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Development of an Instrument to Asses Critical Thinking Skills for Elementary School Students on Energy Topics

Yosi Gumala[1]✉, Yohamintin[2], Husna Farhana[3], Ernawulan Syaodih[4], Achmad Samsudin[5]
Guru Sekolah Dasar, Universitas Bhayangkara Jakarta Raya, Indonesia[1,2,3]
Pendidikan Anak Usia Dini, Universitas Pendidikan Indonesia, Indonesia[4]
Pendidikan Fisika, Universitas Pendidikan Indonesia, Indonesia[5]
e-mail : yosi.gumala@dsn.ubharajaya.ac.id

Abstrak

Penelitian ini bertujuan mengembangkan instrumen tes kemampuan berpikir kritis pada pembelajaran sains sekolah dasar dengan melihat tingkat validitas isi, validitas konstruk, reliabilitas, tingkat kesulitan serta indeks daya beda butir. Penelitian ini melibatkan 35 siswa kelas v disekolah dasar negeri kabupaten Bekasi Indonesia. Metode pengembangan digunakan dalam proses penelitian ini. Instrumen yang digunakan merupakan instrumen yang berorientasi pada kemampuan berpikir tingkat tinggi khususnya kemampuan berpikir kritis dengan tipe soal pilihan ganda. Berdasarkan hasil riset didapatkan (!) terdapat 30 item yang dinyatakan valid dari 40 item yang diujikan, (2) perolehan koofisien reliabilitas pada kategori tinggi, instrumen juga memilki kategori baik. Dengan demikian instrumen kemampuan berpikir kritis yang dikembangkan yang berpedoman pada HOTS ini dapat diandalkan dan dapat digunakan dalam proses pengambilan dan mengumpulkan data riset. Pengembangan instrumen yang tepat dan andal diharapkan mampu mensintesis hasil penelitian yang sesuai dan mampu meningkatkan kemampuan berpikir kritis. Namun masih dibutuhkan penelitian lanjutan untuk mengembangkan instrumen khususnya pada sub indikator berpikir kritis lebih mendalam.
Kata Kunci: Kemampuan Berpikir Kritis, Pengembangan Instrumen Belajar, Intrumen HOTS, Validitas Instrumen, Reliabilitas.

Abstract

The goal of this research is to create a test instrument that measures critical thinking abilities in science instruction in elementary schools by examining content validity, construct validity, reliability, item differentiation index, and degree of difficulty. Thirty-five fifth graders from state elementary schools in Indonesia's Bekasi district participated in this study. This research process makes use of the development method. The tool being used is designed to test advanced cognitive abilities, particularly critical thinking abilities with multiple-choice questions. According to the study findings, it was discovered (1) that 30 of the 40 items examined were deemed valid; (2) the reliability coefficient was found to be in the high category; and (3) the instrument also had a good category. As a result, the instrument for measuring critical thinking ability that was created based on HOTS is trustworthy and useful for gathering research data. It is anticipated that the creation of suitable and trustworthy instruments will enhance critical thinking abilities and enable the synthesis of suitable research findings. To develop instruments, particularly critical thinking sub-indicators, in greater detail, more research is still required.
Keywords: *critical thinking, Development Learning Tools, HOTS Instrument, validity Instrument, reliability.*

✉ Corresponding author :
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INTRODUCTION

Critical thinking involves comprehending the deeper meaning of a problem while staying open to all different viewpoints(Reynders,et.al, 2020). The aim of cultivating students' critical thinking skills is to train students to become critical thinkers, able to solve problems, and converted independent thinkers, so they can face life, overcome every problem they face, and make correct and responsible decisions(Ardianti, et.al, 2020; Hebebci & Usta, 2022). Students can develop their knowledge extensively by using critical thinking in their learning. Critical thinking skills are also basic in a learning process(Sarwinda, et.al, 2020). Critical thinking skills need to be advanced from the elementary school, so that students' knowledge and understanding of science relate to science content, science products, and scientific work processes to understand existing scientific phenomena and grow students' critical thinking abilities(O'Reilly, et.al, 2022). As a result, this research is crucial. Our development of instruments to measure achievement in energy science learning is based on the encouragement of links to analyze and assess students' critical thinking abilities.

