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The Content Validity: Multiple Choices Complex Physics Instrument to Measure Critical Thinking Skills

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Received: September 9th, 2023. Revised: October 4th, 2023. Accepted: October 9th, 2023

Keywords :

Critical Thinking Skills;
Content Validity; Physics Test
Instrument

ABSTRACT

This research is part of the development of critical thinking skills instruments in physics lessons for eleventh-grade high school students. In this section, the purpose of this study is to analyze the content validity of the instrument. The instruments developed consist of 20 multiple-choice questions constructed based on indicators of critical thinking skills, namely interpretation, analysis, evaluation, inference, and explanation. Furthermore, this instrument was assessed qualitatively and quantitatively by 6 experts with assessment aspects including: 1) The questions fit the CTS indicator, 2) The stimulus/stem fits the questions, 3) The questions are clearly formulated, and 4) The problem description is clear and unambiguous. The method used in this research is a descriptive analysis method for content validation based on Aikens' Formula. Data for content validation were obtained from 9 experts, comprising 6 lecturers and 3 physics teachers from high schools in Jakarta. Based on the results and discussion, it can be concluded that 20 items of the complex multiple-choice test instrument to measure the critical thinking ability of eleventh-grade high school physics students are declared valid based on Aiken's Validity.

INTRODUCTION

Physics education in schools today should be conducted contextually, meaning it should link physics concepts to phenomena that occur in real life [1] [2]. To study physics in this manner, it requires a deep analytical capability and a strong understanding of complex concepts. These abilities are possessed by students with good high-level thinking skills. One of these high-level thinking skills is critical thinking.

Critical thinking skills are also one of the 21st-century skills needed by students, along with communication, collaboration, and creativity [3] [4] [5]. Critical thinking skills involve the ability to analyze and synthesize information, and these skills can be taught, practiced, and mastered. Critical thinking also refers to other skills such as communication, information literacy, and the ability to investigate, analyze, interpret, and evaluate evidence. Critical thinking skills are competencies, goals,

and targets aimed at by education in Indonesia [6] [7]. In physics learning, students need to have critical thinking skills to understand complex and abstract physics concepts [8] [9]. With strong critical thinking skills, students can understand and analyze complex physics theories, thus developing a deeper understanding. Given the importance of critical thinking skills, critical thinking plays a crucial role for students as it supports the innovation process, especially in developing students' intellectual capacity in the learning process.

Teachers play a role in improving the quality of education in general by enhancing the quality of instruction and the assessment system [10]. In the context of lesson planning, teachers are required to have the ability to manage the classroom during instruction while simultaneously engaging in the assessment process. Assessment in education runs in tandem and is inseparable from instruction. Therefore, the assessments conducted by teachers should be continuous, serving the purpose of monitoring students' learning progress [11] [12].

A well-designed assessment system can motivate teachers to enhance the quality of instruction by creating effective teaching strategies. Thus, the accuracy in selecting assessment methods greatly influences the objectivity and validity of assessment results, generating objective and valid information regarding the quality of education [13] [14]. Through assessment, teachers can gauge students' skills, evaluate the effectiveness of teaching methods, and assess students' success in achieving predetermined competencies. Assessments can take the form of a series of questions that students must answer or tasks that they must complete. These questions may include problem-solving inquiries that require students to possess high-level thinking abilities. Additionally, students must integrate their knowledge, understanding, and skills and apply them to new situations.

An instrument is a tool used for assessment, serving as a means to measure information related to the characteristics of an object. The object of assessment could be students' skills, attitudes, interests, or motivation. Apart from determining the profiles of students' skills, instruments can also nurture students' higher-level thinking skills. One form of test instrument used to measure critical thinking skills is complex multiple-choice questions. Complex multiple-choice questions, which consist of questions with answers that may have more than one correct option or no correct option, can be an effective tool for assessing critical thinking abilities [15] [16].

