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Assessment Quality in Mathematics Learning: An Analysis of Critical Thinking Instruments for Derivative Topics

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Abstract: The assessment of students' critical thinking abilities is crucial for the learning process; however, numerous educators have been unable to select high-quality evaluation tools. A question that is effective must satisfy the following criteria: adequate validity, reliability, difficulty level, differentiating power, and effectiveness of the checker. A quantitative approach was employed in this study, which employed descriptive methods in one of the high schools in Yogyakarta. 15 summative test items on derivative material were administered to 30 students as the research subjects. The question is declared valid, as the content validity results using V-Aiken's indicate a value of 0.8889. This value is classified as high. The reliability test yielded a value of 0.924 for choice questions and 0.777 for description questions, suggesting that the questions were reliable. The analysis of the items revealed that item number 6 required deletion due to its low differential power, while item number 7 required revision. Questions 10 and 12 should be addressed in accordance with the level of difficulty. The exemptions are ineffective, necessitating revision of the answer options in question numbers 9 and 10. This research underscores the significance of enhancing evaluation instruments to facilitate the attainment of student learning indicators.

Keywords: Critical Thinking, Item Analysis, Reliability, Validity.

INTRODUCTION

Critical thinking and problem-solving skills, collaboration skills, communication skills, creativity, and innovation skills are among the 21st-century life skills that must be cultivated and refined through the educational process (Roudlo, 2020). It is crucial for students to possess critical thinking skills in order to resolve issues in their personal lives. Critical thinking is crucial for all students because it can enhance their analytical abilities, creativity, and curiosity (Susilawati et al., 2020). Learning mathematics can also facilitate the development of students' critical thinking abilities. By studying mathematics, an individual becomes accustomed to thinking systematically, scientifically, critically, and using logic, and their creativity can be enhanced (Bernard, 2015).

The capacity to objectively process and evaluate information in order to make effective and appropriate decisions is known as critical thinking skills (Novianti et al., 2023).The questions that are available at school tend to test aspects related to memory and do not train students' higher-level thinking skills, which is one of the challenges that trigger the low critical thinking skills of students today (Mandini & Hartono, 2018). One of the contributing factors is that students in Indonesia are less trained in the process of solving questions that measure HOTS and HOTS. HOTS skills connect, shape, and transform information and their experiences, whereas critical thinking can encourage students' critical thinking (Nurmalia & Sari, 2023).

The challenges of critical thinking skills in students can be surmounted by preparing students to become accustomed to encountering problems or situations that prompt them to employ their critical thinking skills. Additionally, students can be trained to complete tests or questions that are more specific, sustainable, and high-level, such as those that require analysis, evaluation, and creativity (Herawati et al., 2022; Sundari & Sarkity, 2021).

According to the indicators to be assessed, administering tests in the form of questions is one method of achieving learning outcomes in students. To enhance students' critical thinking abilities, questions must be capable of meeting the indicators that are

intended to be achieved in this area. The critical thinking indicators employed in this investigation were cited by Ennis (2009). In critical thinking, there are six indicators: Focus, Reason, Inference, Situation, Clarity, and Overview.

Table 1. Indicators of Critical Thinking Ability

No	Indicator	Sub Indicator
1.	*Focus*	Students can write the known things and things asked in the problem
2.	*Reason*	Students are able to write down the steps in solving the problem or students can provide relevant reasons in making a conclusion.
3.	*Inference*	Students are able to make conclusions from the reasons that have been stated correctly.
4.	*Situation*	Students are able to use all information that has been adjusted to the problem
5.	*Clarity*	Students are able to distinguish several things clearly in a problem
6.	*Overview*	Students are able to re-examine answers and are able to find other alternatives to solve the problem.

It is crucial for a teacher to evaluate critical thinking skills as part of the learning process. Nevertheless, a significant number of educators have yet to select appropriate evaluation tools (questions). Teachers have been unsuccessful in distinguishing between high-quality and low-quality questions during the development of evaluation tools (questions). Despite the fact that this is crucial for the support of learning indicators (Revita et al., 2018).