Critical thinking can be seen as a student's thinking ability to compare two or more pieces of information, for example, information received from outside with the information they have. If there are differences or similarities, questions or comments will be asked with the aim of getting an explanation. The ability to think critically is one of the basic capital or intellectual capital that is very important for every person and is a fundamental part of human maturity(Ramdani, et.al, 2021; Rıstanto, et.al, 2022). Therefore, developing critical thinking skills is very important for students at every level of education. Students can practice a range of thinking skills, particularly critical thinking skills, through critical thinking, which involves learning advanced thinking skills. The development of critical thinking skills is crucial as they are not inherent(Liu & Pásztor, 2022). In addition, the aim of training critical thinking skills is to prepare students to become critical thinkers, able to solve problems and become independent thinkers so that they can face life, avoid indoctrination, fraud, and brainwashing, overcome every problem they face, and create decisions appropriately and responsibly.

The assessment process in learning involves using assessment instruments(Fitriani, et.al, 2022). What is to be measured determines the availability of measuring instruments. The quality of learning is determined by the measurement used in learning. Achieving real chemistry learning objectives requires the use of assessment instruments that not only include memorization and understanding but also require an assessment that train critical thinking skills so that students can be competent, critical and independent when faced with a problem(Ardhian, et.al, 2020; Supriyatno, et.al, 2020). Apart from that, facing the development of Science and Technology requires the ability to select information, the ability to decide on a course of action, the ability to solve problems, the ability to conclude and other abilities related to critical thinking skills. The development of assessment instruments for critical thinking skills is crucial.

Critical thinking skills mean skills in reasoning and reflective thinking that are specific to deciding what to do (Remiswal, 2020). Critical thinking skills are commonly referred to as skills for acquiring knowledge in critical thinking(Chusni, et.al, 2020; Jaenudin, et.al, 2020). Students begin the stretch with the special abilities they acquire through experience and practice, which help them carry out tasks well and effectively refer to changes (Razak et al., 2022). Critical thinking skills emphasize the actual performance and successful completion of individual tasks, with these skills as abilities that can be defined within oneself. Critical thinking skills can be assessed through the use of indicators.

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Table 1 Critical thinking skills Indicators

No	Critical Thinking Skills Indicators	Sub Indicators
1	Basic Classification	Focusing Statements
		Analyzing Arguments
		Ask questions and answer clarifying or challenging questions
2	Basis for making decisions or support	Assess the credibility of the source
		Make observations and assess observation reports
3	Inference	Deducing and evaluating deductions
		Inducing and assessing induction
		Create and assess value statements
4	Advanced Classification	Defining terms and assessing definitions
5	Strategy and Tactics	Identify assumptions
		Determine the action
		Interact with other people

Critical thinking skills are a person's self-awareness in thinking and assessing a problem based on orientation, accuracy, process, theory, method, and background of the problem so that they can make appropriate decisions. Critical thinking includes concrete thinking processes and abstract thinking. Critical thinking is an essential way of thinking in analyzing, investigating, and evaluating problems based on scientific evidence. It is not enough for students to have critical thinking skills, students are also expected to be able to apply critical thinking skills.

METHOD

The research design used in developing critical thinking skills instruments on the topic of energy is the ADDIE model instructional development design which consists of the analysis stage (analysis), design stage (design), develop stage (development), implementation stage (implementation), and evaluation stage (evaluation). The instrument development phase and the instrument effectiveness testing phase are the two primary phases of these stages. The instrument development phase consists of analysis, design, and develop stages. The implementation and evaluation stages are part of the instrument effectiveness testing phase.

The instrument effectiveness testing phase is intended to gather a comprehensive understanding of the degree to which instrument implementation improves creative critical thinking skills of elementary school students. The implementation of the instrument in science learning activities on energy topics results in instrument testing. The instrument effectiveness testing phase consists of the implementation and evaluation stages. The method used in testing the use of the instrument was a quasi-experiment with a one-group pretest-posttest design. The subjects involved in testing the instrument were elementary school students at one of the schools in Bekasi City. Test subjects were gathered into a single learning class. Use critical thinking skills tools to explore the topic of energy before and after conducting the practicum. In general, the evaluation stage is aimed at getting an idea of the extent to which the critical thinking instruments that have been developed can improve students' higher-order thinking skills through practicum activities, getting an idea of the ease and difficulties (strengths and limitations). during the implementation of the model, as well as obtaining an overview of students' perceptions of the ability of critical thinking skills instruments on the topic of energy in improving critical thinking abilities.

