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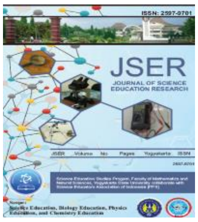

Scientific Literacy Assessment Instrument on Addictive Substances Topic in Ethnoscience Integrated Inquiry Based-Learning

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ABSTRACT

A skill needed in the 21st-century learning is scientific literacy (SL). Ethnoscience integrated inquiry-based learning (IBL) is expected to train the SL. The SL ability can be measured using an instrument. The purposes of the research were i) to produce a valid and reliable instrument on the ability to measure the SL using ethnoscience integrated IBL and ii) to know the item analysis results of the item test. The research method used was research and development (R&D) with instrument development. Data collection techniques were questionnaires and tests. The instruments of data collection were validation sheets and assessment instruments on SL ability. The data analysis technique used was both descriptive qualitative and quantitative techniques. The qualitative analysis was aimed to determine the product quality using Aiken's V theory. The quantitative analysis aimed to determine the product quality empirically using Rasch model. A valid and reliable instrument was produced with 15 test items for additive substances topic with integrated ethnoscience in learning.

INTRODUCTION

The rapid development of science and technology affects various fields. Along with this development, the competencies in the 21st century have emerge that have challenges in the ability to produce knowledge for the learning process. 21st-century skills are needed by students to face the changes in the increasingly complex life. According to the Organization for Economic Cooperation and Development (OECD) (2015), many challenges are faced in the 21st century that require innovative solutions and demand people to have good scientific literacy (SL) abilities and a basis in scientific thinking and scientific discoveries. Rapid changes that occur in the field of science and technology are often accompanied by new problems related to ethics, morals, and global issues that can threatened human life. People who have SL are needed to solve these problems (Turiman et al., 2012).

The ability of SL needs to be developed and mastered by students, i.e.: i) the ability to know the surrounding environment and other problems that occur in the environment, ii) the ability and creativity to use scientific knowledge and skills in solving problems of everyday life, as well as iii) making accountable decisions with the aim that students are ready to face the complex global challenges (Höttecke & Allchin, 2020). Literacy is important because it helps students in addressing and making decisions related to science issues in everyday life, then develop knowledge, skills, and use science both as citizens and as individuals (Rahayu, 2017).

SL is very important for science education (Laugksch, 2001). A study shows that the SL is poor among prospective science teachers in Indonesia (El Islami & Nuangchalerm, 2020). Factors that affect the poor SL among students are poor cognitive abilities, rare activities of independent scientific investigation, the lecture process and learning approach that do not support increasing SL (Hastuti et al., 2018). Treacy et al. (2011) also stated that SL, especially in the globalization era, is very important for students as the key to facing the challenges of globalization. This is urgent as science and technology are easily found in every aspect of life (O'neal, 2013). Students who have a high level of SL skills will quickly know the conditions or daily problems around them.

SL is the knowledge and understanding of concepts and processes of science. This ability is needed to participate in community and cultural affairs, economic, and personal decision making (National Research Council, 1996). Improving SL through science education means developing the ability to use both knowledge and skills of science based on empirical evidence creatively, especially those relevant to careers and daily life. The purposes are to solve problems and make socio-scientific decisions (Holbrook & Rannikmae, 2009). Furthermore, a person who has SL will have the ability to use scientific knowledge to identify questions and draw conclusions based on evidence to understand the phenomenon and make decisions on the natural environment and its changes caused by human activities (OECD, 2015; Liu, 2009).

The component of SL is described in four domains. They are the context of science, the content of science, scientific process, and attitude in science (El Islami & Nuangchalerm, 2020). While the OECD (2015) states the four domains of SL including context, scientific knowledge, attitudes, and competencies. The domain of competency requires knowledge. This means that scientific phenomena require knowledge of science. This is then referred to as content knowledge. The competency is used to evaluate and design a scientific investigation. Also, interpreting data and scientific evidence requires more than content knowledge and depends on an understanding of how scientific knowledge is established and the level of trust (Turiman et al., 2012b). Recognizing and identifying the features of scientific inquiry characteristics also requires knowledge of the standard procedures that become the basis of the various methods and practices that are used to build scientific knowledge, i.e. procedural knowledge. Finally, the competency of scientific literacy also requires epistemic knowledge, which is defined as an understanding of the rationale for common scientific investigations, the claim status, and the meaning of basic terms such as theory, hypothesis, and data. The domains of context, scientific knowledge, and competence are domains that measure scientific literacy skills in terms of students' cognitive skills. OECD (2015) explains that the competency domain has three aspects, i.e.: identifying scientific problems, explaining phenomena scientifically, and using scientific evidence.

