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Development of an Environment-Based Critical Thinking Skills Test Instrument for Class VII Middle School Science Learning

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Abstract: This research developed an environment-based critical thinking skills test instrument for science learning in class VII middle school to answer the problem of students' low critical thinking skills in Indonesia. The aim of the research is to produce a valid and reliable instrument to measure students' critical thinking skills in an environmental context. The research method uses the ADDIE development model with a pre-experimental design (one group pretest-posttest). Research findings show that the instrument developed has high validity and reliability and is able to significantly improve students' critical thinking skills. The conclusion of this research is that environment-based test instruments are effective in measuring and improving students' critical thinking skills. The implications of this research show the importance of integrating environmental issues in learning modules to improve the quality of science education in Indonesia.

Keywords: ADDIE model science learning; Critical thinking skills; Environment based; Test instruments

Introduction

The world has entered the era of revolution 4.0, marked by the combination of technology and the blurring of the lines of physical, digital and biological space in every human activity which is slowly converting from manual digital. World demands require the education sector to carry out various innovations in improving human resource (HR) competencies through increasing critical thinking skills which are expected to help students filter and develop the information obtained (Perdanasari et al., 2021; Dwivedi et al., 2023). Critical thinking skills are mental activities that students must have, especially in the science learning process to help formulate, identify and solve problems (Nurfaizah et al., 2022; Aswanti & Isnaeni, 2023). However, the results of the Program for International Student Assessment (PISA) survey and The Trends in International Mathematics and Science Study (TIMSS) show that Indonesia is ranked in the bottom 10 and the quality of Indonesian education, especially in the field of science, is only ranked 44th out of 49 countries. TIMSS added that students in Indonesia are still weak in terms of high-level cognitive skills such as reasoning, analyzing, evaluating so that critical thinking abilities are classified as low.

Students' poor critical thinking abilities are also due to learning models that are not yet optimal, many children have difficulty understanding concepts and stutter when applying them (Ningrum et al., 2021). One learning model that is suitable for problem-based learning in order to empower students' critical thinking skills is the Problem and Research Based Learning (PRBL) model (Arifianto & Koeswanti, 2022; Suhirman & Khotimah, 2020). This model makes students carry out experiments with the aim of making students more active, dare to give opinions, and find solutions (Smiderle et al., 2020).

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Learning modules play an important role in designing quality student learning (Dewi et al., 2022; Ahmad Zabidi et al., 2017). Modules that are not adapted to current developments and are not interesting make students bored of learning (Marlena et al., 2022; Mulyati et al., 2022). The modules used as student teaching materials are also the cause of students' low level of critical thinking (Pratiwi et al., 2021). Technological sophistication is a solution in improving this module by making the module in digital form or called an e-module (Zakiyah & Dwiningsih, 2022). This e-module, which has been equipped with appropriate teaching materials and learning models, is expected to be a form of learning that can improve students' critical thinking abilities. The large need for development needed to improve students' critical thinking skills learning in the field of science with the concept of environmental pollution using e-modules is the aim of the research to be carried out (Wati et al., 2023; Dwi Novita et al., 2022).

Looking at the education curriculum in Indonesia, especially at the junior high school level, there is still a need to develop instruments that can measure and evaluate students' critical thinking skills effectively, especially in the context of environment-based science learning (Parmini et al., 2023). This research aims to develop a test instrument that is not only curricularly relevant, but also able to integrate environmental issues to make the teaching and learning process more dynamic and applicable (Kioupi & Voulvoulis, 2022). By developing an environment-based critical thinking skills test instrument, it is hoped that it can provide tools for teachers to measure and understand the extent to which students can apply critical thinking skills in a broader and multidisciplinary context (Harahap et al., 2020). It is also hoped that this can motivate students to be more active in the teaching and learning process, while increasing their awareness and participation in environmental issues. Therefore, the development of this instrument is very relevant and significant in creating education that is more adaptive and responsive to global challenges and local needs.

Method

This research uses development methods or is often referred to as development research. The development procedure used refers to the ADDIE model which can be carried out continuously (Dwitiyanti et al., 2020). The research design uses pre-experiment (one group pretest-posttest). Pre-experimental research where there is no control group or random assignment procedure (Haswan et al., 2024). Data analysis was carried out descriptively using a quantitative approach to students' creative thinking abilities. Using the Aiken Index to analyze the feasibility of the instrument being developed. The analysis stage was carried out to determine instrument needs, analyze students' creative thinking abilities, material analysis, and environmental analysis (Nufus et al., 2024). The design stage is carried out after the analysis stage such as determining appropriate material, test forms, and the chosen learning approach. The development stage is carried out by developing the question grid into question items by adhering to a predetermined approach. The results of developing the question items are then validated by experts and revised according to the validator's suggestions. Implementation was carried out at MTsN 1 Sukoharjo. The small class test was carried out in Class VII with 26 students. Evaluation is carried out after the instrument has been tested.

