Inventory of scientific literacy ability of junior high school students based on the evaluation of PISA framework competency criteria

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Abstract. This study aims to interpret the inventory of students' scientific literacy ability. It used systematic review method of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). Descriptive technique based on the percentage of students’ scientific literacy abilities was used to analyse the data. Based on the results of PISA in 2012 and 2015 students’ scientific literacy abilities were in very low level, that is, 41.53%. Specifically, based on the results of the competency aspects of 2012 PISA, the students’ abilities to identify scientific problems and to use scientific evidence were in moderate category, while the students’ abilities to explain the phenomena scientifically were in low category. On the other hand, based on the results of the competency aspects of 2015 and 2018 PISA, the students’ abilities to explain phenomena scientific, to evaluate and design scientifically, and to interpret data and scientific evidence obtained a percentage value of 34.24%, 34.70%, and 40.15% respectively, and all of them were in very low category. The implication of this study is that the students’ overall scientific literacy abilities are still very low. Accordingly, there must be effective measures to improve students’ scientific literacy through a set of learning innovations and strategies.

1. Introduction
Recently, the world, especially the education field focuses on and puts more attention on the skills required in this twenty-first century. The skills needed for this era refer to learning and innovation skills, information, media and technology skills, and life and career skills [1]. The twenty-first-century skills are very closely related to science learning. The National Science Teacher Association recognizes that science education plays a significant role in the achievement of these skills [2]. One very important point in the achievement of the twenty-first-century skills is by increasing scientific literacy in students [3]. Thus, in facing this twenty-first-century challenge, educators are encouraged to develop students' scientific literacy skills in learning.

Science literacy is defined as the ability to use scientific knowledge, identify questions, and draw evidence to understand and help in drawing conclusions about science [4]. Science literacy is a goal to be achieved in a group of science subjects, namely physics, chemistry, and biology. Science literacy must be mastered by students in order to face the challenges of modern society in the future [5]. Someone who has scientific literacy is characterized by having the ability to solve problems using scientific concepts that are obtained, familiar with technology products, making technology products and can make decisions based on the cultural values of society [6].
The Program for International Student Assessment (PISA) is one of the international programs that assess scientific literacy carried out by the Organization for Economic Coordination and Development (OECD). PISA is a study of reading literacy assessment, mathematics literacy, and scientific literacy of children at the age of 12-15 years. The results of PISA Indonesia in 2018 stated that Indonesia declined again to the rank 72 from 78 countries [7]. PISA literacy results in 2018 decreased significantly compared to the PISA 2015 results. The most declining literacy is shown in reading literacy of 371, mathematical literacy of 379, and followed by scientific literacy of 396.

The results of the 2018 scientific literacy become an important reference for educators, especially science teachers in increasing the scientific literacy of students. Many efforts in improving the quality of education, especially those that support the improvement of students' scientific literacy, have been conducted. The low level of literacy ability of Indonesian students can be influenced by several points, such as the curriculum, the use of learning methods and models, learning facilities, and teaching materials [8]. These improvement efforts must be supported by information on the extent to which scientific literacy is being achieved. The profile of students' scientific literacy skills can be a provision for teachers and the government to improve the quality of education in schools.

The problem in this research is the level of the junior high school students' scientific literacy ability based on the evaluation results of the PISA framework competency criteria. In addition, the research objectives based on the problem description that has been presented is to interpret the inventory of junior high school students' scientific literacy abilities based on the evaluation results of the PISA framework competency criteria.

2. Methods
This study uses systematic review research with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) methods. The systematic review was developed by Moher [9]. This research method aims to identify, evaluate, and interpret all relevant research results related to certain research or certain topics [10]. The steps in this method are defining the eligibility criteria, defining information sources, selecting literature, collecting data, and selecting data items. Retrieval of data begins with the search for scientific literacy with Google Scholar and IOP science databases so that as many as 108 articles related to scientific literacy are found. Furthermore, the article is filtered based on predetermined criteria, titles, abstracts, and keywords, so as to produce 53 that fall into the category of titles, abstracts, and keywords as a whole result of scientific literacy. The results of the article are reviewed by summarizing the information needed to answer the profile of junior high school students' scientific literacy skills.

