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The Validity and Reliability Questionnaire of Students' Critical Thinking Skills in General Biology Course

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Abstract: Critical thinking skills are very important for biology learning. However, it has not been thoroughly researched because the current evaluation technique cannot test students' critical thinking skills in studying biology. To make it easier for students to apply the concepts they have learned, an evaluation instrument must be made to assess how well they are progressing in developing their critical thinking skills. A valid and reliable critical thinking questionnaire is the goal of this study. The type of research used is called research and development (R&D). Based on the findings of the validity test, the resulting evaluation tool has 31 valid statements and 5 invalid statements with a reliability value of 0.93 which is included in the very high category. In general biology classes, the instruments developed can evaluate students' critical thinking skills. Therefore, it can be concluded that a questionnaire designed to measure students' critical thinking skills in general biology courses is feasible to use.

Keywords: Critical thinking skills; Questionnaire; Reliability; Validity

Introduction

Biology is a branch of science that focuses on the complexity of life. Biology learning influences the knowledge students will learn, so biology learning requires special consideration from the point of view of how learning will be applied. Studying biology requires a scientific mindset such as curiosity, openness, honesty and other qualities. For example analyzing things, natural events, birth and development through scientific methods such as observation and experimentation (Santosso et al., 2017).

Biology learning will be interesting and engaging if it can stimulate or move students' thinking, especially by encouraging them to think critically (Miftahussa'adiah et al., 2020). The ability to think critically and independently, explore a topic (Facione, 2011), identify questions, analyze and evaluate all available information, use data, and synthesize it are examples of critical thinking (Lau, 2011). The attitude known as critical thinking has a tendency to assess and think about problems that develop based on experience. John Dewey (Kartimi et al., 2012) first emphasized his belief that critical thinking is a person's active thinking process, thinking about something, asking questions and seeking information for oneself.

The process of critical thinking is challenging and demands logical reasoning in the right way. According to Facione (1990), a person deliberately trains critical thinking skills to gain accuracy when interpreting, analyzing, evaluating, concluding and offering explanations. The link between critical thinking and learning according to (Imran et al., 2021) is a requirement for training students to become trustworthy problem solvers, responsible decision makers, and lifelong learners. As can be understood from the definition of critical thinking, adapting critical thinking skills into the education system is important (Gürsan et al., 2022), to achieve a critical societal structure consisting of individuals who can think critically.

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Students should be able to find real arguments and ideas that are appropriate to the problem at hand. When a thinker attempts to thoroughly study arguments and situations, seeks supporting data and useful solutions, and arrives at a convincing conclusion that motivates them to believe and act in a certain way, they are said to be engaging in critical thinking. To become independent individuals and achieve the desired results, students need to have the ability to think critically and process information carefully. Competencies that must be possessed to compete on a global scale in the twenty-first century workplace, according to (Kivunja, 2015), include creative, critical, independent, working with teams, communitive, and independence in learning.

Critical thinking skills help decision makers to navigate between potentially conflicting or mutually exclusive solutions (Samaras et al., 2022). There are five stages of critical thinking associated with each aspect, according to (Ennis, 2013). Begin by giving a short explanation which includes asking and answering questions regarding the explanation and focusing the questions and analysis of the statement. Second, developing basic skills such as evaluating the credibility of sources, making observations, and reporting these observations. Third, drawing conclusions, which includes making judgments and deciding on their value, as well as concluding something and considering the implications. Fourth, provide more detail by defining terminology, discussing it in three dimensions, and mentioning initial guesses. Fifth, organize predetermined methods and tactics consisting of choosing activities, interacting with people, and developing strategies.

Based on the explanation given, it can be explained that critical thinking is an assertive communication capacity. Students who are proficient in critical thinking can filter various events and information in everyday life to determine the truth. Therefore, the way students analyze arguments, understand each meaning and interpretation, and develop logical reasoning patterns is a sign of their critical thinking skills.

Applying critical thinking skills is very important. According to research (Warouw et al., 2012), the urgency level of critical thinking skills in biology learning with details (11.11%), important (51.85%), less important (0%), and (37.04%) not respond. Students must be able to understand and apply the information they receive to study. This requires critical thinking. In other words, the more knowledge gained, the more knowledge will also increase, thus enabling students to better prepare for the future (Sudirman, 2019). It is the responsibility of educators in this situation to turn concepts into tools so as to foster critical thinking skills and to emphasize their knowledge.