Quality questions must satisfy the following criteria: validity, reliability, difficulty level, differentiating power, and the effectiveness of triggers (Ardhani, 2020). A question is considered valid if it is capable of measuring the object being measured. A question is considered reliable if the results of the question remain consistent when tested on multiple occasions. A test that possesses differentiating power for students is capable of distinguishing between students who are members of high-achieving groups and those who are members of low-achieving groups. A test is considered satisfactory if the question is neither excessively challenging nor excessively straightforward.

The item analysis process is the initial step in determining the quality of the question. The teacher is required to conduct item analysis in order to enhance the quality of the questions that have been composed. The objective of item analysis, as stated by Aiken (1994) in (Depdiknas, 2008), is to enhance the quality of test items and ascertain diagnostic information about students. A question of quality is one that can provide information with the greatest degree of precision, thereby enabling the identification of students who have mastered the material and those who have not. According to the foregoing description, there is still a requirement for research on the quality of items used to assess students' critical thinking abilities with respect to derivative material.

METHODS

The descriptive analysis method is employed in this quantitative research. The study was conducted at a high school in Yogykarata. A summative test question (15 questions) on derivative material is the focus of this research, which involves a total of 30 students. A student critical thinking test was implemented as the research instrument. Test questions from the preparation of critical thinking test instruments on derivative material were used to assess students' critical thinking skills. The test consisted of 12 multiple-choice questions and 3 descriptive questions.

Quantitative methodologies are implemented during item analysis. A classical approach to quantitative analysis encompasses reliability and validity. The Anbuso program is used to conduct item analysis on the data obtained, and Microsoft Excel is used to determine the level of reliability of the question. A research instrument will be deemed satisfactory if its reliability and validity fall within the

categories of reliable and valid. The reliability of an instrument is determined by the degree of confidence and consistency of its measurements over time, while the validity of an instrument is determined by the degree to which it accurately measures its intended purpose (Miller, 2009). The instrument items that were analysed will be explained in the following manner.

a. Question Item Validity Test

Content and construct validity are the two types of validity. Content validity can be achieved by analysing the opinions of experts who comprehend the concepts or theories contained in each statement item or question using V-Aiken's. The instrument validation scoring guidelines are based on Sugiyono (2013). Table 2 displays the instrument validation scoring guidelines that are based on Sugiyono (2013).

Table 2. Contains The Scoring Guidelines For Instrument Validation

Description	Score
Very Less	1
Less	2
Enough	3
Good	4
Very Good	5

b. Question Item Reliability Test

After the initial phase, the instrument's dependability is evaluated. The Cronbach Alpha coefficient was employed to measure the reliability of the item instrument in this study. The reliability of the instrument was determined through the application of relevant theory. Consequently, the criteria for interpreting the minimum limit of the reliability coefficient were applied in the instrument validity category, which adheres to the validation classification recommended by Guilford: (Haq, Vick, Ainun., 2022)

Table 3. Reliability Classification

Category	Test Reliability
$0{,}80 < r_{11} \leq 1{,}00$	Very High
$0{,}60 < r_{11} \leq 0{,}80$	High
$0{,}40 < r_{11} \leq 0{,}60$	Medium
$0{,}20 < r_{11} \leq 0{,}40$	Low
$0{,}00 < r_{11} \leq 0{,}20$	Very Low

c. Item Analysis

1. Item Differentiation Test

A question item's differentiating power is its capacity to ascertain whether it is capable of distinguishing between high-ability participants and low-ability trainees. The discrimination index number (D) of the item is used to determine the classification of distinguishing power. Determining the D value can be accomplished through the equation or by employing Anbuso Software.

$$D = \frac{A_B}{A} - \frac{B_B}{B} = P_A - P_B$$

Description:
D: Index of discrimination
A: The quantity of upper groups
A_B: Participants in the upper group who provided accurate responses
B: The number of participants in the lower group
B_B: Participants in the lower group who provided accurate responses
P_A: Difficulty level of the upper group
P_B: Group with a lower level of difficulty

In this relationship, an item is considered to possess differentiating power if its discrimination index number is positive (D>0). The table below provides a more detailed explanation of the criteria for the magnitude of the differentiating power coefficient.

