Validity of the Instrument for the Critical Analysis Ability of Prospective Biology Teacher

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Abstract. This research aims to evaluate the validity and reliability of an instrument designed to measure the critical analysis skills of prospective biology teacher students. Content validity was calculated using the Content Validity Ratio (CVR) and Content Validity Index (CVI), which involved five biology education experts. Of the nine items tested, seven were declared valid with a CVR value 1.0, while the other two were declared invalid. The empirical validity and reliability of the instrument were tested on 60 students using SPSS 23. The results of the empirical validity test showed that all items were valid with a Pearson Correlation value greater than r-table (0.254). The instrument's reliability was also good, with a Cronbach's Alpha value of 0.714. The research results show that this instrument is valid and reliable for measuring the critical analysis skills of prospective biology teacher students.

Keywords: critical analysis skills; content validity; Content Validity Ratio; Content Validity Index; empirical validity; reliability; prospective biology teacher students.

INTRODUCTION

Critical analysis is an intellectual process that involves evaluating, synthesising, and interpreting information to make decisions or judgments based on evidence and logical thinking. This ability is rooted in critical thinking, which includes thinking clearly and rationally, understanding logical relationships between ideas, and identifying, building, and evaluating arguments. Critical analysis allows students to break down information into smaller parts for in-depth understanding or to connect various parts to obtain comprehensive meaning, which ultimately supports making the right decisions [1, 2]. Making the right decisions is closely related to the ability to evaluate [3], where evaluation helps find weaknesses and strengths in information, resulting in innovations.

In academic contexts, critical analysis allows researchers and students to dissect complex theories, evaluate empirical evidence, and contribute new insights to their fields of study [4]. In the professional world, critical analysis underlies strategic planning, policy development, and organisational decision-making, enabling forecasting potential outcomes and assessing the feasibility of various strategies [5]. This ability requires logical, critical, and creative thinking to solve problems [6].

The first step in critical analysis involves evaluating the evidence's quality, relevance, and reliability, including assessing data sources, research findings, and theoretical frameworks. Learning in higher education that emphasises the transfer of information supports the development of students' dispositions, critical thinking skills, and critical analysis as relevant through critical thinking skills and critical analysis [6]. Essential analysis skills in this research include several indicators such as organising information, connecting variables, interpreting data, evaluating information, reflecting on processes, and making relevant decisions [7].

Indicators of critical analysis abilities, according to [7], which include organising information, connecting variables, interpreting data, evaluat-

ing information, reflecting on processes, and making decisions, can be explained as follows: first, organising information is the ability to arrange information in a structured manner, separating relevant information from what isn't, and grouping it so it's easy to understand and access. Second, connecting variables involves finding relationships between existing variables, identifying patterns or correlations between variables, and understanding how these variables influence each other. Third, interpreting data is the ability to analyse the data obtained, determine the meaning behind the data, and conclude relevant information from existing data. Fourth, evaluating information involves assessing the reliability, relevance, and credibility of the information obtained and identifying the weaknesses and strengths of the information. Fifth, reflecting on the process is the ability to reflect on the analysis process carried out, consider the approach used, identify deficiencies in the analysis process, and think about ways to improve the process. Finally, making relevant decisions is the ability to use information that has been carefully analysed to make decisions that are appropriate, rational, and based on existing evidence.

Critical analysis skills are essential for prospective biology teacher students facing the complexity of effective biology teaching. Critical thinking skills enable these prospective educators to identify problems, formulate solution strategies, reflect on their approaches, and analyse biological issues [8]. Research shows that using problem-based learning models, such as those assisted by Vee diagrams, significantly improves the critical thinking abilities of prospective biology teachers [9]. This is very important because critical thinking is related to problem-solving, decision-making, problem management, and clinical judgment, all essential educator skills [10].

It is essential to consider the rigorous validation processes used in educational research to ensure the development of valid instruments to measure critical analysis skills. Validation of assessment instruments is necessary to establish measurement reliability and accuracy [11]. Validity, a fundamental aspect of instrument development, is required to establish the credibility and reliability of the data collected [12]. In measuring critical thinking skills, the validation process involves assessing various aspects such as construct, content, and criterion [13].

Construct validity, which assesses the degree to which an instrument measures the construct in question, is crucial in developing assessment tools for critical analysis skills [14]. This type of validity ensures that the instrument accurately captures the basic concepts of critical thinking and is not influenced by external factors [15]. In addition, content validity, which ensures that the instrument covers all relevant aspects of the measured construct, is fundamental in assessing critical analysis skills [16]. The instrument can holistically evaluate students' analytical abilities by integrating essential thinking components.