According to Setyorini et al. (2011), the integration of critical thinking skills into biology learning is by connecting what is learned by applying it in everyday life, helping students in solving problems, teaching them how to make effective decisions, and motivate them to keep learning. Because critical thinking skills are considered important for studying biology, educators must create an evaluation system that can divert students' attention from seeing facts to a critical mindset (Kartimi et al., 2012). Given its nature, critical thinking requires practice, including through routinely completing evaluation questions that foster critical thinking skills.

To find out and ensure the level of students' critical thinking skills, an assessment method is needed that can measure this talent. Measurement is very important for education because it allows the teacher to know exactly where each student is at any given moment or during an activity. Measurement in the field of education aims to assess the quality of certain students. Only those with special abilities and training can measure the psychological features of a person due to the complexity of the activity.

Critical thinking indicators used in this study refer to indicators (Ennis, 2013). Choosing actual indicators that are consistent with the ideas that will be generated is the first step in creating critical thinking measurement tools. Measuring tools are made using indicators of students' thinking skills in addition to certain learning objectives. Therefore, this measurement tool combines indicators of critical thinking skills with learning objectives.

Based on the background that has been described, it is necessary to develop a questionnaire for students' critical thinking skills in general biology courses to determine the level of critical thinking skills possessed by students. The purpose of this research is to develop a valid and reliable critical thinking questionnaire.

Method

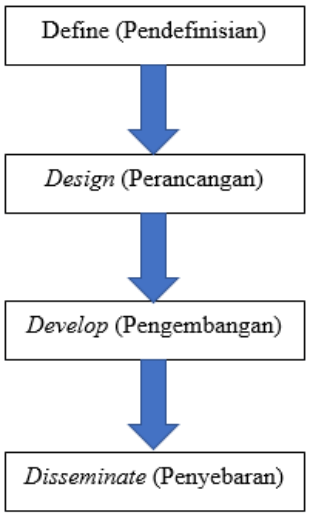

Figure 1. 4-D model flow

The development of this critical thinking questionnaire was carried out by applying the 4-D development model by Thiagarajan et al. The flow of the development stages can be seen in Figure 1, which includes the stages of Define, Design, Develop, and Disseminate. In the definition process, it is necessary to formulate indicators based on indicators of critical thinking ability referring to the opinions of three experts namely Ennis, Kuswana, and Johnson. Referring to the three experts, it was found that there were similarities in the indicators presented.

Define (Formulation of Indicators)

The indicators were designed and modified from the indicators of critical thinking skills of Ennis, Kuswana, and Johnson (Normadhita, 2018) which are described in Table 1. There are several similarities in the indicators of critical thinking skills based on the three experts. The author concludes that the 11 indicators can adequately capture all indicators of critical thinking skills.

Table 1. Opinion of Some Experts About Critical Thinking Indicators

According to Ennis	According to Kuswana	According to Johnson
Focusing questions	Analyze the focus of the problem, questions and conclusions	Examine opinion assumptions
Examine arguments	Analyze arguments/opinions	Investigate the problem
Ask and answer questions	Ask and answer questions	Acknowledge different points of view
Consider the legitimacy of a source	Identify decisions and deal with them accordingly	Consider the meaning of words
Observe and consider the results of observations	Monitor and assess observation reports	Record engagement and conclusions
Make deductions and consider the results of deductions	Summarize and evaluate decisions	Assess evidence
Create an induction and consider an induction	Weighing the reasons without allowing uncertainty and doubt	
Make and consider value decisions	Combines other capabilities and manages decision making and sustaining	
Explain in considering the results		
Explain assumptions		
Define an action		
Interact with others		

Based on the conclusions of the three experts, 11 indicators were determined. These indicators include the ability to formulate issues, ask questions, answer questions, analyze arguments/opinions, select logical, relevant and accurate arguments/opinions, solve problems, evaluate and assess observations, disclose facts/information needed to resolve an issue, identify bias/prejudice based on multiple points of view, ascertain the impact of the selected statement as a decision and be able to draw conclusions.

Design (Draft I Questionnaire)

Respondents only need to choose one of the available alternatives for each statement in the closed questionnaire used for this study. Forms of statements in the form of positive and negative statements in the questionnaire. This was done to encourage respondents to be wiser in their comments and to avoid answering the same questions over and over again. The indicators and statements in the questionnaire are as follows.