The stages of the research are: (1) Determination of the criteria taken with a maximum term of 9 years publication of the journal, namely from 2012 to 2020, (2) Determination of sources of information used in this study using online searches with Google Scholar and IOP science. The types of journals selected are national journals and international journals that provide full text and the data needed. The languages used in the journal are Indonesian and English, (3) Selection of journal literature to be used by using keywords search analysis of scientific literacy abilities and profiles of scientific literacy abilities, (4) Data collection is conducted manually using observational data tables or observation forms consisting of: search name, journal or conference name, year, title, author's name, and results of scientific literacy, and (5) Data selection is based on article information, which is the research subject of junior high school students in Indonesia and the overall literacy results of the article based on the year of the framework and also based on aspects of the 2012 PISA framework [11], 2015 [12] and 2018 [13] with the measured capabilities that can be explained in Table 1 below:
Table 1. Analysed PISA Framework

| Pisa Framework | Measured Science Literacy Ability |
|----------------|-----------------------------------|
| 2012           | Identify scientific issues         |
|                | Explain phenomena scientifically   |
|                | Using scientific evidence          |
| 2015 and 2018  | Explain phenomena scientifically   |
|                | Evaluate and design scientific enquiry |
|                | Interpret data and evidence        |
|                | scientifically                      |

The data analysis for each result of scientific literacy is calculated with the following formula:

\[ \text{Scientific Literacy Analysis Result} = \frac{\text{The sum of the percentage of Articles}}{\text{The total of Articles}} \]  

Furthermore, these results are interpreted into the assessment criteria of students' scientific literacy abilities based on Purwanto [14], which can be shown in the following Table 2.

Table 2. Assessment Criteria of Scientific Literacy Ability

| Category    | Interval   |
|-------------|------------|
| Very High   | 86% - 100% |
| High        | 76% - 85%  |
| Moderate    | 60% - 75%  |
| Low         | 55% - 59%  |
| Very Low    | \(\leq 54\%\) |

3. Result and Discussion

3.1. Result

3.1.1. Analysis Based on Entire Articles Based on Year Framework

As a result of the information review presented in the articles, the information of the results of overall student literacy for several years is collected. The following Table 3 shows the results of an analysis of the ability of scientific literacy of the entire article based on the PISA framework year.

Table 3. The Result of Analysis of Students’ Scientific Literacy Ability Based on the PISA framework year.

| Framework Year | Analysis Result | Category |
|----------------|-----------------|----------|
| 2012           | 45.62%          | Very Low |
| 2015           | 37.44%          | Very Low |
| Total          | 41.53%          | Very Low |

Table 3 shows that the results of scientific literacy based on the framework of the year amounted to 41.53% which is included in the very low category. The lowest scientific literacy was in 2015 at 37.44% in the very low category, while in 2012 it was 45.62% in the very low category. The results of scientific literacy indicate that the results of scientific literacy analysis of students from 2012 to 2015 declined significantly.
3.1.2. Analysis Based on the PISA Framework Competency Aspects in 2012

Based on the results of searching for articles that meet the overall criteria, there are articles that meet the competency aspects of the PISA framework in 2012. The results of the analysis of article data on aspects of the PISA framework in 2012 are illustrated in Figure 4.

Table 4. The results of the analysis of competency on aspects of the PISA framework in 2012

| Article | Identify scientific problems | Explain the Phenomena Scientifically | Use Scientific Evidence | Result | Category |
|---------|------------------------------|--------------------------------------|-------------------------|--------|----------|
| 1       | 57.00%                       | 22.00%                               | 52.00%                  | 43.67% | Very low |
| 2       | 65.80%                       | 63.36%                               | 70.96%                  | 66.71% | Moderate |
| 3       | 77.00%                       | 72.00%                               | 59.00%                  | 69.33% | Moderate |
| 4       | 38.60%                       | 42.00%                               | 60.40%                  | 47.00% | Very low |
| 5       | 76.00%                       | 74.00%                               | 66.00%                  | 72.00% | Low      |
| 6       | 56.43%                       | 55.43%                               | 59.67%                  | 57.18% | Moderate |
| Total   | 61.81%                       | 54.80%                               | 61.34%                  | 59.31% | Moderate |

Based on the data in Table 4, the overall results of the aspects of the 2012 PISA framework competence were 59.31% with a low category. The analysis of aspects PISA 2012 competency framework which has the lowest percentage value is on the aspect of explaining the phenomenon scientifically at 54.80% in the low category. In addition, the competence of identifying scientific problems is 61.81% with the moderate category and using scientific evidence of 61.34% with the moderate category.

3.1.3. Analysis Based on Competencies Aspects of the PISA Framework 2015 and 2018

Based on the results of analyzing articles, some articles that meet the criteria for competency aspects in the frameworks in 2015 and 2018 are found. The results of data analysis of scientific literacy capabilities from various articles can be presented in Table 5.