Criterion validity, which involves comparing instrument results with external criteria or existing measures, is essential for validating instruments used to assess critical thinking skills [17]. By demonstrating solid correlations between instrument results and established benchmarks for critical analysis, researchers can establish the instrument's effectiveness in accurately measuring these cognitive abilities. Reliability, which ensures the consistency and stability of an instrument's measurements over time, is another critical aspect to consider in validation.

This research aims to measure the validity and reliability of critical analysis instruments to assess and improve students' and professionals' essential analysis skills. This instrument is expected to help users identify and evaluate information and integrate it with other evidence and arguments to make more precise and reasoned decisions. The development of this instrument is significant because it provides educators with a tool to measure student progress objectively and can be adapted for professional training, helping companies hone employees' critical decision-making skills.

This research will focus on two main aspects in validating critical analysis instruments, namely content validity and empirical validity. Content validity will be evaluated using Lawshe's Content Validity Ratio (CVR) and Content Validity Index (CVI). CVR is a method commonly used to measure content validity by asking experts or validators to assess the extent to which an instrument's items reflect the measured construct [18]. The experts provided judgment regarding the relevance of each item, and the CVR was calculated based on the level of agreement between them. High CVR values indicate strong agreement among experts about the significance of the items in the instrument. Apart from CVR, the CVI is also

used to evaluate the instrument's content validity. Using these two methods, researchers can measure the instrument's content validity by considering expert agreement regarding the relevance and representation of the items to the measured construct. Therefore, Lawshe's CVR provides a robust framework for evaluating the content validity of instruments in measuring critical analysis skills [19].

Apart from content validity, this research will also assess the empirical validity of the instrument by testing the validity and reliability of the questions [20]. In developing instruments to measure critical analysis skills, empirical validity is crucial to ensure that the instrument can produce consistent and reliable data in measuring students' critical thinking abilities [21]. Reliability testing is also necessary to show how consistent the instrument is in measuring essential analysis skills over time.

Overall, this research is expected to make a significant contribution to the field of education, especially in the development of valid and reliable instruments for measuring the critical analysis skills of prospective biology teacher students. With the instruments developed through this research, it is hoped that a more effective and measurable learning approach can be created to improve students' critical analysis skills and support the development of more comprehensive essential analysis skills among future educators.

METHOD

This research uses a qualitative descriptive approach that aims to evaluate and obtain the quality of a valid instrument to measure the critical analysis skills of prospective biology teacher students. This qualitative descriptive design was chosen because it can provide an in-depth description of the content validity and empirical validity of the instruments developed [22, 23, 24]. The instrument used in this research consists of 9 question items designed to measure students' critical analysis abilities. Instrument validation was carried out in two main stages: content and empirical.

Content Validation using the Lawshe Technique. In the context of this research, the content validity of the instrument used to measure the critical analysis skills of prospective biology teacher students was evaluated using Lawshe's CVR and CVI techniques. Five experts were asked to rate the nine instrument items based on essential and non-essential categories. The CVR value for each item is calculated, and items with a high CVR value indicate a high level of agreement among experts regarding the relevance of that item. Next, the CVI was calculated to provide an idea of the overall content validity of the instrument.

Thus, Lawshe's CVR and CVI in this research provide a robust framework for evaluating and ensuring the content validity of the instruments used in measuring critical analysis skills. This technique helps identify relevant and significant items and ensures that the instrument can provide accurate and reliable measurements of the essential abilities of analysis of prospective biology teacher students [25, 26]. To calculate the CVR and CVI values, use *the Content Validity Ratio* (CVR) and *Content Validity Index* (CVI) formulas as follows:

$$CVR = \frac{\left(Ne - \frac{N}{2}\right)}{\frac{N}{2}} \quad (1)$$

where *CVR – Content Validity Ratio;* N_e – number of assessors/experts who declared essential (*the number of panellists indicating "essential"*); N – number of assessors/experts (*total number of panellists).*

Table 1 – CVR Minimum Standards based on SME [35]

Number of SMEs (experts)	Minimum CVR value
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62

$$CVI = \frac{\sum CVR}{k}, \quad (3)$$

where *CVI = Content Validity Index;* $\sum CVR$= Total-*Content Validity Ratio;* k – number/amount of items.

