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Developing an Instrument of Scientific Literacy Asessment on the Cycle Theme

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ABSTRACT

The purpose of this study is to develop scientific literacy evaluation instrument that tested its validity, reliability, and characteristics to measure the skill of student's scientific literacy used four scientific literacy, categories as follow: science as a body of knowledge (category A), science as a way of thinking (category B), science as a way of investigating (category C), and the interaction between science, technology, and society (category D). The subjects of this developing study were 9th grade student of junior high schoolin Kudus. Validity test is done by the content, construct, and concurrent validation. Reliability testing is done by calculating a reliability coefficient "r". Characteristics tested by determining the level of difficulty, distinguishing features, and the proportion or ratio of scientific literacy category in the instrument. Profile of scientific literacy ability is determined by measuring students' mastery of scientific literacy. The result of reliability test is the price of"r" at first trial is 0.59 and the last trial is 0.74. Validity test results indicate that the instrument meets the content, construct, and concurrent validity with valid, very valid, and valid category. Characteristics of evaluation instruments developed shows that the instrument has a level of difficulty that the proportion of about 13% easy, 67% about the medium, and 20% about the difficult. The results of the analysis of discrimination power combined with a level of difficulty and obtained 5 items with poor quality and should be discarded. Comparison category A: B: C: D is 7: 2: 3: 3. Profile of literacy skills mastery of science shows that scientific literacy is still low at below 50% for all categories. Evaluation instruments developed meet the content validity, construct, and alignment with valid, very valid, and valid criteria.

KEYWORDS

Evaluation instrument, scientific literacy, skill of scientific literacy

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Introduction

In the 21st century, the progress of science and technology in various countries is rapidly increasing. The key for the advancement of science education including the quality of applied learning in each country. Science education as one of the subjects in junior high school became an important foundation in the form of qualified human resources. Based on the opinions expressed in Rusilowati (2013), building science education students to think in understanding natural phenomena or events with scientific methods as do scientists. However, science educationis stillhaving less attention in learning in the country.

The quality of education, especially science education in Indonesia is still low when compared to other developing countries. Weak education in Indonesia, especially science education indicated by the low level of scientific literacy achievement in PISA (Program for International Student Assessment). Indonesia has always obtained a score below the average score. In 2000, the science subjects put Indonesia on order 38 out of 41 participating countries. In 2003, Indonesia was ranked 38 out of the 40 participants. In 2006 the number of participating countries increased, Indonesia was ranked 50 out of 57 countries, while 60 out of 65 countries obtained Indonesia in 2009. Based on the data from PISA 2012, Indonesia received ratings 64 of the 65 participating countries with an average acquisition value of science literacy component of Indonesian children was 382 (OECD, 2014: 5).

Achievement level of scientific literacy Indonesia for 12 years participation has always ranked fifth bottom when scientific literacy is very important in determining the quality of education in a country (Hayat & Yusuf, 2011). The scientific literacy is very important mastered by students in relation to how they perceive the environment, health, economy, and the problems of modern society more dependent on technology and progress and development of science. Therefore, measurement of scientific literacy is very important to know the extent to which the student has literated science thus improving the quality of education in Indonesia can be done and can compete with other countries.

Preparation of evaluation instruments based scientific literacy is one way to measure the literacy skills of students, especially in science or science. Sulistiawati (2015) stated that in order to measure the students' science literacy skills can be used on a few questions from PISA. Holbrook & Rannikmae (2009) state that the emphasis on enhancing scientific literacy is placed on an appreciation of nature of science, the development of personal attributes and the acquisition of socioscientific skills and values. Chiappetta et al. (1991) stated that there are four categories of scientific literacy that science as a body of knowledge, science as a way of thinking, science as a way of Investigating, and the interaction between science, technology, and society. Rusilowati, et al (2015) expand the catogory of sciencetific literacy of interaction science with environment.

Based on those statements, it is necessary to develop scientific literacy-based evaluation instruments to measure students' science literacy skills with the theme of the cycle. The materials are selected based on relation to the theme of the cycle and refers to the matter of PISA. Evaluation instrument based scientific literacy is already there but is still limited. Through the development of evaluation instruments is expected educators can measure students' science literacy skills and familiarize students with problems of international standard

in learning in Indonesia so that to support the improvement of the quality of education at the world level, particularly in the ability of science literacy.

Purpose

The purpose of this study is to develop scientific literacy evaluation instrument that tested its validity, reliability, and characteristics to measure the skill of student's scientific literacy used four scientific literacy, categories as follow:science as a body of knowledge, science as a way of thinking science as a way of investigating, and the interaction between science, technology, and society.

