REVITALIZATION OF RADIATION LITERACY WITH THE MAKING OF SCIENTIFIC LITERACY INSTRUMENTS FOR HIGHER EDUCATION STUDENTS

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ABSTRACT

Scientific literacy is needed to participate in modern society where many things are based on science; therefore, society needs several scientific literacy themes. The theme of radiation, the use of radiation and its sources, is one of the world's multidimensional issues today. Scientific literacy can be shown through learning or evaluation of learning. This study aims to determine the validity and reliability of the radiation literacy test on radiation. The method used is Research and Development with a framework. The research subjects were students of the Physics Education and the Physics Study Program at the Universitas Negeri Semarang. The test was developed in the form of 38 multiple-choice questions. The results of expert validation showed that the test instrument was good with a percentage of 90%. Furthermore, the results of the empirical validation show 23 valid items with a Cronbach Alpha reliability coefficient of 0.81. The benefit of this research is that students are expected to be familiar with scientific literacy-based questions about radiation.

Keywords: evaluation, scientific literacy, radiation

1 INTRODUCTION

Scientific literacy is needed to participate in modern society where many things are based on science. We need to understand the events of everyday life, and sometimes those events set by the laws of science that occur in nature or society (Roberts, *et al.,* 2007). Therefore, society needs several types of scientific literacy (Rungdren, *et al.,* 2012; Ramona & Bradshaw, 2014). Scientific literacy is the ability of students to use scientific concepts to apply in everyday life, explain scientific phenomena and describe these phenomena based on scientific evidence. Scientific literacy has become a new goal and target in science education for now. Indonesian students' scientific literacy skills are still lagging behind during their participation in the PISA program. Until 2018 the literacy ability of Indonesian students was at a score of 396 out of an average OECD score of 489 (PISA, 2018).

The concept of radiation is a concept that contains the concept of energy, radiation can be in the form of waves or particles. The concept of energy has been taught from the basic education level to higher education. Generally, those learning is more focused on the cognitive aspect, emphasizing scientific concepts (Akitsu, *et al.,* 2017). In fact, the concept of energy has many contextual dimensions: political, social, and cultural (Liu, *et al.*, 2010). Therefore, learning in Science Education (including Physics) must pay attention to informative presentations and students' attitudes and awareness and interest in social issues (Khund, 1979).

Conventional energy and nuclear energy for people's lives runs frequently. Modern society requires nuclear energy in addition to conventional energy. The use of radiation and its sources is one of the multidimensional issues facing today. For more than a century, ionizing radiation has been indispensable, especially in medicine and industry. Radiation Research is a multidisciplinary research field that investigates the effects of radiation. Radiation research was very active in the mid to late 20th century, but then faced challenges in funding (Dwyer, *et al.*, 2015).

According Jonson (2012) said learning about radiation produces radiation literacy students and a deeper understanding of the atomic-scale world. According Ueda (2014) said the characteristics of students who have radiation literacy are a). Have an understanding of the difference in radiation, b). Have an understanding of radioactivity and radioactive materials in nature, c). Understand the types of radiation, and places that tend to accumulate radioactive materials, d). Have an understanding of the interaction of radiation with matter, e). Finally, understand radiation causing damage on a molecular scale.

Radiation material in physics learning includes primordial radiation, ionizing radiation, interaction of radiation with matter, and the benefits of radiation. The scientific literacy items in this study correspond to the radiation literacy domain, namely cognitive, affective, and behavioral. For the cognitive domain, items are made in multiple-choice, according to PISA 2018, on aspects of knowledge, competence/process and attitude of science, using existing competencies described in Table 1.

Table 1. Domain, Category, and Competency for Instrument

Domain	PISA Category (Bloom Taxonomy)	Competency	Instrument Tools
Cognitive	Contents Knowledge (C2)	Explain the radiation concept	Multiple Choice
	Explain the scientific phenomena (C3)	Identify the radiation problems	
	Evaluation and Design the Scientific research (C4)	Explain the content knowledge in analyze and diagnose the example of student conceptions related to radiation concept.	
	Interpret the Scientific data and evidence (C4)	Analyze the radiation problems	
	Procedural Knowledge (C6)	Evaluation the potential solution of the radiation problems	
Affective	Response (A2)	Attitude in radiation protection Awareness toward radiation problems	Interview
	Appreciate (A3)	Preference in using radiation	

