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# Validity and Reliability of Critical Thinking Instruments to Measure the Effectiveness of Context-Based Physics E-Module on Wave Materials

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## Abstract

Critical thinking skills can be improved through learning physics. Independent teaching materials such as e-modules are needed. Instruments are needed to measure the success of e-module use. This study aims to develop critical thinking skills instrument on physics learning using e- module-based on the context of the material of mechanical waves and stationary waves. The instrument criteria are valid and reliable. The form of the instrument is an essay test that includes five aspects: Interpretation, Analysis, Evaluation, Explanation, and inference. The instrument consists of 18 items. The development model used is ADDIE, with the stages of Analysis, Design, Development, Implementation, and evaluation. The expert validation for each aspect is content 0.84, construct 0.88, and language 0.83 with valid categories. While the results of the empirical validation for five aspects of critical thinking skills are: interpretation three items, analysis three items, evaluation four items, explanation four items, and inference two items are valid. Four items are invalid. These items were discarded. Reliability for critical thinking instrument obtained 0.78 with good category. Referring to the research finding, it can be concluded that the instrument was feasible to use. The impact of this research is the production of a valid and reliable critical thinking instrument, which is used to measure students' critical thinking skills.

**Keywords:** validity, reliability, critical thinking instrument, context-based e-module, wave

## INTRODUCTION

Critical thinking and problem-solving are skills needed in the 21st century to survive. Critical thinking skills and problem-solving are a process of thinking carefully and not just accepting the opinions of others, namely by reasoning, analyzing, and being able to solve problems with alternative solutions so that they can increase students' knowledge (Sugiyanti et al. 2018; Rahmi & Suparman 2019). Critical thinking is a skill that can determine the success of one's life, both in solving a problem, making a decision, and being a supporter in developing broad knowledge (Herliandry et al. 2019).

Students who think critically will be able to help themselves or others solve a problem (Rankuti & Ridwan 2018). This will be useful for those who will become leaders in the future to face the challenges and problems that occur in life (Hasoubah 2014; Anggreni et al. 2019). Critical thinking is a cognitive process (Tiruneh et al. 2014). The ability to think critically is one of the most important aspects for students to have in participating in the learning process at school, especially in solving problems that require in-depth alternative problem solving (Husnah 2017).

Teaching students to think critically aims to train them to observe a situation, raise questions, formulate hypotheses, make observations, and collect data, then proceed with conclusions (Utami et al. 2018, Wulandari et al. 2021). Critical thinking can train students to think logically and not accept things easily (Sadhu & Laksono 2018, Asrizal et al. 2018). Someone who thinks critically will always ask himself whenever he faces a problem to determine an appropriate, rational, and deep decision (Herliandry et al. 2019, Latifa et al. 2017, Ennis 1985). Resnick in Arends 2012 states that critical thinking skills involve thinking processes in classification, induction, deduction, and reasoning.

Facione (2015) stated that students are said to think critically if students meet several indicators of critical thinking skills, according to Nosics. G (2012), three parts must be met by students to think critically: (1) critical thinking by involving themselves in asking questions. It deals with what needs to be asked, asking good questions, and questions that get to the heart of the matter. (2) critical thinking involves oneself trying to answer questions through reasoning. This process raises students' awareness that there are questions that need to be addressed. (3) critical thinking involves students to believe and being sure of the answers given from the results of their reasoning. Meanwhile, according to Facione (2015) critical thinking indicators include interpretation, analysis, evaluation, explanation, inference, and self-regulation. The achievement of critical thinking skills indicators can be measured using instruments. Critical thinking skills in life need to be honed through the learning process at school.

Critical thinking skills can be honed in the learning process if supported by appropriate media/teaching materials. One teaching material that is expected to hone students' critical thinking skills is the e-module. E-module is a non-printed teaching material that is methodically arranged and uses multimedia technology (Matsun & Saputri 2020), in which sound, video, and images can be input (Mappalessye 2021). Not all e-modules can hone critical thinking skills. One of the e-modules that can hone students' critical thinking skills is context-based e-modules.