Table 4. Catgorization of Distinguishing Power

Description	Score
$0{,}40 \leq D \leq 1{,}00$	Good
$0{,}30 \leq D < 0{,}40$	Moderate (no need for revision)
$0{,}20 \leq D < 0{,}30$	Needs Revision
$-1{,}00 \leq D < 0{,}20$	Not Good

2. Test Item Difficulty

The objective of item analysis is to evaluate the items in terms of their difficulty in order to identify those that fall into the categories of easy, medium, and difficult. Anbuso Software or the equation can be employed to determine the level of difficulty of each item:

$$P = \frac{N_p}{N}$$

Description:
P: Difficulty index
N_p: The number of participants who correctly answered the question
N: The total number of participants who answered

The item is classified based on the index obtained; the lower the index, the more challenging the question. In contrast, the question becomes more straightforward as the index increases. According to Asmawi Zainul (1997), the following table can be employed as a benchmark: the magnitude of the difficulty level ranges from 0.00 to 1.00. The item is classified based on the index obtained; the lower the index, the more challenging the question. In contrast, the question becomes more straightforward as the index increases. According to Asmawi Zainul (1997), the following table can be employed as a benchmark: the magnitude of the difficulty level ranges from 0.00 to 1.00.

Table 5. Categorization of Difficulty

Difficulty Index	Evaluation
$0{,}00 < P \leq 0{,}25$	Difficult
$0{,}25 < p \leq 0{,}75$	Medium
$0{,}75 < P \leq 100$	Easy

3. Effectiveness of Distractors

The analysis of the pattern of distribution of item answers is a term that is frequently used to refer to the evaluation of the effectiveness of distractors. The analysis of answer patterns or the effectiveness of distractors is conducted by counting the number of test takers who select each alternative answer on each item. The criterion for a good exemplar is that it is selected by a minimum of 5% of the test participants. Assessing the distractors of each item can be classified as follows, as per the Department of Education and Culture (1997);

Table 6. Excerpt categorization

Proportion Value	Eligibility
$\geq 0{,}025$	Good
$< 0{,}025$	Moderate (no need for revision)
$= 0{,}000$	Needs Revision

FINDINGS AND DISCUSSION

The instrument analyzed contained 12 multiple choice questions and 3 description questions which were prepared based on four critical thinking indicators, namely: identify, connect, analyze, and solve mathematical problems (Palinussa, 2013). The critical thinking of students was evaluated by mapping the indicators' achievement using the responses to the description questions (Hidayah, 2020). Ennis is FRISCO declares students to possess critical thinking skills when they satisfy all of the indicators (Hidayah, 2020). In the interim, the responses to multiple-choice questions are employed to evaluate critical thinking in accordance with the critical thinking indicators of the questions that were presented. The instrument item indicators are represented in the following table in order of their suitability.

Table 7. Indicators of Critical Thinking Ability Questions

Critical Thinking Indicator	No. Multiple Choice Problem	No. Essay Problem
Focus	1-12	1-3
Reason	1-12	1-3
Inference	1-12	1-3
Situation	1-12	1-3
Clarity	1,2,3,4,5,6,7,11,12	1-3
Overview	1,2,3,4,5,6,7,11,12	1-3

a. Validity

V-Aiken's is employed to analyze the content validity of each statement item or question, which is obtained from three experts who comprehend the concepts or theories contained within them.

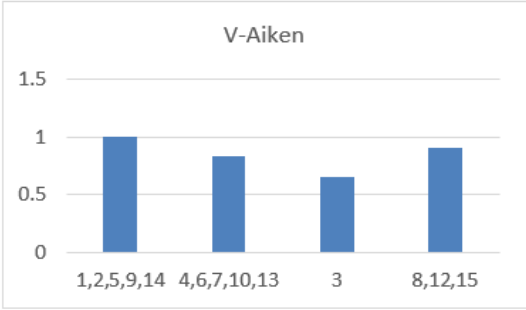

Figure 1. Diagram of the analysis of question results through V-Aiken's

All questions have V-Aiken's values greater than 0.5, as determined by the results of V-Aiken's analysis. Therefore, it can be inferred that all items in the cognitive instrument are valid, as the overall V value is 0.888889, which is in the high category and thereby distributed to the research sample. The data that has been revised and declared valid by the three validators is subsequently utilized for testing with 30 students from class XI Muhammadiyah 2 Yogykarta.The instrument developed is declared empirically valid if it meets the criteria of sufficient to very and r_table (product moment) is less than r_hitung. Consequently, correlation testing is classified as empirically valid. Correlation

testing (construct validity) results for each item are presented below.