Domain	PISA Category (Bloom Taxonomy)	Competency	Instrument Tools
	Choice (A3)	Locus of control Internalization of moral norm	
Behavior	Action (P2)	Action competence; commitment, desire and courage to action	Interview
	Adaptation (P4)	Habits in using radiation at home	
	Practice (P5)	Make wise decision in using radiation	
	Position (P3)	Encourage people to use radiation wisely	

Determining the success rate of mastering radiation literacy will strengthen scientific literacy, understanding the biological consequences of radiation exposure becomes more important with increasing public concern on the risks of radiation and other radiation literacy (Shwartz, *et al.*, 2006). To find out whether education has made citizens have radiation literacy, it is necessary to do research. To develop radiation citation skills, students can train themselves by getting used to working on evaluation questions. In addition, individuals can also find out how far the level of scientific literacy ability they have. Measuring students' scientific literacy ability requires the correct evaluation instrument. There are several types of evaluation tools used in the learning process, one of which is multiple choice.

This study aims to determine the validity and reliability of scientific literacy test assessments on radiation, especially ionizing and non-ionizing radiation according to the material obtained by students.

2 METHOD

Research on the development of evaluation test uses a research and development R&D (Research and Development) that adapts the design according to Kuo, *et al.*, (2015) which includes five stages in the study including l stages in research, namely (1) developing an assessment framework: analyzing components of Radiation literacy and identifying the complexity of the performance of each component using the Delphi method; (2) designing items: designing assessment instruments to obtain radiation literacy from all components and levels of complexity in the framework (3) developing a scoring rubric for each item; (4) conducting trials: collecting initial validation evidence to support the theoretical basis of the construct, (5) conducting test item tests. Multiple-choice tests are selected, as are standardized tests on a large scale. Test the characteristics of this evaluation instrument by determining the level of difficulty, discrimination power and proportion of the PISA category.

The validity test in the development of this instrument includes content and criterion validity. The content validity test was carried out by providing an assessment instrument in a validation questionnaire to several physics lecturers. The criterion validity test was used to determine the correlation between the questions from the developed evaluation instrument and the original PISA questions using the product-moment correlation (r_{xy}). The reliability test is done by calculating the reliability coefficient.

Content validity is the validity of the test instrument used to see the feasibility of the developed test instrument. The level of content validity is provided by lecturers, including 90% material feasibility, 90% construction feasibility and 90% language feasibility. The result is 90% feasibility which is categorized as suitable for use. That means that the instrument can be used for tests.

3 RESULTS AND DISCUSSION

This research begins by developing an assessment framework: analyzing the components of Radiation literacy and identifying the complexity of the performance of each component. Then, to obtain material coverage on the radiation theme by asking for opinions and suggestions from several resource persons using the Delphi method (Nworie, 2011) from BATAN, Physics Lecturer, High School Teacher via email, based on answers from sources, scientific literacy materials on radiation can be shown below:

Natural and artificial radiation
Radioactivity and Radioactive Materials that exist in nature
Interaction of radiation with matter, how to protect yourself
The negative and beneficial effects of radiation are balanced.

3.1. Characteristics of Radiation Science Literacy Test Instruments

After getting the coverage of the material, then researchers make grids and question indicators to make instruments, and make expert validation questionnaires. after validated by experts and make revisions to the test, an on-line test trial is carried out by using google forms to 76 students of Physics Education and Physics Study Program. The results of the analysis of the test instruments can be seen in Figure 1. While the affective and attitude domain research uses interviews through Google Meet.

