Design and Development of PISA-Based Test Instruments on Temperature and Heat Materials Based on Field Analysis Results

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Abstract. This study aims to design and develop a PISA-based test instrument. The test instrument designed is based on the results of the analysis that has been carried out including needs analysis, material and literacy studies. The test instrument used is multiple choice considering that multiple choice has a high level of difficulty in choosing the correct answer among the available answers, so that it will train students' analytical skills. the initial PISA test instrument which was designed was 40 items which were arranged based on PISA scientific literacy competence, namely: explaining scientific phenomena; evaluate and design scientific research; and interpret scientific data and evidence. The designed PISA test instrument will be developed by looking at the content validity aspects carried out by the validator.

Keywords: *PISA Test Instruments, Temperature and Heat, Multiple Choice*

1. Introduction

The development of technology and information in the 21st century has had a significant influence on the world of education. Education is required to produce students with superior human resources in order to compete in the international market. 21st century national education focuses on realizing the ideals of the Indonesian nation, by realizing a prosperous society, having an honorable position and being able to compete with other countries, through the formation of quality human resources.[1]

Scientific literacy is a skill that is very much needed in the 21st century among 16 other skills that have been identified by the World Economic Forum. Scientific literacy is a knowledge to understand scientific facts and the relationship between science, technology and society and their application in real life[2]. It is believed that good students' scientific literacy skills will be able to understand the environment, economy, social, modern and technology. Given the

[1] Pratiwi, I., (2019). Pisa Effect on Curriculum in Indonesia. *Jurnal Pendidikan dan Kebudayaan,* 4 (1): 51-71

[2] Bond, D. (1989). In Pursuit of Chemical Literacy: A Place For Chemical Reactions. *Journal Of Chemical Education*, 66 (2): 157

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importance of scientific literacy, creating a scientifically literate society is the main goal of any educational reform[3].

It is important to measure students' scientific literacy in order to evaluate and improve students' scientific literacy, so that students are able to master one of the 21st century skills. One of the main international-scale assessments that measure scientific literacy skills is PISA. PISA (Programme for International Students Assesment) is a test program in the field of education initiated by countries that are members of the OECD (Organization for Economic Cooperation and Development)[1]. The OECD's objective in conducting the PISA assessment is to improve the quality of education, especially in the fields of scientific literacy, reading literacy, and numerical literacy[4].

The PISA test has been carried out eight times, starting in 2000, 2003, 2006, 2009, 2012, 2015, and lastly 2018. This test has been followed by several countries, both those who have joined the OECD (United States, Canada, Mexico, etc.) non-OECD countries (Argentina, Panama, Chile, Peru, etc.)[5]. Indonesia it self has taken the PISA test several times, from 2000 to 2015[6]. Since Indonesia first took the PISA test, Indonesia has consistently been ranked at the bottom. Indonesia's PISA results in 2018 for scientific literacy competence were ranked 9th from the bottom, namely 71 out of 79 countries, this shows that Indonesia's PISA ability is still relatively low . PISA scores for scientific literacy achieved by the Indonesian people in 2000, 2003, 2006, 2009, 2012,

The low Indonesian PISA test occurs because students are not trained in solving PISA questions and the questions available in physics learning are generally still limited to the LOTS criteria. The results of observations and interviews with several students and physics teachers obtained information that the questions given to students were still rote and calculating, not questions related to life and the world of technology. This kind of learning causes students to become unaccustomed to working on questions that lead to the measurement of scientific literacy, especially scientific literacy questions on PISA. If this process is maintained, it is highly likely that Indonesia will continue to be ranked at the bottom of the PISA test next year.

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[3] DeBoer, G. E. (2000). Scientific Literacy; Another Look at Its Historical and Contempory Meanings and Its Relationship to Science Education Reform. *Journal Of Research In Science Teaching*, 37 (6): 582-601

[4] Odja, A. H., & Payu, C. S. (2014). Analisis Kemampuan Awal Literasi Sains Siswa Pada Konsep IPA. *Prosiding Seminar Nasional Kimia*, ISBN: 978602-0951-00-3. Hal. 40-47.

[5] Murphy, S. (2010). The Pull of PISA: Uncertainty, Influence, and Ignorance. *Interamerican Journal of Education For Democracy*, 3 (1): 28-44

[6] Hawa, A. M., & Putra, L.V., (2015). *Pisa untuk siswa indonesia*.