Table 8. Multiple Choice Question Item Construct Validity Test Results

No.	Calculated r	Critical r	Description
1	0.786	0.349	Valid
2	0.920		Valid
3	0.742		Valid
4	0.872		Valid
5	0.925		Valid
6	0.210		Tidak Valid
7	0.361		Valid
8	0.906		Valid
9	0.906		Valid
10	0.410		Valid
11	0.922		Valid
12	0.680		Valid

Table 9. Results of the Construct Validity Test of the Description Problem Items

No.	Calculated r	Critical r	Description
1	0.866	0.349	Valid
2	0.739		Valid
3	0.901		Valid

14 of the 15 questions that were tested were deemed valid, while 1 question was deemed invalid on multiple-choice questions. Questions that are classified as valid may be implemented and implemented. In the interim, questions with invalid categories may be rectified and subsequently retested or disregarded due to their potential impact on the instrument's high reliability (Arikunto, 2015). There is one question that has been classified as invalid, which is the result of a combination of factors. One of the reasons is that students find the items to be challenging, which results in them having difficulty answering them accurately.

b. Reliability

The reliability test of the test instrument aims to determine the level of accuracy of the instrument in measuring what is measured (Sugiyono, 2015). The results of data analysis through Microsoft Excel are presented in the following table.

Table 10. Reliability Test Results

Test Type	*Alpha Cronbach*	Description
Multiple Choice	0,924	Highly Reliable
Essay	0,777	Reliable

The reliability value of multiple choice questions is classified as "very high," while the reliability value of description questions is classified as "high," according to the source by Guilford: (Haq, Vick, Ainun., 2022). Consequently, this instrument is considered to be dependable. This implies that the results of this assessment instrument will be consistent regardless of the time or occasion on which it is administered to a group.

c. Item Analysis

The following are the results of item analysis of multiple choice test instruments and descriptions using Anbuso Software.

Table 10. Multiple Choice Test Instrument Analysis Results

Item Number	Distinguishing Power		Difficulty Level		Ineffective Finder	Final Conclusion
	Coefficient	Description	Coefficient	Description		
1	0,833	Good	0,833	Easy		Fairly Good
2	0,767	Good	0,767	Easy		Fairly Good
3	0,678	Good	0,667	Moderate		Good
4	0,837	Good	0,667	Moderate		Good
5	0,905	Good	0,700	Moderate		Good
6	0,147	Not Good	0,67	Difficult		Not Good
7	0,260	Fairly Good	0,233	Difficult		Fairly Good
8	0,881	Good	0,700	Moderate		Good
9	0,881	Good	0,700	Moderate	ACD	Distractor Revision
10	0,325	Good	0,833	Easy	A	Distractor Revision
11	0,905	Good	0,700	Moderate		Good
12	0,603	Good	0,603	Moderate		Good

Table 11. Essay Test Instrument Analysis Results

Item Number	Distinguishing Power		Difficulty Level		Ineffective Finder	Final Conclusion
	Coefficient	Description	Coefficient	Description		
1	0,651	Good	0,781	Easy		Fairly Good
2	0,577	Good	0,654	Moderate		Good
3	0,745	Good	0,779	Easy		Fairly Good

1. Analysis of Differentiating Power

Ten questions were identified as having strong differentiators as a result of the item analysis conducted with Anbuso Software to evaluate the differentiating power of the questions. Nevertheless, item number 7 is classified as "good enough." This implies that it is less effective in distinguishing between students who prepare for the test and those who do not. Therefore, the most effective response to ensure that the item remains usable is to revise the question. In contrast, the coefficient value of question item number 6 is 0.147, which is nearly equal to zero, indicating that it has a low differentiating power. Consequently, the item must be eliminated from the question set. This implies that the upper group encountered challenges with the items, while the lower group found them relatively straightforward. In other words, the lower group responded more accurately than the upper group.