Method

Design of this developing study is used Borg & Gall design (2007) that have been simplified into three main stages, namely: (a) the preliminary study stage; (B) the stage of development studies; (C) the evaluation stage.

The preliminary study stage includes the study of literature and field of study. The study of literature was done by searching the literature or data relating to science literacy and science literacy skills while field of studies to obtain facts or findings in the field. Furthermore, the study phase development includes the first product design, test validation by experts, analysis and revision, first trial, analysis and improvement, until the product generates hypothetical. The last stage is the evaluation includes product testing hypothetical at the end of the trial until the final product is produced.

The validity test includes content, construct, and concurrent validity. The content validity test was done through the study of the instrument by the supervisor 1 as the evaluation expert and supervisor 2 as science matter expert, construct validity test performed with validation techniques by expert (judgment experts) through questionnaires validation. The validity of concurrent was used to determine the correlation between matter developed with the question of the original PISA uses a technique product moment correlation (r_{xy}).

Reliability testing was done by calculating the coefficient of reliability. Test of characteristics by determining the level of difficulty, discrimination power, and the proportion or ratio of scientific literacy category in the instrument.

The developed instrument used to measure students' scientific literacy skills. The ability of science literacy test was done by calculating the percentage of mastery of scientific literacy based on Mardapi (2012) which has been combined with four categories of scientific literacy.

Results and Discussion

Validity Evaluation Instrument

The content validity test was done before the evaluation instrument based scientific literacy tested in the first trial to obtain suggestions for improvements. Based on the review experts, the developed instrument that was categorized valid with the revision.

The result of construct validity test which obtained by calculating a score of expert validation in the questionnaire can be seen in Table 1. Based on the results shown in Table 1 it can be concluded that the evaluation instrument developed based on scientific literacy is very valid.

Table 1. The result of the validation of evaluation instruments based on scientific literacy by experts

No	Aspect	Score (%)			Result
		Validator I	Validator II	Average	
1	Material	96	95	95,5	Very Valid
2	Construction	75	75	75	Medium
3	Language	97	95	96	Very Valid
	Construct validity			88,8	Very Valid

The suggestion that was given by some experts is application of a picture must be able to explain the question not only for decoration, application of question's sentences must be effective and the indicator of lattice matter must be fixed with the indicator of science literacy.

The measurement of alignment validity was done with the correlation technique *Product-Moment*. After doing the data analysis, the result will be obtained as shown on r_{xy} calculation is 0.77 with valid category.

The result of measurement shows that the alternative hypothesis accepted, there is a high correlation between PISA question with the question based on science literacy that obtained. If the correlation index has the value +1,00 it means that the correlation has a positive way.

The instrument has a high alignment validity it is due to some factors, there are, (1) The ability of students adequate; (2) The objectivity of teachers in the giving of scores; (3) and the students are on the same level in a group while being tested with the PISA question and question of the development.

According Subiyanto (1988), subjective teacher for students' attitudes may affect the validity or the validity of the instrument. Such attitudes can indeed be considered in the evaluation, but clearly should not affect the measurement results.

Reliability of Evaluation Instrument

Reliability tests performed after first trial of scientific literacy instruments to the 32 test subjects. Reliability test result is 0.59. Researchers testing out the product in the form of 20 items based on scientific literacy that have been validated by experts.

At the end of the test, the test instrument based scientific literacy accompanied by the original PISA instrument as a comparison analysis of reliability ($\alpha = 5\%$) in order to obtain the results presented in Table 2.

Table 2. Result of reliability test data analyzing in the final trial

N	Instrument	$r_{calculation}$	r_{table}	Criteria
60	Instrument 's development	0.72	0.254	Reliable
60	Instrument PISA	0.44	0.254	Reliable

In Table 2 the price is greater than r table. Thus, it can be concluded that the evaluation instrument based scientific literacy tested is reliable.

PISA instrument reliability level is low due to several factors, including: (1) PISA items appropriate to the theme are only 6 questions, and it will be explained on the limitations of the study; (2) The ability of the students are not the same with each other. The reason is based on the factors put forward by Grounlund as quoted by Arifin (2009) that the length of the test will affect the reliability of a test.

Characteristics of Evaluation Instrument

Characteristics of scientific literacy instruments developed include the level of difficulty, discrimination power, and the proportion of scientific literacy category show at Table 3.