DISCUSSION

There are 12 test indicator items containing 5 indicators of critical thinking skills on energy concepts. The distribution of the number of questions for critical thinking skills includes types of energy, energy changes and the benefits of energy for human life. The design of the test matrix and distribution refers to the characteristics of each concept and indicators of critical thinking skills. Next, modifications to the test were carried out in several aspects. The critical thinking skills test used in this research aims to measure the critical abilities of elementary school students, especially on the topic of energy.

Table 2 Critical Skills Test Indicators

Critical Thinking Skills Oriented Test Indicators	**Student Answer Choices**
Clarifying the Basis (Clarification statement)	a. Valid assumptions b. Invalid Assumption
Make decisions	a. Assumptions have correct conclusions b. The assumption does not have enough information to be a correct conclusion
Inference	a. Logical Hypothesis b. Illogical hypothesis
Advanced Classification	a. Correct argument b. The argument is incorrect
Strategy (Conclusion)	a. Conclusions have reasons b. Conclusions have no reason

Terms used to measure critical thinking skills include basic clarification, decision-making, inference, further clarification, and conclusion. In the test being developed, definitions of the terms used in the answer choices are provided in the test instructions section. Alignment of indicators and energy concepts was also carried out to emphasize the tests used to measure elementary school students' critical thinking skills. In this material, what is tested is the concept of energy on science topics at the elementary school level. Adjustments were made because the objects of this research were elementary school students. The preparation of test items is carried out by presenting information in various forms and questions to obtain the expected answers or responses and is carried out by adjusting the test framework. The test instrument developed in this research is a multiple-choice test. Students are given several questions and then students are asked to choose according to the answer choices given. The statements given are related to one another. The instruments that have been prepared are then adapted to the revision process, then proceed to the validation stage to obtain the final product in the form of critical thinking skills test questions on energy concepts for elementary school students(Y. Gumala et al., 2019; Wibowo et al., 2021).

The critical thinking skills test instrument development process includes the initial draft, initial product, and final product. In the process of developing critical thinking skills items, students are provided with instructions and operational definitions for several terms used. The test developed also includes several explanations for each indicator of critical thinking skills as well as explanations for each answer choice. This aims to help students make decisions on answer choices according to each student's understanding in making decisions on the available answer choices. The process of developing the initial to final draft is based on the considerations of the research team and experts. The initial product development process is adjusted to the validator at the validation stage and the final stage produces test questions to measure critical thinking skills.

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The following is a development of questions to measure critical thinking skills
Question Instructions
Write your identity on the answer sheet provided
Choose the answer that you think is most appropriate by marking (X) one of the letters on the answer sheet provided
Each discourse presented consists of three questions in the form of statements
The test instrument consists of several operational definitions used in the answer choices

Figure 1. Instruction Test Critical Thinking

The process of assessing critical thinking skills is necessary because critical thinking skills require students to think at a higher level, not just at the level of memorizing or simply accepting existing information without thinking critically about this concept. Critical thinking skills require complex abilities that require high cognitive ability in processing information(Laili, Gumala, Awiria, Syaodih, & Samsudin, 2023; Suherman et al., 2021). Critical thinking is an actively ongoing cognitive discipline process. Critical thinking skills are not skills that students acquire by chance or heredity, these skills are applied, trained, and developed through a continuous learning process and learning evaluation.

Table 3 Operational Definition

Indicator (Aspect)	**Operational Definition**
Clarifying the Basis (Clarification statement)	An estimate that is considered an element of truth
Make decisions	The temporary answer is still presumptive
Inference	Reasons that can be used to obtain, strengthen or form an opinion
Advanced Classification	According to the proper way
Strategy (Conclusion)	The decisions obtained are based on inductive and deductive thinking methods

The stage for testing the quality of the critical thinking test instrument on the topic of energy for elementary school students is a validity and reliability test process. Validity in this research uses content validity which aims to see the suitability between indicators and question items. Content validity was carried out by 5 expert validators. Expert validators consider the suitability of indicators and question items (Gumala,Et.al, 2023). Validators also provide suggestions for instrument development. The validation data is then processed using content validity ratio (CVR) data processing. CVRhit is then compared with CVRcritical by the number of validators.