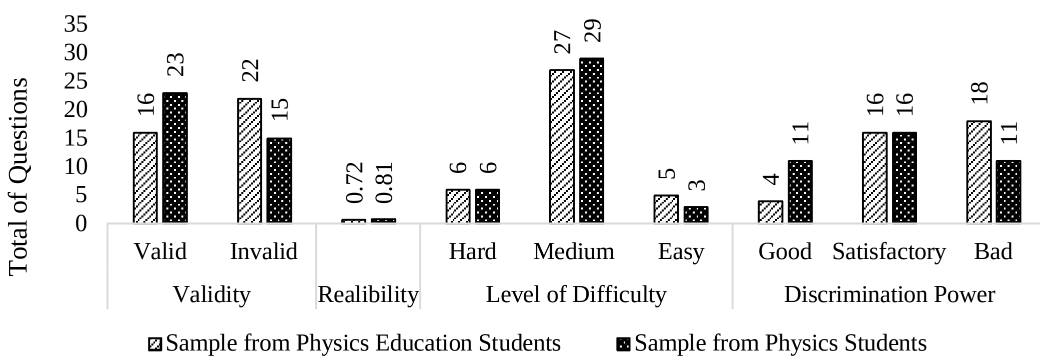

Figure 1. Result of Analysis Instrument

Figure 1. Show that there are 16 valid test questions, with reliability: 0.81 while the level of difficulty tends to be normal, the percentage distribution of easy and difficult tests is around 10% - 15%. The discrimination power of the test used is still quite bad, there are almost 50% of the number of questions.

In the category of PISA contains the category of Knowledge and competence. Knowledge category consists of content knowledge, procedural knowledge and epistemic knowledge. The PISA competency categories consist of explain scientific phenomena, evaluate and design scientific investigations, and interpreted scientific data and evidence. The composition of the PISA categories in the developed tool is presented in Table 2.

Table 2. Composition of PISA Categories in Questions

No	**Category**	**Final Product Trial (%)**	**PISA Question (%)**
1	Content Knowledge (C2)	42	33,34
2	Procedural Knowledge (C6)	5	
3	Epistemic Knowledge (C4)	13	33,33
4	Explain Scientific Phenomena (C3)	3	
5	Evaluate and Design Scientific Investigation (C4)	5	
6	Interpret Scientific Data and Evidence (C4)	31	33,33

Table 3. Composition of Level Of Difficulty in PISA Category (Bloom)

No	Category	Final Product Trial		
		Easy	Medium	Hard
1	Content Knowledge (C2)	4	8	4
2	Procedural Knowledge (C6)	-	1	-
3	Epistemic Knowledge (C4)	1	3	-
4	Explain Scientific Phenomena (C3)	1	1	-
5	Evaluate and Design Scientific Investigation (C4)	-	2	-
6	Interpret Scientific Data and Evidence (C4)	3	8	1

Table 4. Discrimination Power of Scientific Literacy Instrument

No	Category	Item	Percentage (%)
1	Accepted Questions	1,3, 5,7,8, 9, 10, 11, 13, 14, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27,38	55
2	Accepted Questions with Correction	4, 6, 28, 29, 30, 31, 32, 33, 34, 35, 37	29
3	Corrected questions and accepted	2, 12, 15, 18, 28, 36	16

3.2. Result of the Validity Analysis

Testing the criteria's validity is done using the product moment correlation test (r). This validity test is used to determine the relationship between the developed scientific literacy questions and the original PISA questions (which have been translated). The value of the validity of the criteria obtained in the initial product is 0.504 with a sufficient category.

3.3. Results of the Reliability Analysis of the Scientific Literacy Test

The reliability analysis of the scientific literacy test on radiation aims to determine the level of constancy of the developed test. Using the K-R 20 test, the initial product reliability analysis results were 0.72 and categorized as "high". At the final stage, the reliability of 0.81 is categorized as "high" according Rusilowati, *et al.*, (2016). The Final Product used different respondents with a larger number of subjects.

3.4. Result of the Interview To reveal Affective and Behavioral domains

Affective Domain by showing a response (A2), to the question "Why is radiation dangerous?" almost all respondents say radiation is harmful, regardless of its benefits. Domain behavior/attitude-wise decision-making in using radiation (P5), on the question "What do you think about BNCT (Boron Neutron Capture Therapy) and Proton Therapy?" respondents chose another treatment that did not use radiation. The attitude shown by the respondents is not following the results of the research by Tsukobura, *et al.*, (2018) shown that radiation learning can positively change their attitude.

4 Conclusion

The scientific literacy test instrument consisting of 38 questions was declared valid and reliable with a Cronbach Alpha coefficient of 0.81. The scientific literacy test instrument's characteristics are about radiation for students in the categories of content knowledge, procedural knowledge, epistemic knowledge, explain scientific phenomena, evaluate and design scientific investigations, and interpret scientific data and evidence. In addition, while in the affective domain, the category shows the response and the attitude domain, making wise decisions in using radiation.

Acknowledgement

We would like to said thanks to LPPM Unversitas Negeri Semarang, according to the contract: Nomor: 5.7.7AIN37mpK.4.4/2021, Tanggal 6 Mei 2021

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