(1) Level of Difficulty (LD) and Discrimination Power (DP)

Table 3. Level of Difficulty and Discrimination Power

Item	LD	DP	Interpretation
1	0.35	0.23	Item Received with revision
2	0.72	0.40	Item Received
3	0.45	0.20	Item Received with revision
4	0.51	0.42	Item Received
5	0.26	0.05	Item Rejected
6	0.26	0.20	Item Received with revision
7	0.55	0.20	Item Received with revision
8	0.31	0.28	Item Received with revision
9	0.39	0.58	Item Received
10	0.23	0.03	Item Rejected
11	0.23	0.00	Item Rejected
12	0.45	0.20	Item Received with revision
13	0.52	0.06	Item Rejected
14	0.54	0.55	Item Received
15	0.59	0.22	Item Received with revision
16	0.20	0.25	Item Received with revision
17	0.76	0.23	Item Received with revision
18	0.42	0.06	Item Rejected
19	0.66	0.25	Item Received with revision
20	0.59	0.22	Item Received with revision

(2) Proportion of Scientific Literacy Category

The proportion of each category in the scientific literacy test instrument developed by researchers are presented in Table 4.

Based on the table, the category of scientific literacy in the instrument of development and about the PISA results native has a different comparison. Instrument based scientific literacy as the initial product has a ratio of category A: B: C: D of 8: 4: 4: 4 in proportion to Wilkinson *et al.* (1999) which states that the proportion of scientific literacy categories are balanced meet the criteria of scientific literacy in the ratio 2: 1: 1: 1 for each aspect of scientific literacy. Having

been tested on a limited scale, obtained a new comparison of 15 questions were selected, namely Category A: B: C: D by 7: 2: 3: 3. The comparison is not in accordance with the comparison Wilkinson because of several issues which have been analyzed have poor quality items so it must be removed and this affects scientific literacy category comparison before and after tested. Unlike the matter of development results, PISA questions were used in this study only meet the category A and B due to the limitations of the original PISA questions provided. Most of the original PISA questions were found to be in the category B.

Table 4. Proportion of Scientific Literacy Category

No	Scientific Literacy Category	Developed Instrument In the initial trial		Developed Instrument In the final trial		PISA Instrument	
		Items	Percentage	Items	Percentage	Items	Percentage
1	A	8	40%	7	47%	2	33%
2	B	4	20%	2	13%	4	67%
3	C	4	20%	3	20%	-	-
4	D	4	20%	3	20%	-	-

Note:
A= Science as a body knowledge
B= Science as a way of thinking
C= Science as a way of investigating
D= Interaction of science, environment, technology, and society

The Profile of Students Scientific Literacy Skills

Students' science literacy skills can be measured by analyzing the student's mastery of each category of scientific literacy. Mastery of scientific literacy of students is measured by looking at the test results matter science literacy-based development results and PISA test questions in each category of scientific literacy. The results of the analysis about the results showed that the mastery of competencies development category A is equal to 29.88%, amounting to 38.13% of category B, category C 49.03%, and 28.61% for competence mastery Mastery Category D. scientific literacy students diagram presented Figure 1.

In addition to the developed instrument results, students' science literacy skills can also be seen from the mastery of scientific literacy PISA original use problems. Mastery of scientific literacy category A category amounted to only 32.15% and are not much different from the mastery of category B, which only reached 32.5%. The results of the analysis of scientific literacy abilities can be explained using a bar chart is presented in Figure 2.

(1) Science as a body knowledge

In this category, the achievement of scientific literacy on PISA questions is higher than the mastery of the developed instrument due to the number of developed items in this category have more varied material also compared to about PISA so that the possible answers any more.