Result and Discussion

An environment-based critical thinking skills test instrument has been successfully developed and tested in science learning for class VII junior high school. Analysis of the results of developing this test instrument includes an evaluation of the validity, reliability and effectiveness of the instrument in measuring students' critical thinking skills. The instruments used in the experiment have gone through the ADDIE development procedure, which is one of the teaching material development designs that goes through 5 stages (Shakeel et al., 2023), Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model is a learning system design model that shows the basic stages of a learning system that is easy to carry out. The design for developing teaching materials is as follows:

Analysis Stage

Analysis is the first step in the research procedure. The purpose of the analysis stage is to identify problems that allow gaps in learning to occur (Yew & Goh, 2016). At this stage, researchers carry out two types of analysis, namely needs analysis and curriculum analysis. Needs analysis is carried out through observations and interviews with teachers at schools. Through observations and interviews, researchers succeeded in identifying several problems related to critical thinking skills and environmental awareness in science learning. Some of the problems that arise include:

Limitations of Evaluation Instruments

Science subject teachers stated that the existing evaluation instruments were not fully capable of measuring students' critical thinking skills as a whole.

Lack of Environmental Awareness

Class VII students do not have sufficient environmental awareness in the context of science

learning, resulting in a lack of understanding of the impact of human actions on the environment.

Gaps in Curriculum

There is a gap between the existing curriculum and the need for more integrated and environment-based learning of critical thinking skills. Apart from needs analysis, researchers also conducted an analysis of the applicable curriculum. This was done to understand the extent to which the current curriculum supports the development of environment-based critical thinking skills in science learning for grade VII SMP. Thus, the results of this analysis are an important step in developing test instruments that can increase the effectiveness of science learning in developing critical thinking skills and environmental awareness in class VII middle school students. The analysis carried out is a basic stage in product development. After obtaining data from the results of the needs analysis and curriculum analysis, the next thing to do is take solutions related to the existing problems.

The development of an environment-based test instrument that can improve critical thinking skills has been developed and the results obtained are 10 items that are valid, reliable, have differentiating power and the right level of difficulty. Based on research at MTsN 1 Sukoharjo and SMP Daruul Qur'an Colomadu, the results showed that the achievement of critical thinking ability indicators was obtained on average at 80.4% consisting of; The Interpretation indicator analysis was 88%, the Analysis indicator was 79.3%, the Evaluation variable was 85.6%, the Inference variable was 70.2% and the Explanation variable was 79.2%. Improving students' Critical Thinking Ability can be done in various ways such as learning activities, lesson materials, and test instruments that contain indicators of Critical Thinking Ability.

Design Stage

The material used in this PRBL E-module is about environmental pollution, in accordance with Minister of Education and Culture Regulation Number 37 of 2018 concerning Core Competencies and Basic Competencies in the 2013 Curriculum which was presented in class VII semester 2. This material was developed based on KD 3.8, namely analyzing the occurrence of environmental pollution and its impact on the ecosystem, as well as KD 4.8, namely writing about ideas for solving pollution problems in the environment based on the results of observations.

The type of test that will be developed is a description test. This test gives students the opportunity to answer questions with in-depth and detailed explanations. Additionally, this form of test allows students to express their creativity by designing products and creating relevant illustrations. Therefore, the description test is considered more suitable for measuring students' Critical Thinking Abilities. Before developing the questions, a question grid is first drawn up. This grid functions as a guide that helps in creating questions to suit the indicators and sub-indicators of Critical Thinking Ability. With the grid, it is hoped that the question preparation process will be more focused and able to measure students' abilities accurately and comprehensively. See table 1 regarding the design of critical thinking ability test instruments.

Development Stage (Development)

At this stage, an instrument validation sheet is developed to assess the validity of the test. Validation is carried out by experts using content criteria which include suitability of sub-indicators to questions (Sugiarta et al., 2023), suitability of questions to answers, and suitability of questions to Bloom's Taxonomy, as well as considering appropriateness of language and presentation (Kesumawati et al., 2022; Sarwanto et al., 2020). This validation process aims to determine the feasibility of the instrument that has been developed.

