

Research Article

Development Of Assessment Instruments Based On Science Literacy On Class X Environmental-Change Materials

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ABSTRACT

Based on PISA data, it shows that the scientific literacy position of Indonesian students is still in the last 10th rank compared to other countries. This shows the lack of skills of Indonesian students in solving PISA questions because in the learning process the assessment instruments used in schools have not reached the criteria for scientific literacy competence. This study aims to produce an assessment instrument based on environmental-change science literacy in class X students that is valid, practical, has varying levels of difficulty, has good discriminatory power, and is reliable. This type of research is research and development with a 4-D development model. The research subjects consisted of 47 students of class X of SMAN 16 Batam and the validators consisted of 2 lecturers of FMIPA UNP and 1 teacher of SMAN 16 Batam. This study resulted in a logically valid scientific literacy-based assessment instrument (85.26%). The results of the practical test of scientific literacy-based assessment instruments by teachers and students respectively were an average score of 82.77% (teachers) and 82.44% (students). The results of the analysis of instrument items using ANATES Version 4.09 are: on multiple choice questions of 0.40-0.69 (medium to high correlation), and very high reliability (0.90); on the questions of description, compound, and attitude of 0.34-0.80 (low to high correlation), and very high reliability (0.81). In the test of discrimination power of questions and the level of difficulty of the questions, the scores are quite varied.

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INTRODUCTION

Indonesia's national education aims to have the potential of students to become qualified people, as regulated in Law no. 20 of 2003 concerning the National Education System, namely education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential. The application of education in the field is still not optimal. There are still many obstacles and problems

encountered in the field, especially regarding the low quality of education. In an effort to overcome these problems, the government has made a paradigm shift by implementing the 2013 Curriculum using a scientific approach, namely: observing, asking questions, gathering information, associating, and communicating (Rahmawati, 2015: 2). One of the parameters to measure the quality of education is PISA (Program for International Student Assessment). PISA is organized by the OECD (Organization for Economic Co-operation and Development) which evaluates the education systems of several countries around the world. Where every 3 years 15-year-old students from schools are randomly selected to take tests in the main subjects to see literacy achievement in reading, mathematics, and science (Nasution, et al, 2019: 2).

Based on the PISA research by the OECD, it is known that the scientific literacy position of Indonesian students is in the last 10th rank compared to other countries. This shows the lack of skills of Indonesian students to solve PISA questions. In PISA scientific literacy questions, individuals are tested for their scientific knowledge skills to identify questions, explain scientific phenomena, and draw conclusions based on evidence from the problem in question (OECD, 2013: 17).

Seeing the results of the achievement of scientific literacy of students in PISA which is still low, is one of the empirical foundations for the creation of the 2013 curriculum using a scientific approach that accommodates the development of scientific literacy for students. However, in practice, not many schools apply questions that relate to everyday phenomena, so they cannot be used to measure students' scientific literacy (Pratiwi, 2019: 35). Saad & Boujaoude (2012) explained that there is a relationship between the level of knowledge and teaching practice in the classroom. This can be anticipated by socializing the manufacture and use of instruments so that teachers become accustomed to using assessment instruments. Mueller (2005) explains that various assessment methods must be able to measure all aspects that students know and do. Authentic assessment based on scientific literacy is a form of assessment that is real, meaningful for students, able to develop higher-order thinking skills and contains dimensions of scientific literacy (concepts, processes, and contexts).

Based on the results of observations through the distribution of questionnaires to two biology teachers at SMA Negeri 16 Batam, it was found that the assessment instruments used in schools today are not fully directed to questions that involve high-level reasoning and thinking skills. In Bloom's Taxonomy, the formulation of questions involving students' higher-order thinking skills starts at the cognitive level C3 to C6. This result is reinforced by the results of the analysis that the authors conducted together with the biology teacher of SMA Negeri 16 Batam on the semester exam questions made by the class X Biology teacher. The distribution of cognitive levels of semester exam questions for biology class X SMA subjects used at SMA Negeri 16 Batam is still dominated by levels C2 (low) and C3 (moderate), the distribution of questions should be evenly distributed for all cognitive levels of Bloom's taxonomy. Based on the response questionnaire by the class X biology teacher, Mr. Yulpaldi, S.Pd., and Mrs. Tut Anggraeni S.Pd., it also shows that teachers are not familiar with science-literacy assessments. This is also in line with the distribution of questionnaires to 15 students of class X SMA Negeri 16 Batam, it is known that they have never done the PISA science-literacy test or other similar tests.

