The development of scientific literacy assessment to measure student’s scientific literacy skills in energy theme

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Abstract. The research were aimed to develop and find out of validity, reliability, characteristic of scientific literacy assessment, and find out of the profile of students’ scientific literacy skills in Energy themed. The research is conducted in 7th grade of Secondary School at Demak, Central of Java Indonesia. The research design used R&D (Research and Development). The results of the research showed that the scientific literacy assessment was valid and reliable with 0.68 value in the first try out and 0.73 value in the last try out. The characteristics of the scientific literacy assessment are the difficulty index and the discrimination power. The difficulty index and distinguishing are 56.25% easy, 31.25% medium, and 12.5% very difficult with good discrimination power. The proportion of category of scientific literacy as the body of knowledge, the science as a way of investigating, science as a way of thinking, and the interaction among science, environment, technology, and society was 37.5%:25%:18.75%:18.75%. The highest to the lowest profile of students’ scientific literacy skills at Secondary School Demak was 72% in the category of science as a way of thinking and the lowest was 59% in the category of science as the body of knowledge.

1. Introduction

Natural sciences should be look as way to thinking to know the world, investigating, and as a collection of knowledge. The real natural sciences is a body of knowledge, a way of investigating, a way of thinking, and the interaction among science, technology, and society. Because that, a teacher must know the fundamental aspects of natural sciences, so they can give more complete and comprehensive image about science [1].

Natural sciences as one of lesson in secondary school is aimed to prepared students in order to have scientific literacy skills and scientific attitude. National Research Council (NRC) explain that scientific literacy is a knowledge and concept comprehension and science process which anybody needed to make a decision, social participation and culture, and economic productivity [2]. Scientific literacy is science comprehension level and technology that needed to progress the modern industry. The science comprehension included the natural comprehension which is capable of fundamental science, such as chemistry, biology, physics, and the real science comprehension as a scientific investigating become center focus in scientific literacy. Scientific literacy is important to knew by students in order to students’ way to know the environment, health, economy, and other problems which are meet by modern society that’s very depend on progress of technology and developed science knowledge [3]. Scientific literacy skills is showed on PISA (Programme for Student International Achievement) which is international study OECD (Organization for Economic Co-
Scientific literacy is skill to use scientific knowledge to describe results based on facts of science [4]. The results is needed on science learning evaluation in class. Evaluation did not become a separate part from learning process. Evaluation used to measure the reach out of learning process in order to indicator that have been arranged. The measuring of scientific literacy skills is important to know how far students’ “literacy” about science concepts that have been studied.

During the time, evaluation instrument only pressed on content, not pressed on scientific literacy such as science application in daily life or contextual, problem-solving, and other science process skills [5]. It’s a fact that students’ science skills were different, need a development of evaluation instrument scientific literacy which can discriminate between the highest student skills and the lowest students skills.

PISA’s test in energy-themed was only found three categories of scientific literacy, where the category of science as a way of investigating not found. So, it is necessary to develop evaluation instrument scientific literacy to measure students’ scientific literacy skills in energy-themed. Energy-themed was theme that can be relevance with four categories of scientific literacy. The research has benefit for teacher to evaluate students’ scientific literacy skills in science learning process. The expectation of developed evaluation instrument is it become reference to evaluate students’ scientific literacy skills and the datum become reference for basic repair the quality of science learning process.

2. Methods

The research of developing evaluation instrument based on scientific literacy used Research and Development design included potentials and problems, collecting data, product design, design validation, design revision, first trial, product revision, final trial, and final product. The instrument used 20 explanation multiple-choice items and validation questionnaire. The instrument usually used on standard test on large scale [6].

Validity test include content validity, criteria validity, and proper test. Content validity based on study two advisors as experts. Criteria validity based on ratio between PISA’s test and developed instrument by product moment correlation. Proper test based on validation questionnaire analysis.

Reliability test is definite by calculate the value of reliability coefficient. Characteristic test is definite by difficulty level, discrimination power and ratio of scientific literacy in the instrument. Scientific literacy is definite by calculate percentage of scientific literacy capability.

3. Result and Discussion

3.1 Validity of Evaluation Instrument Based on Scientific Literacy

The results of validity analysis shown that evaluation instrument was valid with revision based on rubrics, test and scoring by advisors. The developed instrument according to learned material and proper to used for trial. Criteria validity is used to analyze ratio of final trial instrument and PISA’s test and find out 0.38 or valid. The value was low because score of PISA was very low or very difficult. The results of validation questionnaire by evaluation experts is presented by Table 1.

Based on experts validation of evaluation instrument was found out that evaluation instrument was very proper. The evaluation instrument was very proper to used in final trial with revision. The advices from validator are the test should be appropriated with indicator, the options should be same, noticed the Indonesian grammar, and the options was not repeated with same words.
Table 1. The Results of Expert Validation

| Validator   | Aspects | Percentage (%) | Category      |
|-------------|---------|----------------|---------------|
| Validator 1 | Construct | 98   | 95 | Very Suitable |
|             | Material | 100 |    |               |
|             | Language | 75   |    |               |
| Validator 2 | Construct | 100  | 94 | Very Suitable |
|             | Material | 100  |    |               |
|             | Language | 94   |    |               |
| Average     | Construct | 96.5 |    | Very Suitable |
|             | Material |      |    |               |
|             | Language |      |    |               |

3.2 Reliability of Evaluation Instrument Based on Scientific Literacy

Reliability of explanation multiple choice was calculated by KR-20 formula. The value of reliability test is presented by Table 2 and Table 3.