Complex multiple-choice questions are a more intricate and demanding form of multiple-choice questions compared to traditional ones. They require students to utilize critical thinking, problem-solving, and analysis skills in selecting the correct answers. In complex multiple-choice questions, the correct answers not only require a basic understanding of the tested topic but also the ability to apply concepts, compare and consider various options, and critically evaluate information. These types of questions may also necessitate students to interpret data, read graphs, or make decisions based on specific situations.

Complex multiple-choice questions can be used in various subjects, including science, mathematics, languages, and so on. This type of test instrument is considered more effective in assessing students' critical thinking skills and encouraging them to think deeply and analytically when solving problems. Complex multiple-choice tests require critical thinking to comprehend and evaluate the existing answer options. Critical thinking involves the ability to analyze information, grasp concepts, compare and contrast, as well as critically evaluate different arguments. Therefore, when answering complex multiple-choice questions, students must consider numerous factors and pieces of information to determine the correct answer.

Furthermore, complex multiple-choice questions can assess students' abilities to understand and interpret complex information [17]. These questions often involve intricate information or data that is indirectly related to the discussed topic. Consequently, students must use critical thinking to comprehend such information and determine the most appropriate answer options. Complex multiple-choice questions can evaluate students' abilities to consider different perspectives [18] [19]. In some cases, more than one answer may be correct, and students must consider various perspectives to

determine the most suitable answer. This requires the ability to critically consider different viewpoints and understand nuances in the provided information.

A good assessment process is one that aligns with the intended purpose of the assessment [20] [21]. An appropriate assessment is capable of encouraging students to engage in high-level thinking abilities. To ensure a valid assessment process, the development of standardized and valid instruments is essential.

Validity is a means to demonstrate that the developed instrument is a reliable assessment tool [22] [23]. An instrument can be deemed to have high validity if it serves the purpose of measurement or provides measurement results that align with the intended measurement goal. An instrument that generates data unrelated to the measurement's objective is referred to as having low validity.

There are three types of validity, namely 1) criterion-related validity, 2) construct validity, and 3) content validity [24]. Content validity refers to the extent to which items within an instrument represent the entire content of the measured components and how well the items reflect the characteristics of the behavior being measured. The determination of content validity can be carried out by assessing the alignment between the indicator grid and the operational definition of the instrument, involving at least five experts. Thus, an instrument is considered valid, in terms of content validity, if it effectively represents the indicators for measurement.

Based on the explanation above, validation of an instrument must be conducted to ensure that the instrument used can effectively measure what is intended to be measured. Therefore, this research will analyze the content validity of the complex multiple-choice physics critical thinking skills test instrument. The content validity of the complex multiple-choice physics critical thinking skills test instrument involves 9 experts, including physics subject area lecturers and teachers.

METHOD

The physics critical thinking skills test instrument for high school students was developed in the form of complex multiple-choice questions with a total of 20 questions. These questions were constructed based on indicators of critical thinking skills, including interpretation, analysis, evaluation, inference, and explanation. Furthermore, the instrument was assessed qualitatively and quantitatively by 9 experts with assessment aspects including: 1) The questions fit the CTS indicator, 2) The stimulus/stem fits the questions, 3) The questions are clearly formulated, and 4) The problem description is clear and unambiguous. Data from the qualitative and quantitative assessments were then analyzed using the guidelines presented in table 1 below:

Table 1. Data Analysis

Type of Data Collected	Data Analysis	Uses
Qualitative	Qualitative analysis	used as a guide in improving the content of each item being developed
Quantitative	Aiken Validity	used as a guide in determining the content validity of each item being developed.

Validation of instrument is obtained from review expert with 2 categories: Disagree if a question does not reflect indicators of the question, and agree if an indicator, skills, and material that want to measured are appropriate and construction, language, and material are good. Experts are asked to provide a check mark (√) for every question in the table prepared as shown in figure 1.