Based on the results of the analysis that the researchers have done, it is known that the assessment instruments used by schools today have not been able to develop students' science-literacy skills. Thus, it is necessary to develop science-literacy based assessment instruments that can be used and adapted by teachers to be applied in learning evaluation.

The selection of materials to develop questions that meet the criteria for achieving science-literacy is adjusted to the criteria set by PISA. PISA assesses scientific knowledge using contexts that raise relevant issues, one of which is the environment (OECD, 2019). Based on the characteristics and topics on environmental change material, the development of science-literacy based assessment instruments set by PISA has the potential to be developed. Based on the description above, the authors conducted research on "Development of Assessment Instruments Based on Science-Literacy on Class X Environment-Changes Material".

METHOD

This research is research and development. The assessment instruments based on science-literacy on class X environment-changes material were developed using a 4-D development model.

1. The defining stage

The definition stage is the stage to determine and define the requirements needed in the development of learning. Activities carried out at this stage include early-late analysis, student analysis, analysis of exam questions, and curriculum analysis.

a. Early-late analysis

Activities at this stage are carried out to collect information about problems in learning assessments. The activity began with filling out a questionnaire by two class X teachers at SMA Negeri 16 Batam in October 2020. The questionnaire contained questions about the assessment used by teachers and teachers' knowledge of science literacy. The results of the teacher observation questionnaire analysis obtained information that the two biology subject teachers at the school did not fully know the terms about science literacy by PISA so in evaluating the learning used it was not based on science literacy, whereas, in the 2013 curriculum, science literacy used a scientific approach demanding teachers to develop science literacy for students.

b. Student analysis

The activity at this stage is the observation of class X students of SMA Negeri 16 Batam using an observation questionnaire. The questions asked are questions that have been done by students and knowledge of science literacy. From the results of the questionnaire analysis, it is known that in the evaluation process the assessment learning used still focuses on dominantly rote questions, and the questions tested by teachers in schools are still in the medium category. In addition, the assessment used by the school has not linked the material to everyday life which will lead students to reason and think critically. This shows that the assessment used in learning is not yet based on science literacy. So it is necessary to develop assessments based on science literacy to improve students' scientific literacy skills.

c. Analysis of exam questions

Analysis of exam questions is done to find out the exam questions used by the school. From the results of the analysis of the exam questions for the second semester of class X biology subject at SMA Negeri 16 Batam for the 2019/2020 Academic Year, it is known that the assessment used has not fully implemented instruments based on based literacy. The questions only contain literacy competencies, namely explaining scientific phenomena (7%), evaluating and designing scientific investigations (3%), and interpreting scientific data and evidence (17%). Meanwhile (75%) are questions that are not included in the category of PISA science literacy competence.

d. Curriculum analysis

Curriculum analysis is carried out as a basis for formulating assessment instruments based on science-literacy on class X environment-changes material. This activity is carried out by reviewing the curriculum used by schools. Based on the results of an observation questionnaire on teachers, it is known that SMA Negeri 16 Batam has implemented the 2013 curriculum.

2. Design stage

The activity carried out at this stage is to design an assessment instrument based on scientific literacy. The activities that will be carried out in this design are as follows.

a. Application selection

The application selection aims to help facilitate the design stage of making assessment instruments. The design of the assessment instruments based on science-literacy on class X environment-changes material was carried out using the Microsoft Office Word 2010 application. The components in this instrument include the outer cover, inner cover, instrument working instructions, questions, answer sheets and complete answer keys with scoring guidelines.

b. Format selection

At this stage, the format selection is carried out to prepare assessment instruments based on science literacy on class X environment-changes material framework. The choice of format will determine the appearance of the assessment to be developed. The format chosen must be attractive, clear, unobtrusive, and provide convenience to students in solving questions based on science literacy.

c. Preliminary design

Activities carried out at the initial design stage include the following.

