Development of Biological Science Literacy Questions Based on the PISA Framework

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ABSTRACT
The research objective was to produce valid and practical questions on biological science literacy based on the Program for International Student Assessment (PISA) framework. The development step consists of needs analysis, construction variables and learning objectives, compiling grids, instruments and scoring, validation (theoretical and empirical), and item analysis. The results showed that the content and language validity was very valid with a value of 3.71 and 3.4 respectively, while the construction validity and PISA were categorized as valid with a value of 3.25 and 3.1 respectively. PISA questions developed practically with a value of 4.25. The conclusion from the research is that the product developed is valid and practical and can be applied in learning.

Keywords: *Question development, Biological science literacy, PISA framework, Valid.*

1. INTRODUCTION

One of the external challenges in curriculum 2013 development is transformation in the field of education. Indonesia's participation in the International Trends in International Mathematics and Science Study (TIMSS) study and the Program for International Student Assessment (PISA) since 1999 shows that the achievements of Indonesian children have not been encouraging in several reports issued by TIMSS and PISA. This is because the number of test materials asked in TIMSS and PISA are not included in the Indonesian curriculum [1-3].

The ability of Indonesian students to solve problems that require the ability to analyze, give reasons, communicate them effectively, and solve and interpret problems in various situations is still lacking [4]. The results of research show that only 45% of physics education students can complete high-level PISA framework-based test questions. This is because students have not been able to use scientific concepts that have been learned in solving tests, mastery of concepts is not comprehensive, and have not been trained to find a correlation between one concept and another [5].

Based on data published by the OECD regarding the results of the PISA study, it shows that the scientific literacy achievement of Indonesian students is still low, in 2000 Indonesia was ranked 38th out of 41 participating countries. In 2003, Indonesia was ranked 38 out of 40 countries. In 2006, Indonesia was ranked 50th out of 57 participants. In 2009, it was ranked 64th out of 65. In 2012 Indonesia was ranked 64th out of 65 countries. In 2015, Indonesia's PISA results ranked 62 out of 72 countries [6]. Then in 2018 Indonesia was ranked 74th out of 79 countries [7].

Another thing that causes the low ability of Indonesian students in solving PISA questions, among others, is that the learning outcome assessment instruments used are generally less related to the life context faced by students and do not facilitate students in expressing thought processes and arguing [8]. Meanwhile, according to [9] in general the textbooks used have not covered the four aspects of scientific literacy, including context, content, competence, and attitudes, even aspects of the context in the field of science application have not been found.

PISA is an international assessment program for students aged 15 years. PISA is followed by countries that are members of The Organization for Economic Co-operation and Development (OECD) including Indonesia [10]. PISA is an ongoing program that offers insights into educational policy and practice, and helps monitor trends in the acquisition of knowledge and skills of students across countries in various

demographic subgroups in each country [11]. PISA aims to determine the ability of students in reading literacy, mathematical literacy, and scientific literacy [12]. PISA is held every three years with each year having a different focus.

The main focus of PISA in 2000 was literacy in reading, PISA in 2003 focused on mathematical literacy. In 2006, PISA focused on scientific literacy. In 2009 it focused on reading literacy, 2012 on mathematical literacy and 2015 on scientific literacy [6]. This PISA assessment aims to assess the ability of students to use the abilities and skills that have been learned in school to live daily life in a challenging global era [13]. The literacy tested in PISA consists of three, namely reading, mathematics, and science literacy. Scientific literacy is the ability to use scientific knowledge, identify questions, and draw conclusions based on evidence in order to understand and make decisions regarding nature and changes made to nature through human activities [14].

PISA not only assesses the knowledge that students have learned, but also how students apply knowledge in new situations [13]. PISA assessment measures the extent to which a student has scientific knowledge and uses that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw conclusions based on evidence about related sciences, understand the characteristics of science as a form of human investigation, demonstrate awareness of science knowledge and technology, the intellectual and cultural environment, and engage in science issues and science ideas as reflective citizens [15].

The PISA framework divides the principles of scientific literacy into four interrelated aspects, namely context, knowledge, competence, and attitude [11]. First, context in PISA is interpreted as a situation that is reflected in a problem being tested which consists of personal, local/national contexts, and global/world contexts. Second, the type of knowledge in PISA includes the understanding of important facts, concepts and explanatory theories that form the basis of scientific knowledge. This knowledge includes knowledge of the content, how the ideas are created (procedural knowledge) and an understanding of the reasons underlying the procedure and the justification/reasons expressed (epistemic knowledge). Third, competence in PISA is the ability to explain scientific phenomena, evaluate and design scientific activities, and interpret scientific data and evidence. Fourth, attitudes in PISA are characterized by an interest in science and technology, respect for a scientific approach to investigation, important matters, and perception and awareness of environmental problems [11].

In developing scientific literacy questions based on the PISA framework, these literacy questions must cover these four aspects, which are characteristic of PISA scientific literacy questions. Regarding the content or type of knowledge about scientific literacy, PISA consists of physical systems, living systems, and earth and space systems. In the learning of biology, the content that is closely related is the living system consisting of cell material, the concept of an organism, health, excretion system, circulatory system, reproduction, disease, population, ecosystem, and the biosphere [11].

