Those are students’ unfamiliarity with test construction, low performance on reading, low in connecting available information and question, and limitation on expressing their ideas effectively and easy-read. As the effort, selected PISA test items can be used in accordance teaching topic taught to familiarize students with science literacy.

1. Introduction

Science has been brought to society through various aspects of life, such as medicine, communication, transportation, etc. Therefore, it is important to equip every individual with skills related to science that is useful for everyday life, called science literacy skills. Scientific literacy is defined as the ability to engage in science-related issues, and with the ideas of science, as a reflective citizen [1]. Simply put, science literacy is kind of crucial skills for everyday life whatever career do people choose.

Students’ understanding of science literacy is assessed in international scale by Programme for International Students Assessment (PISA). This PISA assesses reading literacy, mathematic literacy, and science literacy. But we just focus on particular science literacy skills in this study. Within this kind of assessment, the construct of the scientific literacy consists of three competencies that will be tested, namely explain phenomenon scientifically, evaluate and design scientific inquiry, and interpret data and evidence scientifically.

A number of countries have participated in the PISA test, including Indonesia. Reviewing Indonesian students achievement on science literacy for several triennial years, from 2003 to 2015, were 395, 393, 383, 382, and 403. Comparing to OECD students’ results were 500, 500, 501, 501, and 493. The data shows that there is a difference of about 100 points between Indonesian students achievement and OECD country students result. It can be inferred that Indonesian students need
valuable effort to catch up on science literacy skill through learning process because common to all science education reforms around the world is emphasis on achieving science literacy by all children before high school graduation [2].

Science education is in charge to promote science literacy, as main purpose instead [3]. Fostering science literacy skills through science learning is kind of challenging where teachers play a major role. To be able to trace the skills of science literacy properly, the teacher must know the ability of science literacy that has been owned by the students. PISA does assess students’ science literacy, but the results do not provide adequate information for teacher to excavate students’ science literacy in certain topic and particular disciplines or subjects because the measurement by PISA is arranged to real-life contexts and in a wide variety of situation, not limited to applied curriculum and whether the knowledge on the test items have been learned. While the range of materials taught at school depends on the curriculum used. It is impossible to ask students elaborating what they know in various contexts if they are in trouble in a contexts close to them. Therefore, this study aims to investigate the way how junior high school students in Indonesia solve PISA test items. Investigating the ability of science literacy that has been owned by the students can be started by giving PISA test items that they have learned the appropriate knowledge.

2. Research Method
This study used a descriptive method which involved 36 students of 9th grade, they were about 13-15 years old. The study was conducted at Islamic boarding school in Tangerang, Indonesia. Data was collected by using PISA test items in particular unit, that was greenhouse, released items in PISA 2006 which science literacy as a major. One of consideration on selecting the unit was students have learned appropriate concepts correspond to items tested. The instrument was obtained from ebook [4] which consists of three problems, but we just used two of them which examine particular competency of recent PISA framework, i.e. interpret data and evidence scientifically. All the problems used have been translated into Indonesian. Students’ answer was analyzed qualitatively based on the way how students solve the problem and competency tested on the item.

3. Result and Discussion
We analyze students’ answer qualitatively to excavate their particular competency required on the problem. Based on recent PISA framework, these two problems used examine the same competency in different level. As mentioned, particular competency tested was “interpret data and evidence scientifically”. The distribution of students’ answer shown in Table 1.

| Problem | Percentage of students |
|---------|------------------------|
|         | Correct | Partial | Incorrect | No answer |
| 1       | 41.7%   | -       | 58.3%     | -         |
| 2       | 11.1%   | 13.9%   | 55.6%     | 19.4%     |

Data in Table 1 indicate that proportion of students providing no credit answer is majority. The most disappointing result refers to problem 2, almost three fourth of total participated students failed to answer the question correctly. What students did in solving each item will be discussed.

**Problem 1:**
Andre concludes from these two graphs that it is certain that the increase in the average temperature of the Earth’s atmosphere is due to the increase in the carbon dioxide emission.

**What is it about the graphs that support André’s conclusion?**

Students were required to understand not only how the data is represented in the two graphs, but also to consider whether this evidence scientifically justifies a given conclusion. In another word,
solving this problem involves a few linked steps. Students identify the data showed on the graphs and relate it with Andre’s conclusion. Therefore, this item is categorized as level 3.

Expected correct answer refers to the increase of both (average) temperature and carbon dioxide emission or positive relationship between temperature and carbon dioxide emission. Those kinds of answer leads to full credit. Among 15 students who solved the problem correctly, four of them showed the ability to interpret data by looking at the similarities of the two graphs and expressed the answer in the form of verbal representation (written) using effective sentences. Sample of students’ answer shown in Figure 1.

![Figure 1. Example of correct answer of problem 1 using effective sentence](image)

Other eleven students have also demonstrated relevant ability but have difficulty in writing their thoughts by using easy-read and understandable sentences. Sample of students’ answer shown in Figure 2 indicate that main point of the answer is the rise in average temperature and the increase in a number of carbon dioxide emissions (which has been marked with red line). These students have already recognized simple pattern in two graphical data sets in support of a conclusion, but they tend to write unnecessary additional sentences that actually can be confusing.