- 1) Analyzing basic competencies following science literacy competencies.
- 2) Designing a lattice of questions on the material for environmental. change in class X.
- 3) Designing items according to the lattice on the material for environmental changes in class X.
- 4) Prepare the answer key

3. Stage of development

This stage aims to test the validity, practicality, reliability, level of difficulty, and distinguishing power of the assessment instrument are developed.

a. Validity test

The validation of the assessment instruments based on science literacy was carried out with logical and empirical validation. The purpose of logical validation is to determine the value of the assessment instruments based on science literacy in measuring student learning outcomes that are developed based on aspects of the material, construct, and language. After the logical validity test, the questions were tested on class X students of SMAN 16 Batam to test the empirical validity. Validity determines the extent to which the instrument measures what it purports to measure. The way to determine the validity of the instrument is to focus on the value of content validity and construct validity (Gormally et al., 2012).

b. Practical test

The practicality test was carried out using a practicality test questionnaire for teachers and students. The practicality test aims to determine the practicality of the assessment instruments developed both in the implementation, examination, and clear instructions for scientific literacy-based assessment instruments so that they can be used.

c. Reliability

The reliability of the assessment instruments based on science literacy was obtained after the questions were tested on students of SMAN 16 Batam and obtained from item analysis using the ANATES version 4.09 application.

d. Difficulty level

The level of difficulty determines how easy or difficult an item is for students. Good items are items that are not too easy and not too difficult. Data were obtained from item analysis after the assessment instruments were tested on students using the ANATES version 4.09 application.

e. Discrimination power

Discrimination power states how much an item can distinguish between high-ability students and low-ability students. The data used to find the distinguishing power was obtained after the assessment instrument was tested on students using the ANATES version 4.09 application.

The research data were analyzed using the following techniques:

1. Analysis of the validity of the assessment instruments based on science literacy in class X environment-changes material

a. Logical validity

- 1) Give a score of answers with the following Likert Scale modified from Arikunto (2012: 180).

4 = Strongly Agree (SA)

3 = Agree (A)

2 = Disagree (D)

1 = Strongly Disagree (SD)

- 2) Determine the highest score

Highest score = number of validators × maximum score

- 3) Determine the score obtained by adding up the scores from each validator.

4) Determine the value of validity by:

$$\text{Validity value} = \frac{\text{Total score obtained}}{\text{Total highest score}} \times 100\%$$

5) Provide a modified validity assessment from Purwanto (2012: 82) as follows:

90%-100% = Very valid

80%-89% = Valid

60%-79% = Fairly valid

0%-59% = Invalid

b. Empirical validity

Empirical validity is carried out in the following way.

1. Determine the student's score on the item whose validity is calculated.
2. Determine the total score of students.
3. The data were analyzed by the following formula.

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}}$$

Where: R_{xy} = Validity of the question

N = Number of samples

X = Item score

Y = Total score (Arikunto, 2012: 92).

4) The validity value is determined by the following correlation.

0.800-1.00 = Very high

0.600-0.800=High

0.400-0.600 = Enough

0.200-0.400 = Low

0.00-0.200 = Very low (Arikunto, 2012: 89).

2. Analysis of assessment instruments based on science literacy in class X environment-changes material

a. Provide an answer score with criteria based on the following Likert scale.

4 = Strongly agree (SS)

3 = Agree (S)

2 = Disagree (TS)

1 = Strongly disagree (STS)

b. Determine the practicality value with the following formula.

$$\text{Practicality value} = \frac{\text{Total Score Obtained}}{\text{Maximum score}} \times 100\%$$

c. After the percentage is obtained, grouping is carried out according to the criteria modified by Purwanto (2012: 102-103) below.