Table 2. The Value of Instrument Reliability on First Trial

| N   | 𝛼     | r_calculated | r_table | Category         |
|-----|-------|-------------|---------|-----------------|
| 29  | 5%    | 0.68        | 0.367   | Reliable        |

Table 3. The Value of Instrument Reliability on Final Trial

| N   | 𝛼     | r_calculated | r_table | Category         |
|-----|-------|-------------|---------|-----------------|
| 80  | 5%    | 0.73        | 0.220   | Reliable        |

Based on the review about reliability of evaluation instrument based on scientific literacy to measure student’s scientific literacy skills was reliable. The reliability of PISA’s test was 0.44. The differences between them was caused by many factors, such as objective scoring (right was 1 and wrong was 0) but the explanation was not scoring, more students answered by guessed because nothing explanation that written on answer sheet, and mental preparing of students have less enthusiasm to doing the test.

3.3 Characteristics of Evaluation Instrument Based on Scientific Literacy

The results of characteristic of evaluation instrument included difficulty level, discrimination power, and category of scientific literacy. The results of difficulty level and discrimination power based on scientific literacy is presented by Table 4.

Table 4. The Interpretation of Difficulty Level and Discrimination Power of Scientific Literacy Instrument

| No. | Difficulty Level | Discrimination Power | Interpretation |
|-----|------------------|----------------------|----------------|
| 1.  | 0.81             | 0.475                | Easy test, Good Discrimination |
| 2.  | 0.71             | 0.475                | Easy test, Good Discrimination |
| 3.  | 0.55             | 0.4                  | Medium test, Good Discrimination |
| 4.  | 0.30             | 0.55                 | Difficult test, Good Discrimination |
| 5.  | 0.59             | 0.2                  | Medium test, Good Discrimination |
| 6.  | 0.43             | 0.65                 | Medium test, Good Discrimination |
| 7.  | 0.73             | 0.375                | Easy test, Good Discrimination |
| 8.  | 0.79             | 0.525                | Easy test, Good Discrimination |
| 9.  | 0.79             | 0.5                  | Easy test, Good Discrimination |
| 10. | 0.53             | 0.5                  | Medium test, Good Discrimination |
| 11. | 0.64             | 0.525                | Medium test, Good Discrimination |
| 12. | 0.94             | 0.25                 | Easy test, Good Discrimination |
| 13. | 0.3              | 0.525                | Difficult test, Good Discrimination |
| 14. | 0.81             | 0.525                | Easy test, Good Discrimination |
| 15. | 0.89             | 0.375                | Easy test, Good Discrimination |
| 16. | 0.74             | 0.525                | Easy test, Good Discrimination |

Based on Table 4, it found out that 56.25% easy, 31.25% medium, and 12.5 difficult test and have good discrimination power. The percentage of scientific literacy category in evaluation instrument based on scientific literacy is shown by Table 5.
Table 5. The Percentage of Scientific Literacy Categories in The Evaluation Instrument

| Categories as Science | First Trial Test | Final Trial Test | PISA’s Test |
|-----------------------|------------------|------------------|-------------|
|                       | Items  | Percentage | Items  | Percentage | Items | Percentage |
| Body of Knowledge     | 8      | 40%        | 6      | 37.5%      | 4     | 50%        |
| Way of Investigating  | 4      | 20%        | 4      | 25%        | -     | -          |
| Way of Thinking       | 4      | 20%        | 3      | 18.75%     | 2     | 25%        |
| SETS                  | 4      | 20%        | 3      | 18.75%     | 2     | 25%        |

The ratio of category of scientific literacy in the developed evaluation instrument was 37.50% : 25% : 18.75% : 18.75%. The results were in agreement with the ratio of category of scientific literacy 42% : 19% : 19% : 20% [4]. The suitability of science as a body of knowledge is the highest, but inexpediency appeared on the lowest, the category of science as a way of investigating is the lowest, the research explains that the lowest category is science as a way of thinking and interaction among science, technology, and society. The difference was caused by changing the test items that were used and reused for final trial based on discrimination power, so the composition of scientific literacy was changed.

3.4 The Profile of Students’ Scientific Literacy Skills

The term of ‘scientific literacy’ has been used in the literature for more than four decades although not always with the same meaning [7]. Scientific literacy has become the term used to express the broad and encompassing purpose of science education [8]. Even if many definitions about scientific literacy, both center points which become its characteristics are science comprehension, not only know, and application on daily life.

The results of profile of students’ scientific literacy skills are shown by Figure 1.

![Figure 1. The Profile of Scientific Literacy Skills](image)

The final trial results showed that the category of science as a way of thinking is the highest among the other categories is 72. This category requires students to think critically, interpret data, and linking concepts with another one. The category of science as a body of knowledge is only 59, meaning that the ability of the students in understanding science concepts is sufficient.