Table 4 CVR Calculation Processing Table

No	**Indicator**	**Item tested**	**Evidence**
1	Assumes the types of energy used in everyday life	1, 2, 3, 5	Valid
		4, 6	Not valid
2	Assume that energy changes occur	7, 9, 10, 11	Valid
		8	Not valid
3	Concluding energy is capable of having good changes	12, 13, 14, 15,16, 19	Valid
		17, 18, 20	Not valid
4	Develop a hypothesis of factors that influence how quickly energy changes	21, 22, 23, 24, 25,	Valid
		26, 27, 28	Not valid
5	Estimating energy changes in the next stage	29, 30,31, 33, 34	Valid
		32	Not valid

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No	Indicator	Item tested	Evidence
6	Analyzing the use of environmentally friendly energy to support sustainable development goals	35, 36, 37, 38, 39, 40	Valid

The next stage is to calculate the CVI value to determine the content validation for the entire instrument, which is the average of the CVR values for all question items. The CVI calculation results were obtained at 0.86, which indicates that the instrument is categorized as a valid instrument. Furthermore, testing was also carried out to determine the empirical validity for each question item obtained based on the test results at the reliability test stage in this research stage.

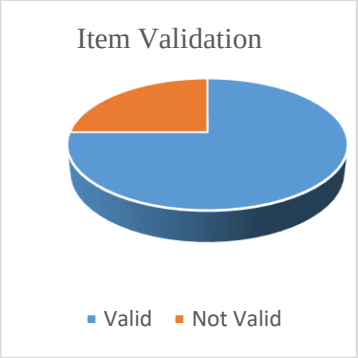

Figure 2. Percentage of valid item

Based on the category of empirical validity value, this question item has empirical validity in the categories low, sufficient and high. The distribution of questions in the low category was 6, the sufficient category was 19, and the high category was 7, The next stage is a reliability test to determine the extent to which the measuring instrument provides a truly reliable picture of a person's abilities. The reliability test in this research was obtained using SPSS 26 software with the Cronbach's alpha method producing a reliability value of 0.88 in the good category. The value obtained in this research shows the good category.

Table 5 Reliability

Reliability Statistics	
Cronbach's Alpha	N of Items
0.88	30

Next, a test was carried out to determine the quality of the test being developed, including testing the level of difficulty and different powers. The difficulty level test was carried out to group the questions developed including difficult, medium, and easy questions(Inganah, Darmayanti, & Rizki, 2023). This test is needed to find out how the questions are distributed so that the questions tested on students are not centered on just one category. Based on the test level results, there are 20 questions in the medium category, 4 in the difficult category, and 6 in the easy category.

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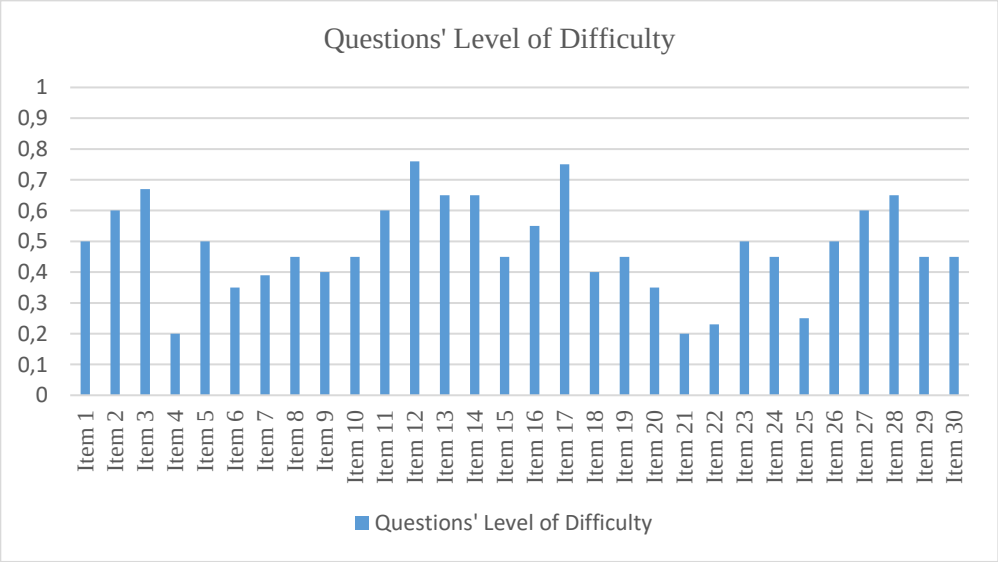