The validation results were then analyzed using the Aiken's V index. The assessment was carried out by 7 experts consisting of 5 teachers and 2 lecturers, using a five-point scale. An instrument is considered eligible if the Aiken index is greater than 0.80 and is considered ineligible if the Aiken index is less than 0.80. The results of this expert validation were presented and analyzed based on the Aiken V Index as shown in Table 2. The validation results obtained several suggestions for making improvements. Improvements are found in the analysis, evaluation and inference indicators. Revisions were made as in Table 1.

Table 1. Critical Thinking Ability Test Instrument Design

Indicator	Material	Questions and answers	Score	Explanation
Interpretation	A person's ability to understand and express the meaning of a situation, data, judgment, rule,	Question: Explain whether it is true that household waste such as detergent, clothes bleach, or bath soap, if thrown directly into the river, could threaten the survival	Question a: 4 = Students can explain correctly and appropriately and provide solutions	Question a, C2. Question b, C4. (Analyze) Question a, C2. Question b, C4. (Analyze)

Indicator	Material	Questions and answers	Score	Explanation
	procedure, or variable criteria.	of the organisms that live in the river! Based on this, try to provide a relationship between human activities and environmental pollution! Answer: Yes, this can affect the survival of the disengai organism. Because detergents, clothes bleach and others can threaten the survival of organisms in the river because these materials contain dangerous chemicals, the fish can experience convulsions, have mucus, gills bleed and can even cause the fish in the river to die and the population The number of fish in the river is decreasing. The relationship between human activities such as washing clothes in the river and also disposing of industrial waste is that the more often local residents wash clothes in the river and the greater the waste disposal carried out, the lower the quality of the river water will be, the fish population will be disturbed and also the ecosystem in the river. will be unbalanced.	3 = Students can explain but are not precise in providing solutions 2 = Students are not precise in explaining and are not able to provide solutions 1 = Students are only able to explain one question for each question 0 = Student did not answer Question b: 4 = Students can explain accurately and appropriately the relationship between human activities and environmental pollution. 3 = Students can explain but are not precise in providing the relationship between human activities and environmental pollution. 2 = Students are not precise in explaining. 1 = The student is only able to explain and the explanation is not appropriate. 0 = Student did not answer	
Analysis	A person's ability to clarify conclusions based on the relationship between information and concepts, with the questions in the problem.	Question: Look at the following picture!  Based on your observations of the photo, name 5 signs of water pollution that is occurring! Analyze what you think about the impact if this happens continuously! Answer: Signs of water pollution that occur include: The water is cloudy, There, is rubbish, The presence of sediment, Disruption of the life of aquatic organisms. Flooding can occur due to waterways being clogged with rubbish, and It smells bad. The impact or consequence that will occur is that the level of pollution that occurs continuously	Question a: 4 = Students can name 5 signs of water pollution that occur according to observations in the picture completely and precisely 3 = Students can name 4 signs of water pollution correctly 2 = Students can name 3/2 signs of water pollution 1 = Students are only able to name 1 sign of water pollution 0 = Student did not answer Question b: 4 = Students can analyze the impacts and consequences that occur appropriately and correctly	Questions a, C2. Problem b, C4. (Analyzing)

Indicator	Material	Questions and answers	Score	Explanation
		will be detrimental to the surrounding environment. This will cause damage to the environment, the natural balance will be disturbed, and the aquatic ecosystem will be reduced. This is because many organisms die due to pollution.	3 = Students can analyze the impact but it is not appropriate 2 = Students can analyze the impact briefly 1 = Students cannot analyze the impacts and consequences that occur 0 = Student did not answer	

Table 2. Content Validity Results with Aiken V (Source: Primary Data, 2024)

Appropriateness	V	Information
Average Content Eligibility	0.87	Valid
Suitability sub. Indicator with questions	0.91	Valid
Conformity of questions to Bloom's Taxonomy	0.90	Valid
Correspondence of questions to answers	0.89	Valid

Table 3. Instrument Revision

Indicator	Sub Indicator	Before	Revision	Information
Interpretation	Explain	Image is not clear	The picture has been clarified	The image could be made clearer, especially the waste water intake
Analysis	Analyze	The problem is still C2	C4 Analyze	Regarding a C2, try using other KKOs, for example: - describe the 3 sources of water pollution, -Relate the phenomenon to sources of pollution, etc -Analyze the sources of water pollution in the ditch.
Evaluation	Evaluate	C4 Analyze	C5 Evaluate	This knockout is still C4, needs to be checked again. It's best to evaluate the impact
Inference	Make decisions	C5 Conclude	C4 Conclude	Concluding what is included in the C5 evaluation category? The editing of this sentence needs to be corrected

The Small Class Test was carried out in Science Class VII B SMP Darul Qur'an Colomadu with 18 students. Achievement of Critical Thinking Ability Indicators as in Table 4. How to categorize the achievement of critical thinking ability indicators. The level of students' creative thinking abilities is as in Table 5.