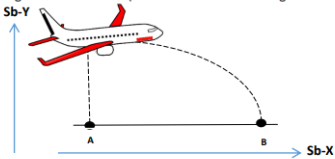
Topic : Gerak Parabola		Critical Thinking Skills aspect : Interpretation																			
Question number : 1																					
<p>Stimulus : Disajikan gambar sebuah pesawat yang menjatuhkan barang</p>		<p>Perhatikan gambar berikut ini! (Nanti tambahkan keterangan sumbu X dan Y)</p> 																			
<p>Critical Thinking Skills (CTS) Indicator : Dapat mengategorikan, menafsirkan dan mengklarifikasi informasi berdasarkan fakta/informasi (Categorization, interpreting and clarifying information).</p>		<p>Pada misi kemanusiaan, Tentara Nasional Indonesia mengutus sebuah Pesawat untuk menyalurkan bantuan, pesawat tersebut bergerak mendatar dengan kecepatan 50 m/s secara konstan dan melepaskan bantuan dari ketinggian 500 m pada titik A, jika paket bantuan tersebut jatuh di titik B dan $g = 10 \text{ m/s}^2$. Berdasarkan ilustrasi di atas, tentukan benar atau salah pendapat-pendapat berikut ini.</p> <table border="1"> <thead> <tr> <th>Statement</th> <th>True</th> <th>False</th> </tr> </thead> <tbody> <tr> <td>Gerak pesawat pada ilustrasi di atas termasuk ke dalam kategori gerak lurus beraturan.</td> <td>V</td> <td></td> </tr> <tr> <td>Gerak bantuan jatuh ke titik B termasuk dalam Kategori penerapan gerak lurus beraturan.</td> <td></td> <td>V</td> </tr> <tr> <td>Berdasarkan ilustrasi di atas dapat ditafsirkan bahwa besar percepatan pesawat adalah nol saat melepaskan bantuan</td> <td>V</td> <td></td> </tr> <tr> <td>Kecepatan pesawat 180 km/jam merupakan kecepatan pada sumbu X sedangkan kecepatan pada sumbu Y adalah nol</td> <td>V</td> <td></td> </tr> <tr> <td>Waktu yang dibutuhkan bantuan untuk tiba sampai tanah dapat di hitung dengan konsep Gerak Lurus Berubah Beraturan (GLBB)</td> <td></td> <td>V</td> </tr> </tbody> </table>		Statement	True	False	Gerak pesawat pada ilustrasi di atas termasuk ke dalam kategori gerak lurus beraturan.	V		Gerak bantuan jatuh ke titik B termasuk dalam Kategori penerapan gerak lurus beraturan.		V	Berdasarkan ilustrasi di atas dapat ditafsirkan bahwa besar percepatan pesawat adalah nol saat melepaskan bantuan	V		Kecepatan pesawat 180 km/jam merupakan kecepatan pada sumbu X sedangkan kecepatan pada sumbu Y adalah nol	V		Waktu yang dibutuhkan bantuan untuk tiba sampai tanah dapat di hitung dengan konsep Gerak Lurus Berubah Beraturan (GLBB)		V
Statement	True	False																			
Gerak pesawat pada ilustrasi di atas termasuk ke dalam kategori gerak lurus beraturan.	V																				
Gerak bantuan jatuh ke titik B termasuk dalam Kategori penerapan gerak lurus beraturan.		V																			
Berdasarkan ilustrasi di atas dapat ditafsirkan bahwa besar percepatan pesawat adalah nol saat melepaskan bantuan	V																				
Kecepatan pesawat 180 km/jam merupakan kecepatan pada sumbu X sedangkan kecepatan pada sumbu Y adalah nol	V																				
Waktu yang dibutuhkan bantuan untuk tiba sampai tanah dapat di hitung dengan konsep Gerak Lurus Berubah Beraturan (GLBB)		V																			
Topic : Gerak Parabola		Critical Thinking Skills Aspect : Interpretasi																			
Question number : 1																					
Please, assess by giving a tick (✓) for the below aspects.																					
a. The questions fit the CTS indicator.	<input type="checkbox"/> agree	<input type="checkbox"/> dis-agree																			
b. The stimulus/stem fits the questions.	<input type="checkbox"/> agree	<input type="checkbox"/> dis-agree																			
c. The questions are clearly formulated.	<input type="checkbox"/> agree	<input type="checkbox"/> dis-agree																			
d. The problem description is clear and unambiguous	<input type="checkbox"/> agree	<input type="checkbox"/> dis-agree																			
Comment / Suggestion:																					