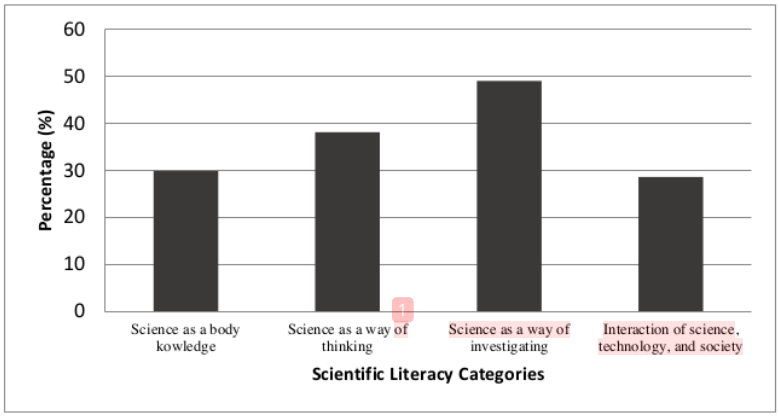

Figure 1. Mastery of Science Literacy in Development Instrument Results

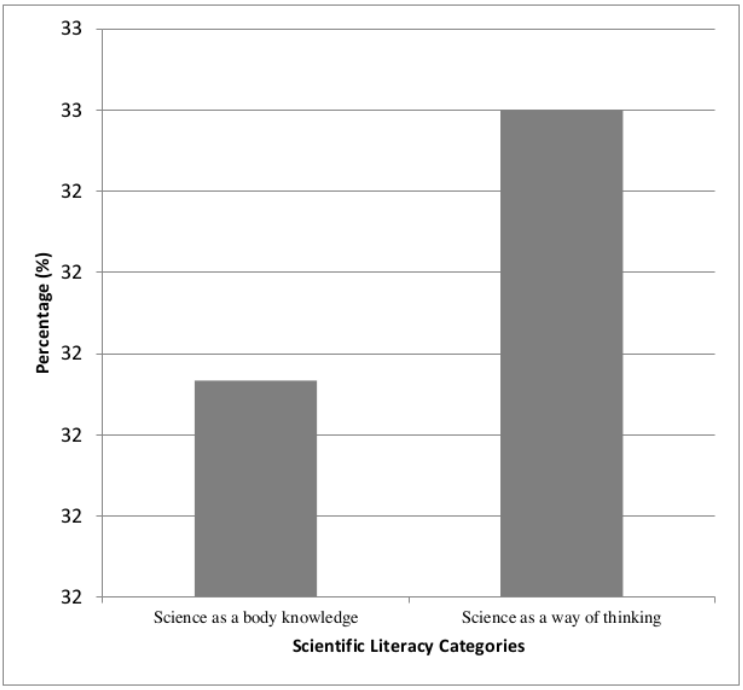

Figure 2. Mastery of Science Literacy in PISA Instrument Results

Possible scientific literacy in this category that still has not reached 50%, namely: (1) Teachers often teach formulas compared with the concept; (2) Students do not understand the basic concept being taught by the teacher; (3)

Students do not have knowledge of the facts, terminology and concepts of science enough. Results of research Odja & Payu (2014) showed that the students' science literacy skills that are in categories where students agree or disagree with a statement or issue but can not give a scientific explanation.

(2) Science as a way of thinking

The results showed an average yield relatively low on both questions. In connection with these results it can be said that the students' skills in critical thinking, inductive deductive reasoning, analyzing causality and analyze scientific data are lacking.

(3) Science as a way of investigating

Results obtained in line with research Odja & Payu (2014) showed that junior high school students who studied the average yet have the ability to communicate the results of the experiment.

Factors causing low mastery of students on science as a way of investigating categories namely: (1) Students rarely doing lab activities; (2) Students do not understand these terms in some scientific investigation activities such as independent variables and the dependent variable; (3) Students spend more time with science that promotes rote learning. According to Leonard, was quoted as saying by Maturradiyah & Rusilowati (2015), a science lesson should be more emphasis on student activity, reducing memorizing knowledge, more emphasis on science process skills to get the concept, and most of the time students spent in the laboratory or field work.

(4) Interaction of science, environment, technology, and society

Compared to other categories, about the interaction of science, technology, and society category is the least mastered by students. These results are in accordance with the students' answers during the interview stating that they lack an understanding of the application of science and technology in everyday life. The level of scientific literacy abilities are lower in these categories indicate a lack of knowledge of students in science and technology.The importance of mastering this category is supported by the opinion of Ibrahim & Aspar (2011: 9) states that without the knowledge of good science, we will become weak and technology users are not able to apply all of the existing technological sophistication.Based on Figure 1 and 2, in general it can be said that the students' science literacy remained low in all categories of scientific literacy is below 50%. Results obtained in line with OECD data (OECD, 2014: 5) placing Indonesia ranked 64th out of 65 participating countries with an average acquisition value of science literacy component of Indonesian children by 382. In addition, Ridwan et al. (2013) in his study also concluded the same thing: the ability SMP studied science literacy is at the functional level where these levels belong in science literacy skills are pretty low.

Conclusion

Evaluation instruments developed meet the content validity, construct, and alignment with valid, very valid, and valid criteria. Reliability of the instrument of 0.59 in initial trials and 0.72 at the end of the trial. The proportion difficulty level obtained by the evaluation instrument has met the 13% ratio easy items, about 67% moderate, and 20% about the difficult. Discrimination power combined with a level of difficulty is used to determine the quality of the items used.

Comparison category A: B: C: D, respectively, are 7: 2: 3: 3. In general, the profile of students' science literacy is low as indicated by the percentage of mastery of scientific literacy is below 50% for each category.

Associated with a lower ability students 'science literacy, the authors suggest the need to develop scientific literacy-based evaluation instrument that can measure students' science literacy skills so that students are familiar with the problems based on scientific literacy.

Disclosure statement

No potential conflict of interest was reported by the authors.

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