Table 2. Indicators and Questionnaire Statements

Indicator	Statements	
	Positive Statements	Negative Statements
Able to formulate the main issues	1. I can analyze the main issues regarding the material being studied 2. I am able to reveal existing facts about the material	1. I am confused in recognizing the material to be taught 2. I am not able to reveal the facts about the material
Ability to ask	1. I will always ask until I get it 2. I can analyze questions according to the material	1. I didn't ask the lecturer, even though I didn't understand the material 2. I have difficulty making interrogative sentences when I want to ask questions
Ability to answer questions	1. I will try to give the right response when the lecturer asks	1. I immediately answered the questions posed by the lecturer, even though I had not analyzed the intent of the questions

Indicator	Statements	
	Positive Statements	Negative Statements
Ability to analyze arguments/opinions	1. I debate different points of view with my group mates to find the best solution 2. After discussing with friends, I can distinguish between right and wrong opinions	1. Without discussing, I easily accept the opinion of my friends 2. It is difficult for me to tell my friend's opinion which is right and wrong
Ability to choose logical, relevant, and accurate arguments	1. I can choose reasons that are suitable, relevant to the problem, and systematic from the whole problem	1.I immediately chose an existing opinion without being selected first
Problem solving ability	1. I use a variety of sources to research a problem or topic until I find the right answer 2. I find it satisfying to keep trying to find solutions to difficult problems 3. In practical and experimental activities, I can understand instructions easily	1. I like to answer questions with multiple choice answers 2. I left out difficult questions to work on 3. In practical activities, it is difficult for me to understand the instructions
Ability to evaluate and assess the results of observations	1. Before sending assignments to lecturers, I double-check the results	1. I quickly turn in assignments without checking them back
The ability to reveal the facts needed in solving a problem	1. I try to find out information about the material well 2. I try to find the right source of reading about the problem being studied	1. I did not seek information about relevant material before the lecture started 2. I only rely on existing reading books without looking for other reading sources regarding the material being studied
Ability to identify bias/prejudice based on multiple points of view	1. I look for alternative answers, when there are answers to problems that do not yet have a strong enough theory of evidence	1. I am only looking for one answer without collecting alternative answers for problem solving
Ability to ascertain the impact of the selected statement as a decision	1. I consider the situation and conditions as a whole regarding the answer to the problem I am looking for	1. I did not consider the situation and conditions as a whole regarding the answer to the problem I was looking for
Ability to draw conclusions	1. I can determine my own conclusions from the experiments conducted 2. I try to be firm when drawing conclusions based on the circumstances	1. With the help of the lecturer, I can complete the material that has been examined 2. I do not pay attention to the situation and conditions when making a final decision

Develop (Draft II Questionnaire)

The questionnaire statement has provided alternative responses. What respondents need to do is choose one of the possible answers available and respond according to their circumstances. The Likert scale is used to calculate the score of the questionnaire. The Likert scale can be used to see the values of attitudes, perceptions, and views of a person or group regarding symptoms or events in the field of education (Suwandi et al., 2019). There are two alternative models for the Likert scale, namely a scale of four, which has four options and a scale of five, which has five options.

The alternative response options used in this study are a scale of four, with alternative choices; Strongly Agree, Agree, Less Agree, Strongly Disagree. In research (Moonma, 2022), the questionnaire was distributed using a Likert scale with 5 points. The use of this Likert scale seeks to avoid central tendency bias. Furthermore, students' responses in general biology courses that utilize critical thinking skills are measured.

Table 3. Questionnaire Scale

Description	Score
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

Table 3 shows the weight of the questionnaire answer scores that have a positive rating with details; Strongly Agree (4), Agree (3), Disagree (2), Strongly Disagree (1). In contrast to a negative rating, with details; Strongly Disagree (4), Disagree (3), Agree (2), Strongly Agree (1) (Sugiyono, 2010).

Disseminate

Questionnaires were given to biology students in general biology courses to see their validity and reliability. The questionnaire respondents consisted of 48 biology students in general biology courses. Calculation of the validity and reliability of the questionnaire was carried out with the help of the SPSS (Statistical Product and Service Solutions) application.

Result and Discussion

The development of a questionnaire must go through the correct stages (Syahfitri et al., 2019). The stages of developing a questionnaire in this study were modified from the method of developing a learning motivation questionnaire instrument by Sudibyo et al. (2017). These stages include: a) formulating indicators of critical thinking skills, b) preparing questionnaire statements based on indicators, d) testing the validity of the questionnaire, and e) testing the reliability of the questionnaire.