Context-based Physics E-Modules can emphasize critical thinking levels because of the combination of material and everyday life contexts. Learning like this will make students more interested in learning and make the learning process more meaningful. Learning that links the material studied with the context of students' daily lives can increase students' activeness in using the knowledge they already have in the learning process (Wulandari et al. 2021, Faddillah 2014), thereby increasing their critical thinking skills. Whether or not context-based e-modules can hone students' critical thinking skills can be measured using critical thinking instruments.

This type of critical thinking research has been done like the research conducted by Amalia & Susilaningsih (2014), which developed a critical thinking ability test in the form of a description of acid-base material. Research by Pradana et al. (2017) developed a critical thinking test on optical material. Mappalessye's research (2021) on the development of critical thinking instruments in the form of objective choices. However, no one has developed a critical thinking instrument for wave material in the form of an essay test.

The critical thinking instrument used can be an essay test. Essay tests have advantages. Namely, teachers can more easily arrange tests and do not take long, students are freer to answer and express thoughts, and they can practice the ability to use sentences with regular language (Purwanto 2010). So it is necessary to develop an instrument for critical thinking in the form of an essay test.

An instrument is a tool used to meet academic requirements to measure an object. The instrument is an integral part of the assessment activity, which supports the accuracy of the assessment design. Instruments are essential in obtaining accurate and reliable information (Asrizal et al. 2015, Kusuma et al. 2021, Mappalessye et al. 2021). The instrument used will help researchers to obtain the required data. The instrument functions by revealing facts into data so that if the quality of the instrument used is good, then the data obtained follows the facts.

Instruments play an essential role in determining the quality of research because the validity or validity of the data obtained will be determined mainly by the quality of the instruments used. If the instruments used have adequate quality in being valid and reliable, the data obtained will follow the facts or actual conditions in the field. Meanwhile, suppose the quality of the instrument used is not good in the sense of having low validity and reliability. In that case, the data obtained is also invalid or does not follow the facts in the field, so it can produce erroneous conclusions (Arifin 2017). Whether or not an instrument is determined by its validity and reliability.

One of the instruments that need to be developed and tested for validity and reliability instrument. This instrument is essential to see the critical thinking skills possessed by students. Based on these problems, the researchers are interested in developing an e-module integrated critical thinking instrument based on a context that is valid and reliable. It is hoped that developing critical thinking questions can help overcome students in solving critical thinking questions and can be used as material for consideration in conducting learning and evaluation.

## METHODS

This research is a research and development research. The product developed is a critical thinking instrument in the form of an essay test instrument consisting of 5 aspects, namely Interpretation, Analysis, Evaluation, Explanation, and inference, which is translated into 18 questions. The ADDIE development model uses the development model, with the stages of Analysis, Design, Development, Implementation, and Evaluation.

The first step is analysis. Activities carried out at this stage are collecting information related to the instrument to be developed. Based on observations and interviews conducted with teachers at schools, it was found that the instruments used by teachers at schools had not fully trained students to think critically and the questions used did not require students to relate concepts to everyday life events. In addition, teachers often take questions in the textbooks and e-modules used.

The second stage designs. The activity carried out at this stage is the instrument's design to be developed. The results obtained at this stage are the creation of a critical thinking instrument grid. The grids are made based on critical thinking indicators. The indicators used are Interpretation, Analysis, Evaluation, Explanation, and Inference

The third stage is development. The activities carried out were instrument writing, expert validation, and field trials. This expert validation was carried out to validate the content, material, and language used in the instrument. Meanwhile, instrument testing was conducted to determine empirical validation and reliability.