2 PISA Science Literacy

PISA (Program for International Student Assessment) is one of the assessment programs in the field of international education. At first PISA was created by OECD (the Organization for Economic Cooperation and Development) countries as an answer to their own needs, now PISA has become an educational policy tool for countries other than OECD. PISA (the program for international student assessment) is a program to measure achievement for 15 year olds in the areas of math, science and reading literacy skills. The assessment carried out by PISA is carried out every 3 (three) years with a focus on the education of a country. There are three aspects that are assessed in PISA, namely mathematical literacy, scientific literacy, and reading literacy, with the following details [7]:

a. Mathematical literacy, which includes the ability to identify and understand, to use the basics of mathematics in life, which a person needs in dealing with everyday life.
b. Scientific literacy includes the ability to use knowledge, identify problems in life in order to understand facts and make decisions about nature and the changes that occur in life.
c. Reading literacy includes the ability to understand, use, and reflect in written form.

Scientific literacy according to the OECD is defined as the ability to engage with science-related issues, and with scientific ideas, as a reflective citizen. Adholpus (2012) states scientific literacy is knowledge and understanding of scientific concepts and processes needed for personal decision making, participation in civic and cultural affairs, and economic productivity[8]. The dimensions of knowledge measured in the PISA assessment for scientific literacy are knowledge of content, procedural and empirical[9]. Meanwhile, the measured competencies related to the three knowledges are as shown in table 1 below:

Table 1. Process Science /PISA Competencies

No	Competence	Ability
1	Explain the phenomenonscientifi c	• Remembering and applying appropriate scientific knowledge • Identify, use, and explain a model and representation • Make and justify correct predictions • Offer a clear hypothesis • Explain the potential implications of scientific knowledge for society
2	Evaluating and designing scientific research	• Identifying questions in a scientific study • Distinguishing questions to investigate scientifically • Propose and evaluate ways of exploring a given question scientifically

[7] OECD. (2019).*"PISA 2018 Science Framework", in PISA 2018 Assessment and Analytical Framework*. Paris: OECD Publishing.

[8] Adholpus. (2012). Improving Scientific Literacy among Secondary School Student through Integration of Information and Communication Technology. *APRN Journal Science and Technology*, 2 (5), 444–448.

[9] Sani, R. A., & Prayitno, W. (2020). *Asesmen Kompetensi Minimum*. Bandung: Rosda

No	Competence	Ability
		• Explain and evaluate the various ways that scientists use to ensure data validity and objectivity
3	Interpreting data and evidencescientific	• Converting data from one representation to another • Analyze and interpret data and draw appropriate conclusions • Identifyassumptions, evidence, and reasoning in science • Distinguish between arguments based on scientific evidence/theories and other considerations • Evaluate scientific arguments and evidence from different sources (eg: newspapers, internet, journals)

(OECD, 2019)

The questions formulated in PISA are generally based on real-life situations that contain problems in everyday life and focus on mastering the process, understanding concepts and the ability to apply them.

3 Research methods

This research uses research and development methods (Research & Development). According to Sugiyono, development research methods are research methods used to produce certain products, and test the effectiveness of these products[10]. The research was conducted through 3 stages, namely analysis, design and development. The flow of the research procedure can be seen in Figure 1 below:

[10] Sugiyono. (2018). *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.