In research Nold (2017), the questionnaire was adopted from research Pintrich et al. (1991) and then designed into several statements in such a way by the researcher. The modified instrument is the MSLQ (Motivated Strategies for Learning Questionnaire). The MSLQ is a self-assessment instrument that originally consisted of 81 questions with 15 constructs grouped into two scales: motivation and learning strategies. The results of research (Motallebzadeh et al., 2018) using a questionnaire are expected to help researchers to examine critical thinking skills in the classroom and find relationships between these skills and some aspects of social, economic or psychological studies. Thus, it is hoped that the existence of these instruments can help researchers see the importance of 21st century skills in the lives of students today, especially in critical thinking skills.

Based on the opinion expressed by Widodo (2006), who argues that because the instruments currently used to assess student self-concept have not been thoroughly investigated and standardized, it is important to test the validity and reliability of student self-assessment instruments. In the study (Sarwanto et al., 2020) also explained that an instrument must be tested first so that there is no bias during the assessment. However, because it can be perceived as one-dimensional or multidimensional, the idea of self-assessment continues to grow. Student self-assessment is related to a questionnaire that looks at the critical thinking skills of biology students in general biology courses.

One of the skills needed in learning is critical thinking skills (Maison et al., 2022). It is often stated in many scientific studies that critical thinking skills are one of the most basic skills in the 21st century (Ekinci, 2017). Critical thinking is at the top of the list of basic skills that individuals need (Palavan, 2020), to be successful in both education and business life.

Critical thinking in Biology needs to be developed because it is useful for analyzing the complexity of biological systems (Saenab et al., 2021). Biology includes studying living things and their interactions with their environment to form complex hierarchical systems consisting of multilevel interactions. Critical thinking of students in Biology is very important because it is an integral part of the natural sciences (Koçer et al., 2022). Biology learning has the potential to facilitate students' critical thinking.

The activity of collecting, evaluating, and interpreting process data and learning outcomes so that it becomes a useful source of information for making educator learning decisions is called an assessment which is characterized as a systematic and ongoing activity (Alifah et al., 2020). Based on the mapping of students' critical thinking characteristics, the results of critical thinking assessments can be used as information to choose more effective learning methods (Sarwanto et al., 2020). The test results are explained as follows.

Questionnaire Validity

Validity is a measure of how reliable and accurate an instrument is. A high validity value indicates a reliable and accurate instrument. Conversely, instruments with poor validity are less reliable and accurate. If a tool can accurately explain data from well-researched aspects/variables, then the instrument is declared valid (Shofiyah, 2016). The degree of instrument validity according to Arikunto (2010) shows how close the data collected is in accordance with the desired validity.

Pearson's formula, also known as product moment correlation, is used to perform the validity test. The correlation value obtained is then compared with the r table value. Items are valid if $r_{count} > r_{table}$. Conversely, items are invalid if $r_{count} < r_{table}$. Researchers use SPSS 25 to calculate the results of validity in research.

The questionnaire was tested on 48 students taking general biology courses in the biology education study program using a questionnaire containing 36 statement items and having a significance value of 5%. There were 31 statements that were declared valid and 5 statements that were determined to be invalid based on the calculation of the validity of the student's critical thinking ability questionnaire. Statements at numbers 17, 19, 20, 24, and 28 are invalid statements. Table 4 and Table 5 describe the conclusions of the validity test calculations and their results.