Figure 3. Item of Question level Difficulty

In addition to the difficulty level testing process, researchers used a different power test to find out how the ability of the questions can differentiate between students who have high ability and students who have low ability. Grouping of question item categories is obtained by referring to grouping.

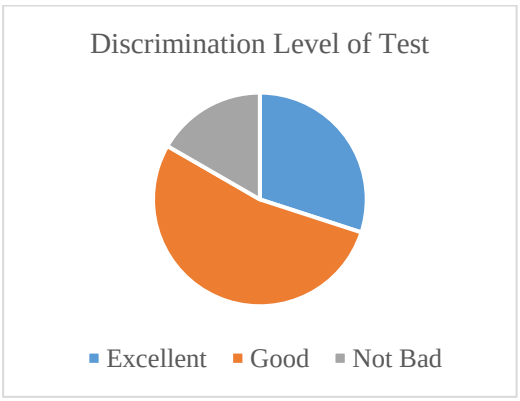

Figure 4. Discrimination Level of Test

Based on the different power tests carried out, there were 9 items in the very good category, 16 items in the good category, and 5 in the fair category. Based on these results, it can be said that the test of students' critical thinking skills can properly differentiate between students who master the material and students who are unable to master the material(Anggraeni et al., 2021; Gumala, et. al, 2020). This research also used a questionnaire intending to see students' responses regarding the instruments developed. The following are the results for each statement based on the questionnaire given to students.

Table 6.

No	Statement	VA	A	N	NA
1	The test instrument for students' critical thinking skills presents questions according to the material I have studied	35	10	13	2
2	The test instrument uses critical thinking skills in an introductory language that is easy for me to understand	37	8	15	0
3	The critical thinking ability test instrument provides	45	6	8	1

No	Statement	VA	A	N	NA
	communication direction in the work and does not give rise to multiple interpretations				
4	The critical thinking ability test instrument presents pictures, tables, and graphs which make the process of working on questions interesting	47	13	0	0
5	The critical thinking ability test instrument provides instructions so that it is easy for me to do it	40	15	5	0
6	The critical thinking ability test instrument presents sentences in the form of questions and statements that are easy for me to understand	33	18	6	3
7	I can easily understand all the items in the critical thinking ability test instrument	35	9	10	6
8	The critical thinking ability test instrument provides an appropriate work process	30	16	9	5
9	The critical thinking ability test instrument provides challenges for me to work on and complete	53	6	1	0
10	The critical thinking ability test instrument provided a different form and process when I took the final test	48	11	1	0
11	The critical thinking ability test instrument has good construction in presentation and is easy to use	38	15	7	0

The results obtained show that students' responses regarding the use of the critical thinking ability test instrument are that most students agree that the critical thinking ability test instrument presents material and questions that are suitable for measuring the critical thinking ability of elementary school students, especially on energy material. Each question can be easily understood and worked on by students. Elementary school students can easily comprehend the critical thinking ability test instrument.

CONCLUTION

Based on the results of the previous research and discussion, several conclusions were obtained, namely that there was an influence of the use of the questions developed on the critical thinking abilities of elementary school students on energy materials. The instrument developed can be used because it meets the criteria of validity, reliability, good discrimination and well-distributed levels of difficulty. Meanwhile, the suggestion and also the impression of this research is that further researchers should be able to complete this research with detailed research on other aspects that have not yet been reached

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