Fig 1. Example of validation table

In figure 1, the sheet of validation complex multiple choice instrument to measure critical thinking skills consists of question indicators, critical thinking indicators, question and answer, the category of validation and suggestion column. Through a sheet of validation, the expert can see the relationship between question indicators, question and critical thinking indicator. The expert provides a check mark (✓) in the appropriate category. Whereas in the suggestion column, the expert can give suggestions regarding question being reviewed.

The result of validation each item from 9 experts were analyzed using Aiken Formula, then obtained the value of content validity of complex multiple choice instrument to measure student critical thinking skills. Aiken formula that used to calculate the content validity coefficient based on the result of validation an item as many and people, the extent to which the item represents the measured indicators is as follows.

$$V = \frac{\sum s}{[n(C-1)]}; \quad s = r - L_o \tag{1}$$

Where,

- V = index of validity Aiken
- L_o = lowest value/category
- r = value/category from expert
- n = number of expert

Criteria used to declare a question said to valid in content validity with 9 experts based on Aiken table is 0,78.

RESULTS AND DISCUSSIONS

The validity of the content on this instrument is determined through item assessment by 9 experts consisting of 6 lecturers and 3 physics teacher. Aspects of assessment which include 1) The questions p-ISSN: 2477-5959 | e-ISSN: 2477-8451

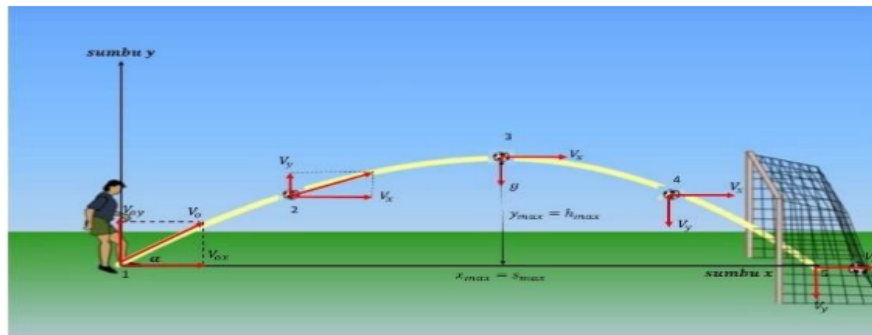
fit the CTS indicator, 2) The stimulus/stem fits the questions, 3) The questions are clearly formulated, and 4) The problem description is clear and unambiguous.

Content validity of a test is based on logical analysis and expert assessment of measurement content such as items, item formats, and constituent sentences [25] [26]. Content validation of instruments is of vital importance in the context of developing assessment instruments or tests [27] [28]. This is done to ensure the accuracy of the aspects being measured, that the assessments made reflect the complexity of the concepts or skills being measured, to avoid measurement bias, enhance the quality of the instruments, and improve the objectivity of research results.

Furthermore, regarding the content of measurement as an aspect of expert judgment, it refers to the opinion of Mardapi [29], who states that the main guidelines in creating multiple-choice tests include clear subject matter, sentences used are appropriate for the developmental level of test-takers, standard language usage, random determination of the correct answer choices location, all answer choices must be logical, relatively similar sentence lengths for answer choices, and no hints to the correct answer. The number of experts for validating the developed instrument aligns with Lynn's opinion, which states that the number of experts used in expert validation should be a minimum of 3 experts and not more than 10 experts.

The results of the development complex multiple choice instrument to measure student critical thinking skills consist of five answer choices. Figure 2 is an example of a question developed.

2. A child takes a penalty kick in a ball game, if we look at the movement of the ball it forms a parabolic trajectory or graph as shown below



Based on the illustration of the case above, which of the following statements is appropriate...