0%-54% = Not practical

55%-64% = Less practical

65%-79% = Quite practical

80%-89% = Practical

90%-100% = Very practical

3. Analysis of the discrimination power of assessment instruments based on science literacy in class X environment-changes material

The discrimination power of assessment instruments based on science literacy is obtained from the results of ANATES version 4.09. The classification of distinguishing power according to Arikunto (2016: 232) is as follows.

D: 0.00-0.20 = Ugly

D: 0.20-0.40 = Enough

D: 0.40-0.70 = Good

D: 0.70-1.00 = Very good

D: Negative, all of them are not good, so all questions that have a negative D score should be discarded.

4. The level of difficulty of the questions

The difficulty level of assessment instruments based on science literacy was obtained from item analysis using ANATES version 4.09. According to Arikunto (2016), the difficulty index is classified as follows.

a. Questions with a difficulty level of 0.00 to 0.30 are classified as difficult.

b. Questions with a difficulty level of 0.31 to 0.70 are classified as moderate.

c. Questions with a difficulty level of 0.71 to 1.00 are relatively easy.

The questions that will be used are questions that are classified as moderate with a difficulty level of 0.31-0.70.

5. Reliability

Reliability for assessment instruments based on science literacy can be seen from item analysis using ANATES version 4.09. The interpretation of the reliability value proposed by Arikunto (2012) is as follows.

0.76-1.00 = Very high

0.51-0.75 = Height

0.26-0.50 = Low

0.00-0.25 = Very low

The reliability criteria used in this study were 0.51-0.75.

RESULT AND DISCUSSION

1. Results of the analysis of the logical validity

The results of the analysis of the logical validity of assessment instruments based on science literacy can be seen in Table 1.

Table 1. Results of Analysis of Logical Validity Assessment instruments based on science literacy

No.	Assessment Aspect	Validity Value	Criteria
1.	Content (Material)	86,27%	Valid
2.	Construction	85,00%	Valid
3.	Language	85,41%	Valid
4.	Technique	84,37%	Valid
Average		85,26%	Valid

The validity of the scientific literacy-based assessment instrument was carried out by three validators. Based on the data obtained from the analysis of logical validity by the validator, in general, the assessment instruments based on science literacy in class X environment-changes material have met the valid criteria with an average validity value of 85.26%. This is in accordance with the modified validity assessment of Purwanto (2012), stating that 80-89% is a validity value with valid criteria.

Aspects of logical validity assessment on assessment instruments based on science literacy are aspects of content/material, construction, language, and technique. Based on the content/material aspect for the assessment instruments based on science literacy developed, it was declared valid by the validator with a validity value of 86.27%. This means that the questions developed are relevant and contain aspects that must be mastered. According to Arikunto (2016), a test is said to have content validity if it measures certain specific objectives that are parallel to the subject matter provided.

The construction aspect for the assessment instrument developed was declared valid by the validator with a validity value of 85.00%. This shows that the formulation of the questions in the assessment instrument has been systematic, clear, and in accordance with the formulation of indicators and learning objectives. Sukardi (2011), states that the subject matter must be clearly formulated and must be related to the material being asked.

The language aspect for the assessment instrument developed was declared valid by the validator with a validity value of 85.41%. This proves that the formulation of the sentence used in the question is communicative, the formulation of the question does not have a double meaning, is easy to understand, and uses language that is in accordance with the rules of the Indonesian language.

The technical aspect of the assessment instrument developed was declared valid by the validator with a validity value of 84.37%. Assessment of this technical aspect is related to the use of the type of size and letter in the questions, and the functioning of the pictures, graphs, tables, and graphs contained in the questions. Based on the assessment given by the validator, shows that this aspect has been achieved.

2. Practicality Test Results

The practicality test of the assessment instrument was carried out on 1 (one) teacher and 47 students of class X SMAN 16 Batam. The results of the practicality analysis by the teacher can be seen in Table 2.

Table 2. The results of the practical analysis of assessment instruments based on science literacy by teachers

No.	Assessment Aspects	Practicality Value (%)	Criteria
1.	Question Instructions	100,00	Very Practical
2.	Ease of Use	88,88	Practical
3.	Time Effectiveness	75,00	Practical enough
4.	Inspection	75,00	Practical enough
5.	Equivalence	75,00	Practical enough
Total		413,88	Practical
Average		82,77	

The results of the analysis of practicality by students can be seen in Table 3.