Based on the description above, the problem formulation in this research is "How to develop valid and practical questions on biological science literacy based on the PISA Framework?" This study aims to produce valid and practical questions of biological science literacy based on the PISA Framework. Meanwhile, the benefit of research is that it can provide additional information, especially for teachers in designing assessment instruments that can be applied in biology learning. Also, literacy questions can be used to practice problem solving skills and the application of learning material in everyday life.

2. METHOD

2.1 Research Procedure

This development research was carried out by following the steps for developing the Djaali and Mulyono instruments [16] as follows.

2.1.1. Need Analysis

This stage begins by analyzing the external challenges of Indonesian education listed in the Minister of Education and Culture Regulation Number 23 of 2016 regarding the low results of Indonesia's PISA. Furthermore, analyzing the PISA framework which includes aspects of context, content, knowledge and attitudes. Meanwhile, curriculum analysis is carried out by analyzing Basic Competencies (BC) in the 2013 curriculum, namely for junior high school science and high school biology subjects. This curriculum analysis is carried out to determine the suitability of biology material in the curriculum with the content aspects of the PISA framework.

2.1.2. Variable Construction and Learning Objectives

Variable construction is carried out using indicators contained in the PISA framework which include context, content, knowledge, and attitudes. Then determine the learning objectives and adjust them to the basic competencies to be achieved.

2.1.3. Creating Question Grids

The question grid is a description of the competencies and material to be tested. The purpose of preparing the question grid is to determine the scope and as a guide in writing questions. The question grid contains basic competencies, question indicators, PISA framework, questions, answer keys, and cognitive domains.

2.1.4. Writing Instruments and Scoring

Based on the lattice questions that have been made, an assessment instrument is prepared which refers to the learning material being taught. The number of questions made was 35 questions. Meanwhile, the final step of writing the resulting assessment instrument is an initial product called prototype 1 which will be ready to be validated.

2.1.5. Theoretical Validation

Theoretical validation is validation carried out by experts on the content of the material, PISA, constructs, and language. Indicators of material validation are the suitability of the material with the learning objectives, the correctness of concepts and definitions, the material is contextual, the distractor functions properly and the answer key is correct. PISA validation covers types of knowledge, competence, context. The construct validation indicator is that the test questions are arranged in detail, clearly, and can be understood. Indicators in language validation are the language used properly and correctly, communicative, and does not have multiple interpretations.

2.1.6. Revision

After the instrument has been validated theoretically, then revisions are made in accordance with comments and suggestions from the validator. The results of this product revision are called prototype 2. At this stage, if the research product (test questions) has been declared valid by experts and then tested on students.

2.1.7. Empirical Validation

The final stage of the development instrument was empirical validation which was carried out by field trials involving two class X grade students of State Senior High School 1 Palembang. Empirical validation to obtain results about the practicality of the test item instruments that have been developed. In addition, data collection was also carried out about the quality of the instrument (validity, reliability, difficulty level, and distinguishing power). At this stage, research is declared practical and impractical in accordance with the results of the analysis carried out.

2.2 Data Collection Technique

2.2.1. Walk through (Expert Validation)

Walk through technique is used to obtain suggestions and comments from experts by filling out the validation sheet. The data collected is in the form of the results of expert judgment on the validation sheet against prototype 1. The validation sheet data in this study were analyzed using a Likert scale, with indicator scores very good (4), good (3), not good (2), and very not good (1) [17].

2.2.2. Questionnaire

The practicality data of the question instruments were collected using a questionnaire containing the presentation of the questions, material, PISA characteristics, and language. The questionnaire scoring uses a Likert scale, namely strongly agree (5), agree (4), doubt (3), disagree (2), and strongly disagree (1) [17].

2.2.3. Test Data

The test technique was carried out during field trials using prototype 2. For analysis of the quality of the test items (validity, reliability, level of difficulty, and differences) using the Anates V4 application.

2.3 Data Analysis Technique

The results of the theoretical validation were analysed and the validity was grouped into four categories, while the results of the questionnaire in the empirical validation were analysed and the results were categorized into five categories. The categories of theoretical and empirical validation results are presented in Table 1.

Table 1. Categories of results of theoretical and empirical validation

Empirical Validity		Empirical Validity	
Score	Category	Score	Category
3,28-4,00	Very valid	4,35 - 4,50	Very practical
2,52-3,27	Valid	4,19 - 4,34	Practical
1,76-2,51	Invalid	4,03 - 4,18	Enough practical
1,00-1,75	Very invalid	3,87 - 4,02	Not practical
		3,71 - 3,86	Very not practical

The quality of the test instruments (validity, reliability, level of difficulty, distinguishing power, and distraction) were analyzed using AnatesV4 software.

2.4 Question Cards

The development of biological science literacy questions based on the PISA framework that has been declared good is then entered into the question card.