Data from expert validation were collected using a questionnaire. Essay tests and questionnaires collected trial data. Determination of the value of expert validity using the Aiken's V equation.

$$V = \frac{\sum s}{[n(c-1)]} \quad (1)$$

Then,

$$s = r - lo \quad (2)$$

Information:

lo = the lowest number of validity assessments (in this case = 1)

c = the highest number of validity assessments (in this case = 5)

r = Numbers given by the validator

The instrument is said to be valid if the validity value is 0.6, while the validity value obtained is < 0.6, including invalid criteria. Invalid instruments will be corrected according to the validator's suggestions to obtain a valid instrument (Azwar 2015). In addition, the developed instrument was also tested for empirical validity.

Empirical validity is used to validate each item. Empirical validity was carried out in class XI MIPA. This validity aims to determine valid items and can be used to measure aspects of critical thinking skills: Interpretation, Analysis, Evaluation, Explanation, and Inference. Empirical validity was measured using the product-moment correlation equation:

$$r_{xy} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{(N \sum X^2 - (\sum X)^2)(N \sum Y^2 - (\sum Y)^2)}} \quad (3)$$

$r_{xy}$  = correlation coefficient between variables X and Y

N = Number of Respondents

X = item score

Y = Total score

Items are said to be valid if the value of  $r_h > r_t$  so that from the calculation of the formula above, it can be known whether or not the questions contained in the instrument are valid. If the level of validity is high, then the question can be accepted; if the validity is low, it will not be used or used with a revision first. The test data also tested reliability using the Cronbach Alpha formula.

The fourth stage is implementation. At this stage, activities are carried out to determine the effectiveness of the developed instrument. The instrument's effectiveness is seen from the value obtained by each student after answering the questions given compared to the KKM used by teachers at school. Students who are above the KKM are considered to have good critical thinking skills.

The last stage is the evaluation stage. This stage consists of formative evaluation and summative evaluation. Formative evaluation is carried out at each stage of ADDIE development which consists of the analysis stage, design stage, development stage, and implementation stage. The summative evaluation aims to see the achievement of the overall instrument development following the expected goals, namely valid and reliability.

## RESULTS AND DISCUSSION

The results of this research is critical thinking skills instrument contains 18 items; consisting of Interpretation item numbers: 6, 9, 14b, 15, Analysis item numbers: 4a, 10,18, Evaluation item numbers: 8, 11, 14a, 17, Explanation item numbers: 1, 4b, 5, 7,13, and Inference item number 2, 3, 12, 16. The instrument made is then given to the validator for internal validation, which is given to 2 Expert validation people. Expert validation was conducted to determine the developed instrument's content, construct, and language validity.

Analysis of the results of the instrument expert validation of critical thinking skills by two validators can be seen in FIGURE 1.

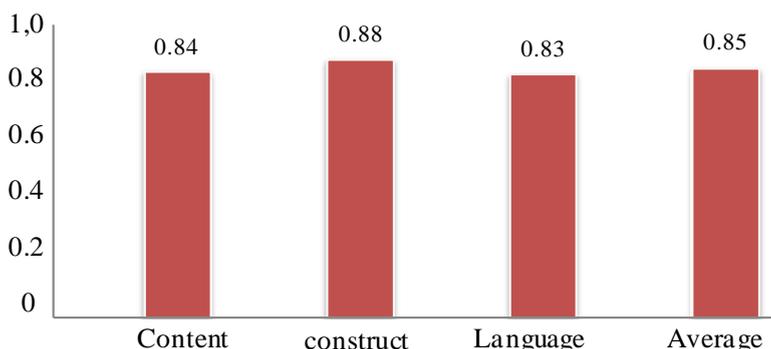


FIGURE 1. Graph of Critical Thinking Instrument Validation Test Results

Based on the validity theory contained in the method, the instrument is said to be valid if the value is above 0.6. It can be seen from graph one that the results of content validity are 0.84, construct validity 0.88, and language validity results are 0.83 so the average validity of the critical thinking instrument is 0.85. value  $0.85 > 0.60$ , so it can be said that the critical thinking instrument is valid.