(1) Science as a body of knowledge

Based on the research results that represented in Figure 1, the percentage of students who answered correctly in this category is 59%. The profile of capability based on PISA scientific literacy is 38. This profile shows that the ability of students who work on science categorized as a body of knowledge is still lower than the other categories. Something that caused the literacy skills of students in the
category of science as a body of knowledge is low, the students do not understand the concepts of energy that has been taught by a teacher, the linking concepts with daily life are less and students tend to memorize the formula and function without understanding the meaning of formulas and concepts of energy.

(2) Science as a way of investigating
Based on research results are represented in Figure 1 percentage skills of scientific literacy category of science as a way of investigating is 68%. This shows that the students' skills in scientific investigation is very good. Science as a way of investigating reflect the aspects of inquiry active and learning, which involves the students in the methods and processes of science such as observing, measuring, classifying, inferring, recording the data, make calculations, experiment, and others [8].

(3) Science as a way of thinking
Based on research results are represented in Figure 1 percentage skills of scientific literacy in category of science as a way of thinking is 72% and 44% in PISA. This shows that the students' skills in critical thinking is very good. students who have critical thinking skills means that they must have capability of deductive and inductive thinking, able to interpret the data, and linking concepts with another one. Today, critical thinking skills are needed for students, because excepts the results of science and technology that can be enjoyed, it appeared some impacts that create problems for humans and the environment.

(4) The interaction among science, technology, and society
Based on the results of the research are represented in Figure 1, the categories of interaction among science, technology, and society based on scientific literacy has 71%, where PISA are obtained that capability in the category of the interaction of science, technology, and society more higher than other categories, which amounted to 88%. This means that the students were able to clarify the matter with daily life, technology, and the benefits to the community.

Based on a review of scientific capabilities in the test based literacy and scientific literacy PISA matter, it can be concluded that students tend to have a higher capacity in the category of science as a way of thinking, its means that students tend to be able to interpret data and critical thinking about something. On average ability students' scientific literacy by all categories is 67% or enough. The ability of students’ scientific literacy of SMP N 2 Demak by using an evaluation instrument based on scientific literacy is most likely caused by differences in learning targets that was implemented in schools while already using the curriculum in 2013 with the target is students’ scientific literacy.

The learning evaluation determines how the students learning well and a part of the investigation to education improved. The learning evaluation provides feedback to students, educators, parents, policy makers, and the public about the effectiveness of educational services [9]. The science learning in schools, including assessments are used more limited and strictly with the material/content of IPA, while the evaluation instruments target based on scientific literacy and PISA more focus on the application of the scientific thinking in daily life and actions in practical knowledge as well as measuring the ability of scientific principles in the context of non-academic.

The students of SMP N 2 Demak not familiar to do test with texts and load graphic discourse that requires the ability of observing. Students need accuracy to read, understand the content of texts and logical reasoning ability. In fact students with high academic achievement have not yet high literacy scientific capabilities [9]. It is necessary to recognise that enhancing scientific literacy is also dependent on the need to develop collective interaction skills, personal development and suitable communication approaches as well as the need to exhibit sound and persuasive reasoning in putting forward socio-scientific arguments [7]. Teachers were invited to start introducing and giving material with various strategy that scientific literacy, such as teaching concepts by experiments which exciting order thinking skills, so students’ scientific literacy skills can be increased well. Evaluation instrument contains scientific literacy aspects in order to students habitually doing test based on scientific literacy. Because of that, it is very suitable to used evaluation instrument based on scientific literacy. The level of scientific literacy abilities are lower this indicated a lack of knowledge of students in scientific and
technology [10]. One of the factors influencing the results of this study of science literacy is the aspect of science attitudes related to emotional factors that include the interest and comfort of learning science as well as low student involvement [11]. The upgrading quality of teaching process in the class, in which the ability of scientific literacy appear is extremely needed to increase the students’ ability of scientific literacy [12]. The ability of science literacy is the ability to obtain scientific evidence, analyze and interpret it to obtain meaningful conclusions [13]. The learning models that can be used to increase science literacy are Problem Base Learning [14] and Project Base Learning [15, 16].

4. Conclusion
The evaluation instrument based on scientific literacy to measure students’ scientific literacy in energy-themed meet content validity, criteria validity, and suitable with valid and very suitable. The reliability of instrument on first trial is 0.68 and final trial is 0.73. the characteristics of instrument evaluation based on difficulty level is 56.25% easy, 31.25% medium, and 12.5% difficult and all of them have good discrimination. Based on the four categories of scientific literacy, science as a body of knowledge is 37.5%, science as a way of investigating is 25%, science as a way of thinking is 18.75%, and the interaction among science, technology, and society is 18.75%. The higher scientific literacy skills of students are science as a way of thinking which have 72% and the lower scientific literacy skills of students are science as a body of knowledge that have 59%.

Based on the research that have done, the advice can be given is the evaluation instrument could be develop with other instrument, except multiple choice with argument and other theme.

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