Table 2 – CVI value categories [35]

Range	Weight
0.00–0.33	Inappropriate/invalid
0.34–0.67	Appropriate/valid
0.68–1.00	Very appropriate/very valid

The validity and reliability of the instrument content are two crucial aspects in developing assessment instruments that must be considered carefully. Instrument content validity refers to the extent to which the instrument measures what it is supposed to measure. In contrast, instrument content reliability refers to the extent to which the instrument consistently provides the same results when used repeatedly [27, 28]. The empirical test was carried out by giving an essay test of 7 question items that declared the content valid. The test was given to 60 students at the Mandalika University of Education who had taken anatomy and plant development courses. Data obtained from respondents were analysed using SPSS 23 software to determine the validity and reliability of the instrument empirically. The critical analysis ability instrument can be declared valid if the significance value is <0.05 and invalid if the significance value is >0.05 [29]. The instrument is declared reliable if the Cronbach's Alpha value is > 0.6 [30, 31]. The basis for making decisions about the validity of an instrument can also be done by comparing the calculated r-value with the r-table. Namely, it is declared valid if (rα > r-table) and reliable if (0.6 ≤ α ≤ 1.0). The r table value at the 5% significance level with the number of respondents (N=60) is 0.254.

RESULTS AND DISCUSSION

The instruments used to evaluate the critical analysis skills of prospective biology teacher students are prepared based on the dimensions of critical analysis according to [7], which consists of 6 dimensions. Based on the dimensions of critical analysis, the researcher then compiled a grid of essential questions of analysis in the Anatomy and plant development course as follows:

Table 3 – Grid of essen-tial questions of analysis in the Anatomy and plant development course

No	Dimensions of Critical Analysis	Indicator	Question item no	Number of questions
1	Organising information	The ability to arrange information in a structured manner, separating relevant information from that which is not and grouping it so that it is easy to understand and access	1, 2	2
2	Connecting Parts or Variables	The ability to find relationships between existing parts or variables, identify patterns or correlations between variables or parts, and understand how these variables influence each other	3, 4	2
3	Data Interpretation	The ability to interpret the data obtained, identify the meaning behind the data, and infer relevant information from existing data.	5, 6	2
4	Information Evaluation	The ability to assess the reliability, relevance, and credibility of the information obtained, as well as identify the weaknesses and strengths of the information.	7	1
5	Process reflection	The ability to reflect on the analysis process carried out, consider the approach used, identify deficiencies in the analysis process, and think about ways to improve the process in the future	8	1
6	Decision Making	The ability to use information that has been carefully analysed to make informed, rational decisions based on available evidence.	9	1

Content validity results (content validity). The following are validation results from 5 biology education experts from the Mandalika University of Education.

Table 4 shows a recapitulation of all experts' assessments of the contents of the instruments tested.

Five experts conducted the evaluation, scoring 1 if the item was considered relevant and 0 if it was not. Content Validity Ratio is calculated for each item based on the level of agreement between experts. Items 1, 3, 4, 5, 7, 8, and 9 received a CVR value of 1.0, indicating complete agreement among experts that these seven items were declared valid. Meanwhile, items 2 and 6 received CVR values of -0.2 and -0.6, respectively, indicating that experts considered these items invalid.

Table 4 – Recapitulation of assessments of all content experts

Items	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	CVR	Information	CVI/Items
1	1	1	1	1	1	1.0	Valid	1
2	1	1	0	0	0	-0.2	Invalid	0.4
3	1	1	1	1	1	1.0	Valid	1
4	1	1	1	1	1	1.0	Valid	1
5	1	1	1	1	1	1.0	Valid	1
6	1	0	0	0	0	-0.6	Invalid	0.2
7	1	1	1	1	1	1.0	Valid	1
8	1	1	1	1	1	1.0	Valid	1
9	1	1	1	1	1	1.0	Valid	1
Total CVI								0.778
Information								Very valid

Content Validity Index (CVI) was also calculated for each item, with a result of 1 for items 1, 3, 4, 5, 7, 8, and 9, indicating that these items are very valid. In contrast, items 2 and 6 had CVI values of 0.4 and 0.2, respectively, indicating low validity. Overall, the total CVI of this instrument is 0.778, which means that this instrument is considered very valid according to expert assessment.

Empirical Validity and Reliability Test Results. Based on the results of content validity tests carried out by five experts, seven items were declared valid, namely item numbers 1, 3, 4, 5, 7, 8, and 9. After ensuring the content validity of these seven items, the next step was to carry out empirical tests to assess the reliability and validity of the items in a broader context. Empirical tests were conducted on 60 students of the Biology Education study program at Mandalika University of Education. The student is given an essay question containing seven valid items that have been tested for content.

The data obtained from this empirical test is then analysed to evaluate the extent to which the items can measure the construct in question consistently and accurately. The analysis results from this empirical test will provide further information regarding the reliability and validity of the items and whether these items can be used effectively in further research or evaluation in the context of biology education. The following are the results of the empirical validity and reliability test of the critical analysis ability instrument for prospective biology teacher students, which can be seen in Tables 5 and 6.