Instruments that experts have validated are then tested in the field. The test of this instrument aims to determine the empirical validity and reliability of each item developed. This trial was conducted on 20 samples. The questions that students have answered are then calculated for validity using the product-moment correlation formula. The results of the analysis of the validity of the critical thinking instrument trial on 20 students can be presented in TABLE 1.

**TABLE 1.** The Results of the Analysis of the Validity of the Critical Thinking Instrument

No	Critical Thinking Indicator	$r_h$	$r_t$	Criteria
1	Explanation	0.48	0.44	Valid
2	Inference	0.73	0.44	Valid
3	Inference	0.38	0.44	Invalid
4a	Analysis	0.45	0.44	Valid
4b	Explanation	0.48	0.44	Valid
5	Explanation	0.71	0.44	Valid
6	Interpretation	0.64	0.44	Valid
7	Explanation	0.43	0.44	Invalid
8	Evaluation	0.54	0.44	Valid
9	Interpretation	0.51	0.44	Valid
10	Analysis	0.66	0.44	Valid
11	Evaluation	0.58	0.44	Valid
12	Inference	0.40	0.44	Invalid
13	Explanation	0.70	0.44	Valid
14a	Evaluation	0.60	0.44	Valid
14b	Interpretation	0.53	0.44	Valid
15	Interpretation	0.40	0.44	Invalid
16	Inference	0.75	0.44	Valid
17	Evaluation	0.57	0.44	Valid
18	Analysis	0.61	0.44	Valid

The item is said to be valid if  $r_h > r_t$ , for respondents 20 ( $n=20$ ), the significance level of 5% based on the Product Moment correlation table is obtained  $r_t=0.04$ . Table 1 shows that there are 14 questions with valid categories (8 mechanical waves and 6 stationary waves) while 4 questions are invalid. The number of valid items for each aspect of the critical thinking instrument are Interpretation: 3 items (6, 9, 14b) , Analysis: 3 items (4a, 10,18), Evaluation: 4 items (8, 11, 14a, 17), Explanation: 4 items (1, 4b, 5,13), and inference: 2 items (2,16). Valid questions will be used to measure critical thinking skills while invalid questions will be discarded.

A valid critical thinking instrument is then calculated as the reliability coefficient. The number of valid critical thinking instruments is 14 items. The total score variance for each question is 22.59, and the total score variance is 81.10. After calculating the reliability for critical thinking, the instruments is 0.78 with a good category, so the developed instrument is feasible to use.

In theory, validity and reliability are explained by Van and Akker in Rochmad (2011) who states: That the validity of a product development refers to whether the design is based on the state of the art knowledge and whether the various components of the product are related to each other. Consistently. The results of theoretical and empirical validity have shown that the critical thinking ability instrument test is valid, and the valid items are reliable. Theoretically, the developed test has also met the reliable category. The same study's results were also developed by Jamaluddin et al. (2020) that the critical thinking instrument developed was valid and reliable for junior high school science material.

Critical thinking instruments that are proven to be valid and reliable are then implemented in the field. This implementation was carried out in class 11 MIPA with a sample of 93 people. Based on the analysis conducted on 93 students, 75 students scored above the KKM, and 15 students were below the KKM. The average value obtained for critical thinking skills is 67.70, with sufficient category

## CONCLUSION

Based on the study results, it can be concluded that the instrument developed is valid and feasible to use. The results of the content validity for the critical thinking instrument were 0.84, the construct validity was 0.88, and the language validity results were 0.83, so the average validity of the critical thinking instrument is 0.85. After being tested to determine the empirical validity of the 18 questions for the wave material, there were 14 questions in the valid category and four questions in the invalid category. The number of valid items for each aspect of the critical thinking instrument is Interpretation: 3 items, Analysis: 3 items, Evaluation: 4 items, Explanation: 4, and inference: 2 items. Valid instruments are used while invalid ones are discarded. Reliability for critical thinking instrument

obtained 0.78 with good category. Referring to the research finding, it can be concluded that the instrument was feasible to use.

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