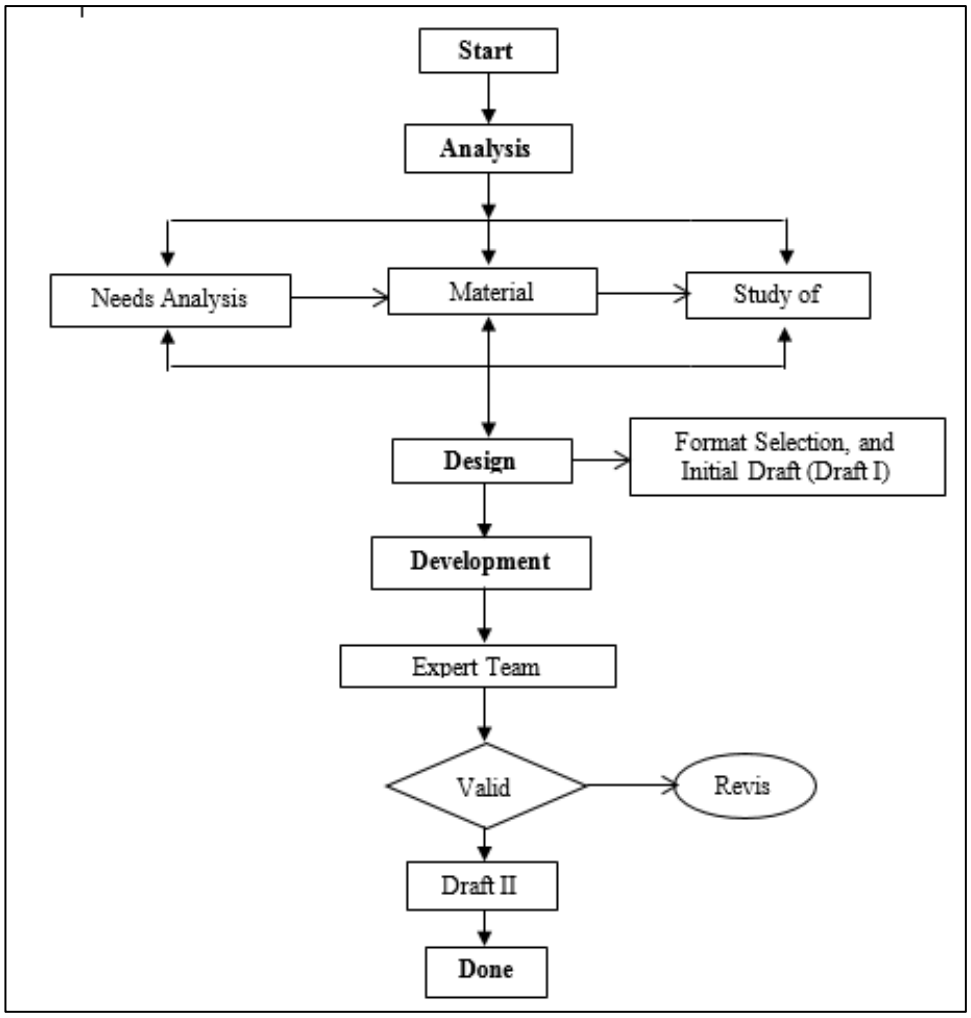

Image 1. Research Procedure Flow

4 Discussion

1. Stage of Analysis (Analysis)

- ***Needs Analysis***

Needs analysis aims to determine the basic problems encountered in learning. This analysis will be carried out by observing and interviewing teachers in the field of study to see the characteristics of students, the teaching and learning process, and documenting the value of student learning outcomes. The results of interviews with teachers in the field of study found that the average character of class XI IPA MAN 1 Tapanuli Tengah students had an interest in learning in the medium category. Students' scientific literacy skills are

also still minimal, this is because variations in assessment make students less able to develop scientific literacy skills and students are also less socialized about PISA-based questions. While students' knowledge of PISA is still very minimal, many students are still not familiar with PISA, and have never encountered PISA questions.

- ***Material Analysis***

The material in the research is temperature and heat material, the selection of material is chosen based on the needs of students who still rarely get PISA-based questions on temperature and heat material. In addition, the material temperature and heat are very closely implemented in everyday life. Many problems that often occur in everyday life are related to temperature and heat. The qualifications of the materials used in the research are indicators obtained from scientific literacy competence in the PISA assessment, namely; explain phenomena scientifically; evaluate and design scientific research; and interpreting scientific data and evidence.

- ***Study of literature***

Literature studies are carried out by looking for accurate information either through books or scientific publications about PISA, PISA questions on temperature and heat material, various questions used in PISA and validators.

2. Stage of Design (Design)

The initial stage of planning is determining the purpose of the test and determining the form of the test that is in accordance with the analysis. The design analysis stage is completed, followed by making a grid of questions that refer to the indicators of achievement of scientific literacy competencies that have been determined. The purpose of the developed test is to train students to get used to solving science literacy-based questions that are usually given in PISA competitions. The form of the test instrument used is multiple choice, by looking at the advantages of the multiple choice test, the researcher believes this test will be better and able to be used to measure the level of understanding or ability of students about scientific literacy on temperature and heat material, because this test has serious difficulties. in selecting the most appropriate answer among the other answer choices.