3. RESULT AND DISCUSSION

3.1 Description of The Development of Test Question

In this study, data were obtained through needs analysis, variable construction and learning objectives, making question grids, writing instruments and scoring, theoretical validation and revision, empirical validation, and data analysis. The results of the analysis of the aspects of knowledge content in the PISA science (Biology) framework, namely living systems include 6 things: 1) Cells (structure and function, DNA, plants and animals); 2) The concept of an organism (unicellular and multicellular); 3) Humans (nutritional health, digestive system, respiration, circulation, excretion, reproduction, and their relationships); 4) Population (species, evolution, biodiversity, genetic variation); 5) Ecosystem (food chain, matter and energy flow); and 6) Biosphere (ecosystem services, sustainability). The results of the analysis of the material in the science curriculum for junior high school level and biology for the high school level, found 10 topics that correspond to these aspects of PISA content.

Variable construction and learning objectives, using the variables used is the 2015 PISA framework. The following is in detail the PISA framework developed into biological science literacy questions is presented in Table 2.

Table 2. Distribution of questions based on the PISA framework

No	Framework PISA	Amount
Context		
1	Personal	10
2	Local/National	12/13
Content of PISA (Living system)		
1	Cell	5
2	The concept of an organism	4
3	Human	26
Competency		
1	Explaining phenomena scientifically	13
2	Evaluating and designing scientific research	9
3	Interpreted the data and evidence scientifically	13
Attitude		
1	Support for scientific investigation	5
2	The beliefs of students as a scientist	4
3	Interest in science	5

Table 2 shows the PISA framework developed by the number of questions per indicator. Next, make a grid of questions. The number of questions in this study amounted to 35 questions, namely 30 multiple choice and five essay questions. These questions were grouped into 16 questions having an intermediate cognitive domain and 19 questions having a high cognitive domain. Writing instruments and scoring, 15 discourses were developed. Theoretical validation and revision. Theoretical validation of the questions that have been developed is done by asking the opinions of four experts. The results of the theoretical validation are shown in Table 3 below.

Table 3. The result of theoretical validation

No.	Validation Aspect	Average Score	Categories
1	Content	3,71	Very valid
2	Construct	3,25	Valid
3	PISA	3,1	Valid
4	Language	3,4	Very valid
Average Score		3,37	Very valid

Table 3 shows the mean total score of the four experts and it is concluded that the questions of biological science literacy based on the PISA framework developed are in the very valid category.

Empirical validation, validation that is tried out on research subjects. With the aim of knowing the validity of the questions and practicality. Regarding the validity of the questions, 26 items were stated as valid items, namely 21 multiple choice questions and 5 essay questions. The practicality of the questions can be seen in Table 4.

Table 4 shows the results of students' assessment of the practicality of biological science literacy questions based on the PISA framework of 4.25. After being converted, the question is categorized as practical. Meanwhile, the reliability value can be seen in Table 5.

Table 5 shows that the multiple-choice questions obtained the test reliability coefficient of 0.84. The reliability coefficient of 0.84 is included in the high category. Meanwhile, in the essay questions obtained a reliability coefficient of 0.67, where $r_{count} < r_{table}$ so that the category does not have high reliability. Analysis of item tests, including the level of difficulty, distinguishing power, and the function of the distractor. The following is a detailed analysis of the items can be seen in Table 6.

Table 4. The result of theoretical validation

No	Aspect	Value
1.	Presentation of question	4, 43
2.	Mastery of content	4, 24
3.	PISA characteristic	4, 10
4.	Language	4, 23
Average		4, 25
Category		Practical

Table 5. The result of reliability test

No.	Question Form	Kind of Coefficient	Value
1	Multiple choice	Reliability value coefficient	0,70
		Reliability test coefficient	0,84
2	Essay	Reliability value coefficient	0,70
		Reliability test coefficient	0,67

Table 6 presents the results of calculating biological science literacy items based on the PISA framework, which is the final result of the evaluation of question development. Based on the results of the analysis of the items, the problem is then connected with the results of validation and reliability, so the questions of biological science literacy based on the PISA framework developed are classified as good.

Table 6. Analysis results of items tests

No	Question Form	Level of difficulty (%)	Distinguishing power (%)	Distractor
1	Multiple choice	Very easy (7%)	Value 0 (7%)	Most distractors perform their functions well
		Easy (40%)	Negative (7%)	
		Moderate (40%)	Ugly (3%)	
		Difficult (3%)	Moderate (30%)	
		Very difficult (10%)	well (43%)	
			Very good (10%)	
2	Essay	Moderate (40%)	well (100%)	
		Easy (60%)		

4. CONCLUSION

Based on the results of the study, it can be concluded that the theoretical validity is content validity and language validity in the very valid category, while the construct validity and PISA characteristics are valid. From the four theoretical validity results obtained an average value of 3.37 with a very valid category. The practicality score at the empirical validation (trial) stage was 4.25 with the practical category. This research produces a product in the form of a collection of valid and practical questions and card questions on biological science literacy based on the PISA framework.

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