Table 4. Results of Achievement of Critical Thinking Ability Indicators

Indicator	Percentage	Category
Interpretation	81.30	Tall
Analysis	68.80	Currently
Evaluation	79.20	Tall
Inference	58.30	Low
Explanation	66.70	Tall

Table 5. Results of Creative Thinking Ability Levels

Criteria	f	Percentage
Very Critical	14	53.84
Critical	7	26.92
Quite Critical	3	11.53
Less Critical	2	7.69

At this small class test stage, problems were found with the Inference indicator where the students tested got a low score of 58.30% so they were concluded to be less critical. As for the tests on other questions, there are no obstacles in completing the tests so they can be continued with other class tests. At this development stage, the instrument was tested in Science Class VII A as many as 26 students. Achievement of Critical Thinking Ability Indicators as in Table 6 below:

Table 6. Results of Achievement of Critical Thinking Ability Indicators

Indikator	Percentage	Category
Interpretation	91.80	Very high
Analysis	93.80	Very high
Evaluation	76	Currently
Inference	88.50	Tall
Explanation	78.80	Tall

Table 7. The Level of Students' Critical Thinking Abilities in the Science Class VII A Trial is as in Table 7

Criteria	f	Percentage
Very Critical	18	69.23
Critical	6	23.07
Quite Critical	2	7.69

Based on the data above, the level of Critical Thinking Ability of students tested in small classes, namely Science Class VII B and VII A, is different because the number of Class VII A students is more, and Class VII A students have more ability in providing critical analysis of the question items. The next development is implementation in Class VII MTs 1 Sukoharjo so that the results can be used as a comparison.

Implementation Stage

From the data above, we can see the level of critical thinking ability of Class IIV Middle School students from environmental-based questions. At the implementation stage, researchers used question sheets and answers which were tested on students based on critical thinking ability indicators (Amrul et al., 2022); (dos Santos Accioly Lins et al., 2021). The following is the application of critical thinking skills based on the interpretation indicators in Figure 1.

Figure 1. Answer sheet for questions 1 and 2 from the interpretation ability indicator

The application of critical thinking skills to interpretation indicators consists of two questions, namely assessing students' ability to identify and explain. From the answer sheet, question 1, it can be seen that students are able to identify the household waste problem described in question 1. Furthermore, question 2 shows that students are also able to provide an explanation of the relationship between human activities and environmental pollution (Hove et al., 2020). Next, apply critical thinking skills to analysis indicators.

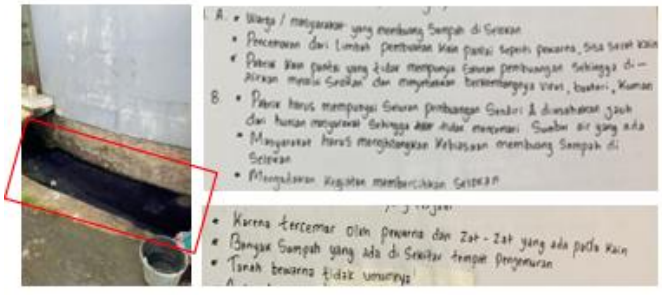

Figure 2. Answer sheet for questions 3 and 4 from the analytical ability indicators

The application of analytical skills can be seen from students' ability to understand data and events. Question 3 directs students to analyze the image and provide 5 signs of water pollution. As for question 4, students are asked to provide an analysis of the impact of environmental pollution. Then, apply critical thinking skills to evaluation indicators (Febri et al., 2019).

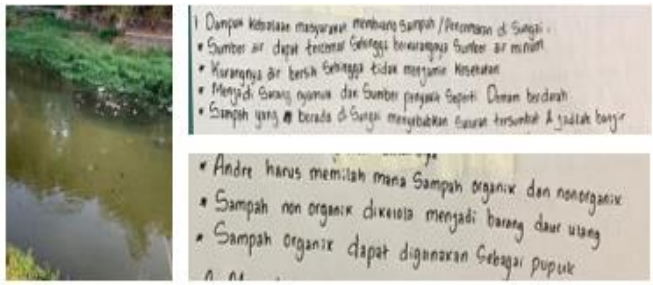

Figure 3. Answer sheet for questions 5 and 6 from the evaluation ability indicators

The application of evaluation skills can be seen in the student answer sheet, Figure 3. From the answers given, it appears that students understand the questions well, they can provide arguments for the impacts caused by river water pollution and are able to relate them to everyday life. Students can critically differentiate various types of waste, both organic and non-organic (Arifin et al., 2023). Then, apply critical thinking skills to explanation indicators (Ramadhani & Nurita, 2022).