![Figure 2. Example of correct answer of problem 1 using ineffective sentence](image)

Meanwhile, 21 students, more than half of total participants, failed to solve the problem properly. Six of them provided responses that refer to the increase of either the (average) temperature or the carbon dioxide emission. Other three responses refer to temperature and carbon dioxide emission without being clear about the nature of the relationship. Sample of students’ answer can be shown in Figure 3. This figure shows that the students have already demonstrated their ability on interpreting supplied data, but partially. It is not enough to explain what was being asked in the problem. These students got no credit because expected correct answer must manifest relation of both graphs in supporting given conclusion.

![Figure 3. Example of incorrect answer of problem 1 (partial interpretation of data)](image)

While the rest twelve students gave irrelevant answer such as inverting sentences on the question (2 students) or giving the explanation about causes of rising temperatures and carbon dioxide emissions (10 students). Sample of students’ answer shown in Figure 4 illustrated that they did not even use supplied data to answer this question, they just explained what they know about causative factor leading to increasing temperature and carbon dioxide emissions.
Figure 4. Example of incorrect answer of problem 1

The way how students answer this problem indicate that they were not familiar yet with science literacy question, particularly which used data and evidence in answering. Most of them did not even use the data in answering indeed, despite small percentage of them did. Therefore, it is important to familiarize students with science literacy oriented test because an individual must be able to think along with the evidence to be a science-literate [5]. If they are able to solve the problem presented, perhaps they can far transfer into real-life context in solving everyday problems.

**Problem 2**

Another student, Jeanne, disagrees with André’s conclusion. She compares the two graphs and says that some parts of the graphs do not support his conclusion.

Give an example of a part of the graphs that does not support André’s conclusion. Explain your answer.

Similar to the previous problem, this question examines students’ competency on interpreting data and evidence scientifically but in more detail. Therefore, this problem is categorized as level 5. Students were required to analyze irregularity specific part of both graphs which did not provide evidence of conclusion. Correct answer was scored full and partial credit correspond to the way how students solve the problem.

Figure 5. Example of correct answer of problem 2

Sample of students’ answer shown in Figure 5 indicate that they have provided excellent responses by denoting one particular part of the graphs in which the curves are not both descending or both climbing and give a corresponding explanation. Locating specific portion of graphs leads to full credit and there were four students demonstrating this kind of answer. Similar to students’ answer in previous problem, they still wrote unnecessary sentence although the whole answer was still quite understandable.

Another case was applied for students who exemplified either difference between two curves without mentioning a specific period (1 student) or an irregularity in one of the graphs (4 students). They presented incomplete answer obviously but have already demonstrated the ability to interpret data. So that, those kinds of answers were scored in partial credit.

Corresponding to incorrect answer, there were 7 students who did not understand the meaning of the question and giving no answer. And the rest 20 students did not show competency to interpret data and evidence, sample answer shown in Figure 6. It can be seen clearly in the Figure 6 that students provided explanation without using given data in the graphs. Question was presented in verbal (text) but they could not catch what was being asked. Consequently, they failed to associate what they needed to do in solving this problem.
A large number of students experienced incorrect answer of problem two, about 75%. How they answered the question indicated low performance in reading neither information presented on verbal (i.e. text) nor visual (i.e. graph). Reading performance plays a major role in science literacy because students who had higher reading skills also had higher science skills [6]. So, enhancing reading performance might help to increase students’ scientific literacy.

Reviewing student’s ability on expressing their ideas, almost all students gave a few longer explanation. Means, they were familiar enough with questions which required them to elaborate their ideas. But the evidences proved that they had difficulties on expressing their thoughts and transferred the informations from one representation to another, i.e. from graph to text (from visual to verbal). This ability belongs to one of indicator framed by PISA which we focus on this discussion.

Both problems discussed assess similar competency, that is “interpret data and evidence scientifically”. The number of students who provided correct answer on problem two were less than problem one. It is acceptable because problem two examines higher level of difficulty than problem one. But it is unacceptable by looking at the number of students who provide correct answer for each section. The results assert that students need to bone up on their science literacy skills through various resources and media, specifically on learning and teaching activity.

Findings of this study leads us to prepare proper way to guide students on achieving science literacy skills through learning science, especially for junior high school students because assessing scientific literacy during school years does not determine the final level of literacy a person will attain [7]. It absolutely needs continuous process as life-long participation, school and education just as a media to build up potential competencies.

Various methods can be used as an effort to practise students’ science literacy through teaching and learning activity, two of them are instructional methods used and instructional materials chosen which support science literacy competencies. There is strong evidence that the choice of instructional materials has effects that rival in size associated with differences in teacher effectiveness [8]. Instructional materials envelope wide variety resources such as textbooks, workbooks, homework, quizzes, and tests. According to the last three resources mentioned, we suggest the teachers using selected PISA test unit which is appropriate to current science teaching topic taught to familiarize students with science literacy competencies, test items, and how to answer the questions.

4. Conclusion

According to items tested in greenhouse theme, the lacking ability of students in solving PISA test items can be identified based on the way how students answer the questions. A number identified factors are students unfamiliarity with test construction, low in connecting supplied information or evidence and question, limitation on expressing their ideas effectively and easy-read, and low performance in reading. However, this study just limited on greenhouse theme, further research is needed to gain comprehensive evidence.

Everyone is in charge for the availability of supporting tools to help young students achieving proper science literacy skills before school graduation, especially teachers who play a major role in the learning activity. In fact, PISA test units do not bond to any curriculum used at school in certain, but we highly recommend to bring selected PISA test unit into class. A number of released items of science literacy test which were constructed by PISA since first launching are available. By
considering science topic taught, selected items or units which appropriate can be used and adaptated to facilitate students on recognizing science literacy.

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