Table 4. Significance of r_{table} Value

N	Df	Alpha	r_{table}
48	46	0.05	0.284

Table 5. Calculation Results of the Questionnaire Validity Test

Item	r_{count}	r_{table}	Information
1	0.338	0.284	Valid
2	0.522	0.284	Valid
3	0.4	0.284	Valid
4	0.476	0.284	Valid
5	0.455	0.284	Valid
6	0.638	0.284	Valid
7	0.592	0.284	Valid
8	0.782	0.284	Valid
9	0.569	0.284	Valid
10	0.549	0.284	Valid
11	0.616	0.284	Valid
12	0.559	0.284	Valid
13	0.322	0.284	Valid
14	0.354	0.284	Valid
15	0.504	0.284	Valid
16	0.665	0.284	Valid
17	-0.151	0.284	Invalid
18	0.652	0.284	Valid
19	-0.293	0.284	Invalid
20	0.107	0.284	Invalid
21	0.758	0.284	Valid
22	0.742	0.284	Valid
23	0.411	0.284	Valid
24	-0.361	0.284	Invalid
25	0.619	0.284	Valid
26	0.541	0.284	Valid
27	0.663	0.284	Valid
28	0.25	0.284	Invalid
29	0.583	0.284	Valid
30	0.567	0.284	Valid
31	0.605	0.284	Valid
32	0.611	0.284	Valid
33	0.614	0.284	Valid
34	0.596	0.284	Valid
35	0.678	0.284	Valid
36	0.539	0.284	Valid

Questionnaire Reliability

Questionnaire reliability, refers to the level of trust in an instrument that is already good, so that it can be used as a data collection instrument. A good instrument has no tendency to influence respondents to choose certain responses. Striving to be reliable is the data, not just the instrument, which makes the instrument reliable and capable of producing data that can also be trusted (Sugiyono, 2010).

Furthermore, to calculate the reliability of the critical thinking questionnaire, the researcher used the Cronbach Alpha formula in SPSS 25. The Cronbach Alpha values obtained were compared with the Cronbach Alpha coefficient value intervals according to theory (Arikunto, 2010). The criteria for Cronbach's alpha value category according to Arikunto (2010) are as follows.

Table 6. Cronbach Alpha Value

Coefficient Intervals	Description
< 0.50	Low
0.50 – 0.70	Medium
0.71 – 0.90	High
> 0.90	Very High

The results of the reliability test of the critical thinking skills questionnaire show that the questionnaire has a very high reliability value. That is, even though the questionnaire is used repeatedly to retrieve data, the results will always be the same. Table 7 provides an explanation of the calculation results of the questionnaire reliability test.

Table 7. Reliability Test Calculation Results

Cronbach Alpha Value	Description
0.93	Perfect

The results of the questionnaire reliability test using the Cronbach Alpha formula obtained a value of 0.93. This means that the developed questionnaire has a very high reliability value. The very high level of reliability indicates the consistency of student answers to the statements given. Therefore, it can be concluded that the questionnaire can be used to assess students' critical thinking skills.

The design of the questionnaire statement formulation according to the expert definition that has been tested on indications of critical thinking ability is used to analyze the acquisition of a very high reliability score. In contrast, the learning process-both theoretical and practical-coincides with the development process, and this information has been compiled in the contents of the questionnaire. The research Priska et al. (2021) explains that the instruments developed must be in accordance with the basic competencies and learning objectives that have been set, and have an attractive appearance.

When they are faced with a situation similar to the statement given, it is hoped that this condition will inspire students to provide answers based on their learning experience and self-evaluation. This is in line with research by Idris (2022), that the development of a questionnaire must be adapted to the situations and conditions of learning. Without external or internal pressure, students are more honest in their responses. According to Setyawan (2006), when people feel free from pressure and the influence of external causes, critical situations that are influenced by the environment can occur.

Building the critical character of prospective teachers begins with a critical thinking phase. Because students are expected to be able to overcome the various difficulties they face and be able to determine or make decisions on the right solution, the capacity to think critically is very important for them. According to

Kholid (2021) critical thinking is the capacity to make decisions and solve problems. The main components of critical thinking skills are the ability to assess claims made by others and the ability to understand and analyze a problem to identify solutions for its completion.

Critical thinking is closely related to various fundamental thinking skills, both in various work fields and in everyday life, such as decision making and metacognition. Decision making and critical thinking are so interdependent that some experts view decision making as the ultimate goal of critical thinking. Indeed, there are many critical thinking assessment tools, so that critical thinking assessment is also a tool for decision making (Bissonnette et al., 2021). Critical thinking is also related to metacognition (Gerdts-andresen, 2022), because a person needs to reflect on his own thinking to be sufficiently critical (A. Al Roomy, 2022) and also needs to be self-critical to achieve metacognition.

Conclusion

The results of validation of the critical thinking ability questionnaire for biology students taking general biology courses obtained 31 valid statements and 5 invalid statements. While getting a very high category in the assessment of reliability.

Unknowledgement

I would like to thank all those who have contributed to this research. The hope for the future is that this research can be used as a reference for the development of critical thinking skills instruments and the selection of effective learning approaches according to the mapping of students' critical thinking aspects.

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