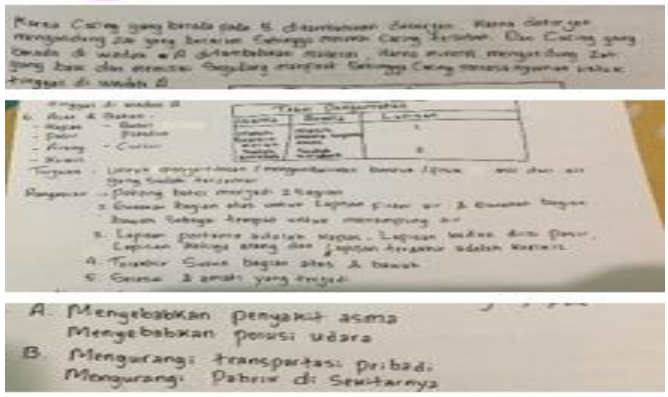

Figure 4. Answer sheet for questions 7, 8 and 9 from the explanation ability indicator

Question 7 students provide a comparative analysis of two cases of good worms to the surface of the soil. In question 8 students are asked to create an experimental design for water purification. And in question 9 students are asked to make a hypothesis based on this design. From the answer sheets received, it can be seen that students are able to provide explanations skillfully, and can even draw up a plan for an experiment to overcome the problem of cloudy water or polluted water. Then,

apply critical thinking skills to the conclusion (inference) indicators.

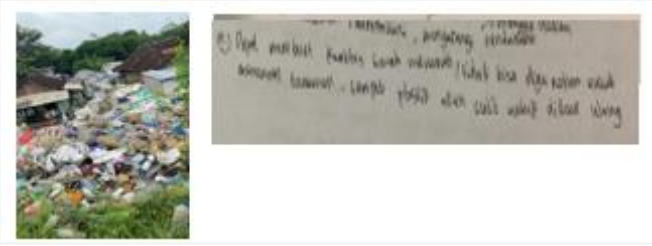

Figure 5. Answer sheet for question 10 of the inference ability indicators

The following is the final indicator that is assessed to determine students' ability to conclude questions. Students are asked to analyze the effect of using plastic waste in daily life on soil fertility.

Evaluation stage

This environment-based Critical Thinking Ability Instrument, according to expert assessments, has succeeded in fulfilling elements of local wisdom and aspects of Problem and Research Based Learning (PRBL). However, there is still room for further development so that this instrument can have a more significant impact on learning (Uma'iyah et al., 2023; Kim et al., 2019; Coman et al., 2020). The environmental aspects integrated in this instrument helps students to better understand and appreciate local cultural values, while the PRBL aspect encourages students to think critically in solving problems relevant to their environment (Papilaya & Tuapattinaya, 2022; Hendri & Setiawan, 2016).

In addition, it is important to apply this instrument to learning in other schools so that areas that need improvement and adjustments can be identified. In this way, this instrument can continue to be refined and adapted to various educational needs (Gligorea et al., 2023; Kamalov & Gurrib, 2023). To avoid subjectivity in determining innovative design criteria, it is necessary to standardize scoring based on a scale that has been developed by experts. This standardization will ensure that the assessments provided are more objective and consistent, so that these instruments can be applied more effectively in various educational contexts.

Conclusion

Based on the results of research and development of environment-based critical thinking skills test instruments in science learning for class VII SMP, it can be concluded that the instruments that have been developed are able to measure students' critical thinking skills with high validity and reliability. Through the application of the ADDIE model, this instrument has successfully gone through the stages of analysis, design, development, implementation and evaluation well. The test results show that this instrument can identify the level of students' critical thinking abilities in various aspects such as interpretation, analysis, evaluation and inference. The application of this instrument at MTsN 1 Sukoharjo and Darul Qur'an Middle School Colomadu shows a significant increase in students' critical thinking skills, especially in the context of environment-based learning. Apart from that, this research also found that learning modules equipped with environment-based test instruments can increase student activity and participation in the teaching and learning process.

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