The domain of SL is used as the basis for developing the SL assessment to determine the students' mastery of SL. Mastery of SL will develop an understanding of the scientific concepts and processes to participate in community and cultural affairs, as well as decision making. The application of science concepts and experiences in learning is expected to help students master the application of knowledge and can solve the contextual problems in everyday life, such as the problem related to ethnoscience. The problem is that science learning has not been a source of ethnoscience experience to be investigated for scientific truth. Inquiry-based learning (IBL) is used to investigate the scientific truth. IBL can facilitate students to find and build self-knowledge by investigating phenomena around them (Gibson, 2018). Inquiry is process-oriented learning and aims to teach students to practice skills, knowledge, and attitudes.

The skills, knowledge, and attitudes are used to answer the question of a contextual problem (Kennedy & Odell, 2014). Students need to understand the subject matter, nature of science (NOS), and inquiry in an effort to develop the SL (Lederman et al., 2013). An assessment instrument is needed to assess the ability of SL effectively. The instrument must be able to measure SL in IBL with integrated ethnoscience. Other requirements are valid, reliable, and following the NOS learning. Moreover, the test instrument is composed of several items, developed by referring to the SL domain. The objectives of the study are to 1) produce a valid instrument that can measure the SL ability in the framework of IBL with integrated ethnoscience, and 2) analyze the items to determine the level of SL.

METHOD

This study used the research and development (R&D) method based on the instrument development model developed by Mardapi (2012). The model consisted of 8 stages including preparation of test specifications, tests review, implementation of initial tests, analyzing test items, revising test items, conducting final tests, and interpreting test scores. The main product of the study was an assessment instrument to measure SL skills with 15 item questions, described from aspects and indicators proposed by OECD, and presented in Table 1. The initial test on additive material was performed on 75 students as the subjects at the Department of Science Education, Universitas Negeri Yogyakarta.

The data collection techniques were questionnaires and tests. The data collection instruments were validation sheets and instruments of SL assessment.

The data analysis technique used was descriptive qualitative and quantitative analysis. The qualitative analysis was aimed to determine the theoretical product quality, while the quantitative analysis was aimed to determine the empirical product quality. Aiken validity was used to analyze the validation results. The theoretical validation was performed by 7 experts who had an educational background of doctoral and master of science education. The content-validity coefficient was referred to as the assessment result provided by 7 experts to perform a qualitative review of the items using the V statistic (Aiken, 1985). The formula is:

$$V = \frac{\sum s}{n(c-1)}, \qquad (1)$$

with $s = r - lo$; lo is the lowest validity rating score; c is the highest validity rating score; and r is the number given by rater. Moreover, the analysis of the empirical test was carried out using the Rasch model with Winsteps 3.73 software.

RESULTS AND DISCUSSION

Developing the assessment instrument of SL is carried out in three stages. First, reviewing the literature related to SL, IBL, and ethnoscience as the characteristics of the developed instrument. Second, conducting a test review, validation by experts, and analyzing using Aiken's V. Third, initial test of the validated instrument and analyzing it using the Rasch model.

Table 1. *Aspects of SL on the Competency Domain*

No.	Aspect	Indicator
1.	Explain phenomena scientifically.	a. Identify simple pictures to explain the scientific phenomena. b. Make the right prediction. c. Offer an explanatory hypothesis. d. Explain the potential participation of scientific knowledge for society.
2.	Evaluate and design a scientific investigation in the scientific process.	a. Identify the investigated question in a particular scientific study. b. Propose a way to investigate a particular question scientifically (problem formulation). c. Evaluate a scientific investigation. d. Evaluate the methods used by scientists to ensure data reliability and objectivity of explanations.
3.	Interpret data and evidence scientifically.	a. Convert data from one representation to another. b. Analyze and interpret data, then draw the right conclusions. c. Identify assumptions, evidence, and reasons in science-related texts. d. Evaluate scientific arguments and evidence from various sources (newspapers, internet, journals).

The specification of the developed instrument is to measure the SL on the additive material for IBL with integrated ethnoscience. The instrument consisted of 15 questions integrating SL indicators and learning outcomes for additive material. Additives are materials that are easily found in everyday life. The selected ethnoscience on additive materials is related to the use of additives in local foods of Yogyakarta, for example, "gudeg" and "geplak". Students need to know the concept of additives in foods. Then, they investigate the phenomena and effects on the body. For the output, students are expected to find solutions for safe additives for consumption. Using knowledge and skills based on empirical evidence creatively, especially those relevant to everyday life, to solve problems and make decisions can improve SL (Holbrook & Rannikmae, 2009).

The assessment instrument for SL is validated by 7 experts using a validation sheet, consisting of 5 assessment aspects in 10 indicators. The validation score is analyzed using the Aiken's V formula. If the V score is 0.76 (Vtable with 7 experts), the developed test instrument is valid on content validity from the expert judgment. Table 2 shows that all items are valid. The experts' inputs are used to revise the instrument.