Table 5. The Result of Analysis of Competence Aspects in PISA Framework in 2015 and 2018

| Article | Explain Phenomena Scientifically | Evaluate and Design Scientific Enquiry | Interpret Data and Evidence Scientifically | Result | Category |
|---------|----------------------------------|---------------------------------------|---------------------------------------------|--------|----------|
| 1       | 48.75%                           | 80.83%                                | 91.60%                                      | 73.73% | Moderate |
| 2       | 28.64%                           | 24.48%                                | 31.81%                                      | 28.31% | Very low |
| 3       | 30.00%                           | 16.00%                                | 26.00%                                      | 24.00% | Very low |
| 4       | 57.35%                           | 41.18%                                | 42.65%                                      | 47.06% | Very low |
| 5       | 38.50%                           | 54.60%                                | 55.30%                                      | 49.47% | Very low |
| 6       | 30.87%                           | 40.42%                                | 24.90%                                      | 32.06% | Very low |
| 7       | 16.81%                           | 6.11%                                 | 23.95%                                      | 15.62% | Very low |
| 8       | 23.00%                           | 14.00%                                | 25.00%                                      | 20.67% | Very low |
| Total   | 34.24%                           | 34.70%                                | 40.15%                                      | 36.36% | Very Low |

The results in Table 5 show that the articles analyzed based on aspects of the competencies of the PISA frameworks in 2015 and 2018 are all very low percentages. The overall percentage of the aspects of the 2015 and 2018 PISA framework competence were 36.36% with very low categories from the three aspects of the competence, aspects of explaining scientific phenomena get the lowest percentage results of 34.24% with very low category. On the other hand, in the aspects of evaluating and designing
scientifically at 34.70% with very low category and aspects of interpreting data and scientific evidence at 40.15% with very low category.

3.2. Discussion
Based on the results of the analysis in Table 3, it can be seen that the scientific literacy ability of middle school students is still very low. This indicates that there are still many junior high school students who have not mastered scientific literacy. This is also in line with Table 4 and Table 5 which shows aspects of the competency of the PISA framework which are in the range of 30%-65% which shows that aspects of these competencies are still relatively low. The low ability of students' scientific literacy can be caused by several factors, some of which are the curriculum, the use of learning methods and models, learning facilities, and teaching materials [15]. In addition, the low level of student scientific literacy is caused by the application of learning strategies that are not appropriate with aspects of scientific literacy competencies. The low results of scientific literacy of these students can result in students will be less responsive to the development of science and technology that continues to grow rapidly and also students lack the skills they need in the 21st century. So students will not be able to compete in facing the challenges of modern society in the future. Finally, students will not be able to compete globally.

Various efforts to improve students' scientific literacy skills have been conducted by providing learning innovations and teaching material innovations. Some of them are by applying worksheet based on discovery learning models and developing science literacy oriented textbooks used in science learning. The application of the worksheet based on the discovery learning model has been done by Mustofa, Kuswanti and Hidayati who showed that the worksheet based on the discovery learning model is very effective in improving scientific literacy [16]. In addition, the research on the development of science literacy-oriented textbooks has been carried out by Budiningsih, Rusilowati and Marwoto that shows that developing teaching materials are very effective in improving learning outcomes [17].

Strategies to improve aspects of scientific literacy that are still relatively low can be done by providing strategies or learning models that can build aspects of scientific literacy competencies. One of them is to apply the scientific inquiry learning model. Using scientific inquiry is able to build students' thinking power in developing scientific questions and conducting investigations [18]. Scientific inquiry can make students investigate and articulate physical concepts [19]. The scientific inquiry process consists of making observations, asking questions, making hypotheses, developing or conducting experiments, analyzing experimental data, and making conclusions. In the observation stage, this activity will train students to become more skilled in identifying aspects of the problem. The stage of asking questions and hypotheses will train students to be more skilled in explaining scientific phenomena, the stage of conducting experiments will make students skilled in the aspects of evaluating and designing scientifically, and the stage of analyzing data and making conclusions will make students skilled in aspects of interpreting data and evidence scientifically. Structured steps in learning scientific inquiry become one of the solutions to improve the competency aspects of the PISA framework. As research by Suhila, Rochman and Yuningsih, the application of scientific inquiry learning models can improve aspects of scientific literacy [20].

4. Conclusion
Inventory of scientific literacy skills of junior high school students in the 2012 and 2015 PISA frameworks showed 41.53% results. These results indicate that the scientific literacy ability of junior high school students is still very low. The results of the analysis based on aspects of the 2012 PISA competency indicated that competence identified scientific problems of 61.81% in the moderate category, explained the phenomena scientifically at 54.80% in the low category and used scientific evidence of 61.34% in the moderate category. While the results of the analysis of the competency aspects of the PISA 2015 and 2018 frameworks, the competence to explain scientific phenomena obtained a percentage value of 34.24% with a very low category, evaluating and designing scientific enquiry at 34.70% with a very low category and interpreting data and scientific evidence of 40.15% in the very low category. This shows that the ability of students in competency aspects of the PISA Framework
2012, 2015 and 2018 is still relatively low, so there must be efforts to improve scientific literacy and aspects of scientific literacy competencies through learning innovations, learning strategies and learning models.

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