Statement	True	False
The movement of the ball from point 1 to point 3 can be categorized as slowed GLBB motion.		
Based on the information that at point 3 the velocity of the ball is equal to the velocity on the X axis.		
The ball experiences a horizontal velocity on the X axis and a vertical velocity on the Y axis		
The ball reaches its maximum height at point 3 when its velocity about the Y axis is zero.		
The time taken by the ball from points 1 to 3 is different from the time it takes the ball to travel from points 3 to 5.		

Fig 2. Example of a question developed

The result of validation from 9 experts was calculated using Aiken Formula with the help of the Microsoft Excel program. Each item of questions has a value of validation from 9 experts. The result of calculated validation is shown in table 2.

Table 2. Result of calculation of contents validity with Aiken Formula

Number of Question	V obtained	V table	Conclusion
1	0.96	0.78	Valid
2	0.93	0.78	Valid
3	1.00	0.78	Valid
4	1.00	0.78	Valid
5	0.93	0.78	Valid
6	1.00	0.78	Valid
7	0.96	0.78	Valid
8	0.96	0.78	Valid
9	0.96	0.78	Valid
10	0.96	0.78	Valid
11	0.93	0.78	Valid
12	1.00	0.78	Valid
13	0.96	0.78	Valid
14	0.96	0.78	Valid
15	1.00	0.78	Valid
16	0.93	0.78	Valid
17	0.96	0.78	Valid
18	0.96	0.78	Valid
19	0.96	0.78	Valid
20	1.00	0.78	Valid

Values of Vtable in table 2 are obtained from the Aiken Table. The instrument validated by 9 raters with 4 validation categories will be valid if the results of the validation calculation are least 0,78. Based on the calculation of content validity with Aiken formula, the results are V obtained > Vtable, so that 20 item questions that developed can be declared valid. Thus 20 item questions are suitable to measure indicators of higher-order thinking skills that have been determined based on content validity.

Validation by experts can be proof of validity. According to Aiken, there is nothing wrong in using expert judgment if the assessment is made carefully and independently. Retnawati [30] also stated that content validity can be determined using expert agreement in the field, which is stated valid if the expert believes that the instrument can measure what should be measured. The expert's task is to look at the suitability of the indicator with the purpose of developing instrument, the suitability of indicator with scope of the material or the suitability of theory, seeing the suitability of the instrument with item indicators, seeing the truth of the concept questions, key truths, language and culture. Therefore the selection of experts is very important because it will determine the quality of the instrument being developed.

Content validation in an instrument is a crucial step in its development [31]. This is because content validation helps ensure that the instrument truly measures what it is intended to, making its results reliable and accurate [32]. Without proper content validation, the instrument may produce irrelevant or off-target data, which can have adverse effects on decision-making policies in education, evaluation, and research, as the generated information may not be dependable. Therefore, the urgency of content validation lies in ensuring that assessment tools or evaluations used in various educational or research contexts can provide accurate and valuable information for all stakeholders involved.

Content validation using the Aiken formula, often referred to as "Aiken's V," is a statistical method employed to measure the level of consensus among a group of experts regarding questions or items within a test instrument [33]. This method requires a panel of experts to assess each test item based on its relevance and alignment with the measured concept. Each item is rated on a specific scale, typically a Likert scale, and then the Aiken formula is utilized to calculate the degree of consensus among the expert evaluations. Content validation with the Aiken formula helps ensure that these items are relevant and aligned with the measurement objectives while identifying items that may need revision

or removal to enhance the test instrument's validity and reliability in measuring the desired concepts or skills.

CONCLUSION AND SUGGESTION

Based on the results of research and discussion, can be concluded that 20 item questions of the complex multiple choice instrument to measure student critical thinking skills are declared valid based on Aiken Validity. The complex multiple choices instrument represents indicators to measure critical thinking skills.

ACKNOWLEDGMENTS

This research was funded by Ministry of Education, Culture, Research and Technology of the Republic of Indonesia under contract number: 138/E5/PG.02.00.PL/202.

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