3. Development Phase (Development)

This stage aims to produce a draft of a scientific literacy-based test instrument that serves to identify students' scientific literacy skills on temperature and heat materials. Activities at this stage include:

- ***Preparation of Scientific Literacy-Based Test Instruments***

At this stage, the preparation of scientific literacy-based test instruments consists of: a grid of questions, scientific literacy-based test questions, and scoring guidelines which are used as draft I.

- ***Validator Rating***

The scientific literacy-based test instrument that has been compiled (Draft I) is then validated by an expert validator. Validators are asked to provide an assessment of the

scientific literacy-based test instrument that has been developed based on the items on the assessment sheet and provide criticism and suggestions. The validation carried out is the completeness and feasibility of the material content, constructs, and grammar that have been developed. This validity is done by asking for advice or consideration from the experts as many as 5 people.

The results of the assessment given by the validator will be grouped into 3 essential levels, namely essential (3), useful but not essential (2), and not needed (1) and their validity is calculated using the Content Validity Ratio formula, namely:

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad (1)$$

Information:

n_e = the number of SME's who rate an item as essential
n = number of SME's who do the assessment

CVR is interpreted relatively in the range of -1.0 to +1.0. All items that have a negative CVR must be eliminated, while items that have a positive CVR can be used. the validity category can be seen in table 3.1. the following:

Table 2. Content Validator Criteria

CVR	Category
0.5 – 1.0	Valid
0.1 – 0.4	Valid, Need Revision
-0.1 – 1.0	Invalid, Replaced

The following are the results of the validation carried out on the test instrument shown in table 3:

Table 3. Content Validation Review Results

No	Criteria	No Question
1	Essential	1, 5, 10, 12, 13, 22, 23, 29, 30, 33, 34, 35,36, 37, 38, 39, 40
2	Useful but not Essential	2, 3, 6, 7, 8, 14, 18, 19, 20, 21, 27, 31, 32
3	Not required	4, 9, 11, 15, 16, 17, 24, 25, 26, 28

Based on the results of the validators carried out by experts, it can be concluded that from a total of 40 questions that have been designed, those in the Essential category are 17 questions and the Useful but Not Essential category are 13 questions and 10 questions are not needed according to table 3 above. Questions that are in the essential category can be used immediately, while questions in the useful but not essential category must be revised and corrected first in accordance with the suggestions given by the validator, and questions that are in the unnecessary category must be discarded or deleted and cannot be used. The results of the validator showed that there were 30 questions that were valid or that could be used after revision.

5 Conclusion

Based on this description, it can be concluded that Indonesia's low PISA score occurs because of the limited availability of PISA questions and their application in learning activities. The questions that have been designed in the first draft are 40 questions and after being validated against the validator the questions become 30.

References

[1] Pratiwi, I., (2019). Pisa Effect on Curriculum in Indonesia. Journal of Education and Culture, 4 (1): 51-71

[2] Bond, D. (1989). In Pursuit of Chemical Literacy: A Place For Chemical Reactions. Journal Of Chemical Education, 66 (2): 157

[3] DeBoer, GE (2000). Scientific Literacy; Another Look at Its Historical and Contempory Meanings and Its Relationship to Science Education Reform. Journal Of Research In Science Teaching, 37(6):582-601

[4] Odja, AH, & Payu, CS (2014). Analysis of Students' Early Science Literacy Ability on Science Concepts. Proceedings of the National Chemistry Seminar, ISBN: 978602-0951-00-3. Thing. 40-47.

[5] Murphy, S. (2010). The Pull of PISA: Uncertainty, Influence, and Ignorance. Interamerican Journal of Education For Democracy, 3 (1): 28-44

[6] Eve, AM, & Putra, LV, (2015). Pisa for Indonesian students.

[7] OECD. (2019).“PISA 2018 Science Framework”, in PISA 2018 Assessment and Analytical Framework. Paris: OECD Publishing.

[8] Sinaga, TT (2015). Development of PISA Model Questions for Integrated Natural Science Subjects Physics Content to Know the Reasoning of Class IX Students. Journal of Physics Innovation and Learning, 4 (2): 194-197

[9] Adholpus. (2012). Improving Scientific Literacy among Secondary School Students through Integration of Information and Communication Technology. APRN Journal of Science and Technology, 2 (5), 444–448.

[10] Sani, RA, & Prayitno, W. (2020). Minimum Competency Assessment. Bandung: Rosda

[11] Sugiyono. (2018). Educational Research Methods: Quantitative, Qualitative, and R&D Approaches. Bandung: Alphabeta.