Table 5 – Empirical validity test results of students' critical analysis ability instruments

Question No	Pearson Correlation	r-table	Category
1	0.672	0.254	Valid
2	0.683	0.254	Valid
3	0.707	0.254	Valid
4	0.721	0.254	Valid
5	0.715	0.254	Valid
6	0.707	0.254	Valid
7	0.721	0.254	Valid

Table 6 – Empirical reliability of students' critical analysis ability instruments

Cronbach's Alpha	N of items
0,714	7

The table presents the results of empirical validity tests on seven instrument items tested using SPSS 23. Each item is marked with a question number, and the Pearson correlation coefficient value is measured, indicating how the item correlates with the entire instrument. The r-table value for the number of samples used (N=60) is 0.254. Based on the test results, the Pearson Correlation value for each item is as follows: question 1 (0.672), question 2 (0.683), question 3 (0.707), question 4 (0.721), question 5 (0.715), question 6 (0.707), and question 7 (0.721). These values are more significant than the r-table value, indicating that each item is declared valid. Thus, the seven items are empirically valid and reliable for further research or evaluation.

Table 5 presents the results of empirical reliability tests on the instruments used to measure students' critical analysis abilities. Reliability is measured using Cronbach's Alpha coefficient.

Based on the table, the Cronbach's Alpha value obtained is 0.714. An instrument is reliable if Cronbach's Alpha value is more significant than 0.6. Thus, this instrument can be said to be trustworthy because Cronbach's Alpha value of this instrument is 0.714, which is greater than 0.6. This shows that the instrument has good internal consistency and is reliable for measuring students' critical analysis abilities.

Developing this instrument began with assessing content validity using the Content Validity Ratio and Content Validity Index techniques. Five experts assessed nine instrument items based on essential and non-essential categories. According to experts, the results show that seven of the nine items have a CVR value 1.0, indicating that the items are valid. The other two items, namely items 2 and 6, have CVR values of -0.2 and -0.6, respectively, suggesting that these items are invalid. Overall, the total CVI of this instrument is 0.778, which shows that this instrument is very valid [32, 33].

After content validity was established, empirical tests were conducted on 60 students of the Biology Education study program at the Mandalika University of Education. Empirical validity was assessed using the Pearson correlation coefficient, with the results showing that the Pearson Correlation values for the seven valid items ranged from 0.672 to 0.721, all of which were greater than the table value (0.254). This shows that the items are empirically valid.

The instrument's reliability was measured using Cronbach's Alpha coefficient, which indicates the instrument's internal consistency. The Cronbach's Alpha value obtained was 0.714. According to [34], Cronbach's Alpha value is more significant than 0.6 [30, 31], which shows the instrument is reliable. Thus, this instrument has good internal consistency and can be relied on to measure students' critical analysis skills.

Critical analysis allows researchers and students to dissect complex theories, evaluate empirical evidence, and contribute new insights to their field of study [5]. In the professional world, critical analysis underlies strategic planning, policy development, and organisational decision-making, enabling forecasting potential outcomes and assessing the feasibility of various strategies. This skill requires logical, critical, and creative thinking to solve problems [6].

This instrument shows good validity and reliability with a total CVI value of 0.778 and a Cronbach's Alpha value of 0.714. This indicates that this instrument can be relied on to measure students' critical analysis skills with high confidence. This instrument provides a valuable tool for educators to measure and improve students' critical analysis skills. Thus, this research contributes to the academic field and has broad practical implications, supporting more informed and adequate decision-making in various sectors.

The instrument developed is essential to support the development of more comprehensive critical analysis skills among future educators. The instrument's Good validity and reliability ensure that essential analysis skills can be measured accurately and consistently, ultimately supporting a more effective and measurable learning approach. This research emphasises the importance of developing valid and reliable instruments to measure prospective biology teacher students' critical analysis skills so that they can significantly contribute to improving the quality of biology education and teaching.

CONCLUSIONS

This research shows that the instrument developed to measure the critical analysis skills of prospective biology teacher students has good validity and reliability. Seven of the nine items assessed by five experts had a Content Validity Ratio (CVR) value of 1.0, indicating excellent validity, while the other two were invalid. This instrument's total Content Validity Index (CVI) value is 0.778, indicating high overall validity. Empirical validity was tested on 60 students, and the Pearson Correlation value for seven items ranged from 0.672 to 0.721, more significant than the r-table value of 0.254, indicating empirical validity as a good one. The instrument's reliability was measured using Cronbach's Alpha coefficient of 0.714, which means good internal consistency.

Further research should focus on improving this instrument by involving more experts from various fields of biology education to increase its validity and reliability. Besides that:

1. Pilot testing of the instrument in various educational settings and with more diverse student populations is needed to ensure its generalizability and broad utility.

2. This instrument should be updated regularly to maintain relevance with the latest developments in biology education and critical analysis skills. Thus, these instruments can continue to provide accurate and practical measurements, helping educators identify areas of improvement and develop better teaching strategies.

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