Table 3. The results of the analysis of the practicality of assessment instruments based on science literacy by students.

No.	Assessment Aspects	Practicality Value (%)	Criteria
1.	Question Instructions	79,78%	Practical enough
2.	Ease of Use	80,60%	Practical
3.	Time Effectiveness	85,10%	Practical
4.	Equivalence	84,30%	Practical
Total		329,76%	Practical
Average		82,44%	

The practicality test of the assessment instrument was carried out on one teacher and 47 students of class X SMAN 16 Batam. Based on the results of the practicality analysis by the teacher, the practicality value was 82.77% with practical criteria. In comparison, the results of the practicality analysis by students obtained a practicality value of 82.44% with valid criteria. This shows that these assessment instruments based on science literacy can already be used as assessment instruments in learning in schools because they have overall practical value from each aspect.

Aspects of the assessment for the practicality test for teachers and students are almost the same, but for teachers, an examination aspect is added. Overall aspects of the assessment consist of aspects of question instructions, ease of use, time effectiveness, examination, and equivalence,

Based on the aspect of the question instructions, it is considered practical with a value of 89.89%. This shows that the assessment instrument is equipped with clear question instructions. This is in accordance with the opinion of Arikunto (2016) which states, a test is said to be practical if it is equipped with clear instructions so that it can be given to others.

The ease of use aspect is considered practical with a value of 84.74%. This shows that the assessment instrument is easy to implement. Easy to implement means that it does not require a lot of equipment and gives students the freedom to work on the parts that are considered easy by students (Arikunto, 2016).

The aspect of time effectiveness is considered practical with a value of 80.05%. This is because the questions tested amounted to 25 questions with 4 questions in 100 minutes. This is in line with the opinion of Yusuf (2017: 89), stating that several things can be used as a benchmark for an instrument to be said to be practical, one of which is the time given is right and not too long.

The examination aspect is considered quite practical with a value of 75.00%. This assessment shows that the assessment instrument is quite easy to examine. Easy to check, meaning that the test is equipped with answer keys and scoring guidelines (Arikunto, 2016).

The equivalence aspect is considered quite practical with a value of 79.65%. This shows that the assessment instrument has equivalence with the demands of the curriculum applied in schools and the questions presented are needed by students as a tool in the practice of working on questions that involve reasoning and critical thinking students.

3. Analysis of Questions

Item analysis was carried out to obtain the value of empirical validity, reliability, level of difficulty, and distinguishing power of the developed questions. The item analysis for each type of question can be seen in Table 4.

Table 4. Results of item analysis on assessment instruments based on science literacy using ANATES Version 4.09.

Question Type	Empirical Validity (Correlation)	Reliability	Discrimination Power (%)	Difficulty Level (%)
Multiple choice	Valid (0.40-0.69)	Reliable (0.90) Very High Category	Good (82.36) Very Good (17.64)	Easy (23.50) Medium (70.60) Difficult (5.90)
Description, compound, and attitude	Valid (0,34-0,80)	Reliable (0.81) Very High Category	Enough (12,5) Good (62.5) Very Good (25)	Easy (25) Medium (75)

Based on the results of the analysis of the empirical validity of the multiple choice questions, there were 8 questions with a very significant category and 7 questions with a significant category. As for the description, compound, and attitude questions, there are 3 questions with very significant categories and 2 questions with significant categories. This data was obtained by analyzing the items tested using the product moment correlation formula. The problem is said to be significant when the coefficient of the product-moment correlation (r -count) is greater than (r -table).

Furthermore, the reliability obtained from the assessment instrument developed was 0.90 (very high) for multiple-choice questions and 0.81 (very high) for description, compound, and attitude. This shows that the questions developed already have accuracy. This is in line with the opinion of Sudjana (2011), which states that reliability is the determination of a tool to assess what is being assessed. That is, whenever the assessment tool is used it will give relatively the same results.