The revised test items are tested on 75 students. The results are then analyzed using the Rasch model with Winsteps 3.73 to determine the instrument feasibility and the test items characteristics. The results of the item analysis are seen from the output of Winsteps. The analysis result provides the Cronbach's alpha value to see the reliability value of 0.73. So, the SL test has good consistency even when it is applied for students at the same level of academic ability (Sumintono & Widhiarso, 2013). Aspects of person reliability and item reliability are 0.53 and 0.96. Based on these values, it can be concluded that the consistency of students' answers is not good but the item quality in the instrument's reliability aspect is good.

Table 2. *Analysis Result of Aiken's V*

Aiken's V	Item Number	Validity
0.89	2, 4, 7, 14	Valid
0.93	1, 3, 5, 6, 8, 9, 11, 12, 13, 15	Valid
0.96	10	Valid

Table 3. *Analysis Result of Item Difficulty Level*

No	No Item	Measure	Total Score	Category
1	N9	6.98	1	Difficult
2	N7	5.65	3	Difficult
3	N3	0.82	43	Medium
4	N5	0.75	44	Medium
5	N11	0.61	56	Medium
6	N6	0.40	58	Medium
7	N14	-0.21	59	Medium
8	N13	-0.40	61	Medium
9	N4	-0.45	62	Medium
10	N2	-0.71	64	Medium
11	N8	-1.51	67	Easy
12	N10	-1.90	69	Easy
13	N12	-1.90	69	Easy
14	N15	-1.90	69	Easy
15	N1	-2.43	71	Easy

The analysis results of the item difficulty level are presented in Table 3. The results show that number 9 has the highest measure value of 6.98, which has the highest difficulty level as only 1 student gives the correct answer. Meanwhile, item number 1 has the lowest measure value of -2.43. This means that the item has the lowest difficulty level or the easiest as 71 students give the correct answer.

Moreover, if the measured value is positive, the item difficulty level is classified as difficult. In contrast, if the measured value is negative, the item difficulty level is relatively easy. Test items might be classified into difficult, medium, and easy, with percentages of 13.3%, 53.4%, and 33.3%, respectively.

Table 4. *Analysis Result of Item Fit Criteria*

No	No Item	Item Fit Criteria			Result
		Outfit MNSQ	Outfit ZTSD	Pt. Measure Corr	
1	N9	1.16	1.98	0.20	fit
2	N7	1.15	1.90	0.18	fit
3	N11	1.12	0.41	0.32	fit
4	N13	1.11	0.38	0.33	fit
5	N8	1.03	0.30	0.32	fit
6	N14	0.76	-0.41	0.43	fit
7	N10	0.81	0.09	0.32	fit
8	N5	0.84	-0.39	0.51	fit
9	N1	0.79	0.05	0.30	fit
10	N3	0.83	-0.42	0.53	fit
11	N6	0.76	0.42	0.45	fit
12	N12	0.59	-0.20	0.38	fit
13	N2	0.44	-0.68	0.44	fit
14	N4	0.59	-0.43	0.43	fit
15	N5	0.79	0.08	0.42	fit

The discriminatory power of items is the ability to distinguish students who can answer questions (high level of ability) and low ability to answer questions. In the Rasch model, a method of discriminating power analysis is through identifying groups of respondents based on the respondent separation index. The greater the value of the item separation, the instrument quality on all respondents and items is better because it can identify groups of respondents and groups of items (Sumintono & Widhiarso, 2015). Based on the output of the statistics, the person separation value is 1.7 or in decreasing value is 2. The value indicates two groups that are differentiated based on the value of person separation, namely the upper and the lower groups.

The level of item fit is presented in Table 4. Item fit test is reviewed through Outfit Means Square (0.5 < MNSQ < 1.5), Outfit Z-standard (-2.0 < ZSTD < 2.0), and Point Measure Correlation (0.4 < Pt Measure Corr < 0.85) (Sumintono & Widhiarso, 2015). The item is un-fit when the test item does not obtain more than one criteria. The results in Table 4 shows all Items are fit. So, the instrument is feasible to use to measure the SL with integrated-ethnoscience in additives material. The result is in accordance to the results of Bashooir (2017), which also shows that the assessment instrument in a multiple-choice test can measure SL skills.

CONCLUSION

The finding of the research and development shows that the assessment instrument of SL is tested theoretically. Moreover, the SL instrument is empirically feasible to be used based on the validity of the Aiken and Rasch analysis model. The assessment instrument in a multiple-choice test has meet the validity of Aiken with the value of 0.89 – 0.96 with valid criteria given by the experts. The instrument has 15 fit items from the Rasch model for fit analysis. The reliability of the assessment instrument with a Cronbach Alpha value is 0.73 with good criteria. The level of item difficulty on the instrument for assessing the scientific literacy skills of types A and B consists of 13.3% for the difficult category, 53.4% for the medium category, and 33.3% for the easy category.

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