This demonstrates that the items have an inverse differentiating power, indicating that the question is not effective in terms of its differentiating power. An item is considered superior when its differentiating power is greater, and inferior when it is lower. Furthermore, the three questions were found to have a strong differentiator in the test of the differentiating power of the description question. In order to maintain the ability to utilize the three questions without the need for revision.

2. Analysis of Item Difficulty

A question that is relatively not too difficult and relatively not too easy is a good level of difficulty for the final test. According to Depdiknas (2008), the ideal problem difficulty level is represented by a 25%, 50%, and 25% ratio of easy, medium, and difficult

questions. Overall, the percentage of question difficulty is presented as the following graph.

Figure 2. Diagram of the Percentage of Problem Difficulty Level

The questions analyzed are not in accordance with the proportion of the ideal level of difficulty, as indicated by the Anbuso Software analysis. Consequently, there are two questions that do not match the proportion and must be corrected for the appropriate level of difficulty. Specifically, questions number 10 and 12 from the easy and medium categories must be raised to the difficult category.

Depdiknas (2008) suggests that the absence of item exemptions or the comprehension of the question material by certain students may be inferred from the presence of easy question items. The concept of the material asked is not suitable to be realized in the form of a story problem, the question statement is too long, the material given has not been taught, and the question has more than one correct answer key are all interpretations of difficult question items (Depdiknas, 2008).

It is possible to revise the exemptions on the items in order to ensure that they function properly as a follow-up to easy category questions. In the interim, it is possible to reevaluate challenging category questions in order to identify the reasons for the high number of students who are unable to answer them. This will allow for the identification of potential errors in the questions or the incompatibility of the questions with the material being taught. If the question is found to be free of errors, it may continue to be used.

Findings may be presented in the form of tables, graphs, verbal descriptions, or a combination of the three. Tables, graphics, or images should not be too long, too large; please do not present too many figures in the manuscript. Authors are recommended to use a combination of presentation tables, graphs, or verbal descriptions. The tables and graphs presented must be referred to in the main text. The writing style for the tables and figures are presented in Table 1. The table should not contain vertical lines (upright), while horizontal (flat) lines are only on the head and tail of the table. Font sizes for table and picture entries may be reduced.

3. Effectiveness of Distractors

Two items are identified as having inadequate distractors' efficacy, as indicated by the Anbuso Software output. A distractor is considered effective when the exceptions in the question are at least five percent by students, as per Astuti (2020).A, C, and D are the three ineffective alternative answers to question number 9. This implies that there are no students who select answer choices A, C, and D. For question item number 10, the alternative answer that is ineffective is answer choice A. The analysis of the effectiveness of distractors has yielded the conclusion that they are ineffective or do not cause confusion among students, particularly those who are unfamiliar with the concept or have not yet mastered the material. This necessitates the revision of ineffective answer choices in order to facilitate the use of the question.

CONCLUSION

The question was valid based on the results of the recapitulation of three validators, as a value of 0.8889 was obtained based on the content validity using V-Aiken's, which was included in the high category. According to the construct validity results, there is one question item that is invalid due to the fact that the t table value is less than the r table value. Consequently, the question can be eliminated from the instrument. Furthermore, the choice questions yielded a reliability score of 0.924, while the description questions yielded a score of 0.777, indicating that the questions were reliable for use. Based on the analysis of the summative test questions on derivative material, it has been determined that the multiple choice questions at the difficult level in item number 6 should be eliminated. This is due to the fact that the differential power is nearly zero, rendering it incapable of distinguishing between students who truly understand the material and those who do not. Item number 7 may continue to be implemented; however, it must undergo revision due to its inadequate differentiating power. Answer choices A, C, and D will be revised in the analysis of the effectiveness of the number 9 checkers, as

they are not effective, as well as answer choice A for number 10. Questions number 10 and 12 from the easy and medium categories will be elevated to the difficult category based on the level of difficulty test.

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