The discriminating power of questions that have been tested at SMAN 16 Batam for multiple choice questions is in a good category (82.36%) and very good (17.64%). As for the description, compound, and attitude questions, they are categorized as sufficient (12.5%), good (62.5%), and very good (25%). Based on the results of the discriminatory analysis, it is known that the type of multiple-choice questions has a high percentage value, meaning that the questions tested are able to distinguish between high-ability testees and low-ability testees. Meanwhile, the types of description, compound, and attitude questions also show a high percentage of good discriminating power categories. This means that only students who have the ability to understand the question well can provide the correct answer.

Based on the analysis of the level of difficulty of the questions on the assessment instrument, it has varied. Types of multiple choice questions from the analysis results as much as 23.50% are in the easy category, 70.60% are in the medium category, and 5.90% are in the difficult category. As for the description, compound, and attitude questions, 25% are in the easy category and 75% are in the medium category. Based on the results of the analysis of the level of difficulty of the questions, information was obtained that the average items developed were in the medium category. This means that the questions are neither too

easy nor too difficult. This is in line with the opinion of Arikunto (2013), which states that questions that are too easy do not stimulate students to increase their solving efforts. On the other hand, questions that are too difficult will cause students to give up and not be enthusiastic to try again because they are beyond their reach.

CONCLUSION

Based on the research conducted, it was concluded that it had produced an assessment instrument based on science literacy regarding the material of environmental change in class X which was judged to be logically valid and empirically valid with low to high correlation, practicality, very high test reliability, discrimination power and levels of difficulty are varying.

REFERENCES

- Arikunto, S. (2013). *Dasar-Dasar Evaluasi Pendidikan*. Jakarta: Bumi Aksara.
- Arikunto, S. (2016). *Dasar-Dasar Evaluasi Pendidikan*. Jakarta: Bumi Aksara.
- Gormally, C., Brickman, P., & Lut, M. (2012). Developing a test of scientific literacy skills (TOSLS): Measuring undergraduates' evaluation of scientific information and arguments. *CBE Life Sciences Education*, 11(4), 364–377.
<https://doi.org/10.1187/cbe.12-03-0026>.
- Mueller, J. (2005). *The Authentic Assessment Toolbox: Enhancing Student Learning through Online Faculty Development*. North Central College, Volume 1 No. 1. Hal 1-7.
- Nasution, I. B., dkk. (2019). Development of Scientific Literacy Instruments Based on Pisa Framework For High School Students on Global Warming Topic. *Journal of Physics: Conf. Series*, 1157(032063): 1–6.
- OECD. (2013). *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*. OECD Publishing.
- OECD. (2019). *PISA 2018 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*. OECD Publishing.
- Pratiwi, S. N. dkk. (2019). Pembelajaran IPA Abad 21 dengan Literasi Sains Siswa. *Jurnal Materi Dan Pembelajaran Fisika (JMPF)*, 9, 34–42.
- Purwanto, M. N. (2012). *Prinsip-prinsip dan Teknik Evaluasi Pengajaran*. Bandung: PT. Remaja Rosdakarya.
- Rahmawati, D., Alberida, H. dkk. (2015). *Buku Ipa Terpadu Berbasis Problem Solving Dan Literasi Sains Untuk Siswa Kelas Vii Smp Integrated Science Book Based on Problem Solving and Scientific Literacy for Junior High School Students Class Vii*. 421–430.
- Saad, R. & Boujaoude, S. (2012). The Relationship between Teachers' Knowledge and Beliefs about Science and Inquiry and Their Classroom Practices. *Eurasia Journal of Mathematics, Science & Technology Education*, Volume 8 No. 2. Hal 113-128.
- Sudjana, N. (2011). *Penilaian Hasil Proses Belajar Mengajar*. Bandung: PT. Remaja Rosdakarya.
- Sukardi. (2011). *Evaluasi Pendidikan: Prinsip dan Operasionalnya*. Jakarta: Bumi Aksara.
- Yusuf, M. A. (2017). *Asesmen dan Evaluasi Pendidikan*. Jakarta: Prenada Media Group.