

Measuring Critical Thinking Skills in Science Learning: Students' Perception Versus Actual Performance

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Abstract – The success of teaching can be measured by the critical thinking skills of students as demonstrated through their activities and study results. A descriptive quantitative study was conducted using the Student Perception of Critical Thinking Questionnaire (SPCTQ) to determine the perceptions of 82 grade IX secondary school students in Yogyakarta, Indonesia, regarding their critical thinking skills and their actual performance in the learning process using the Critical Thinking Observation Sheet (CTOS). The data was analyzed using correlation test analysis. The findings showed that the SPCTQ score was higher than the CTOS value. However, there was no relationship between students' perceptions of their critical thinking skills and learning performance. Although students believed their critical thinking skills were good, they could have performed better in the learning process. This highlights that students' critical thinking skills cannot be maximized solely based on self-confidence, beliefs, and student motivation in learning. Instead, it is important to maintain and shape students' perceptions of their critical thinking skills to suit the learning process.

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Keywords – Student's perception, critical thinking skills, science learning, SPCTQ, CTOS.

1. Introduction

Technological advancements and rapid societal changes significantly impact educational patterns [1]. Each level of schooling has a unique vision and mission to provide 21st-century skills relevant to achieving success [2]. Learning focuses on being more student-centered, encouraging students to be imaginative and proactive in integrating knowledge [3]. Students must have strong critical thinking skills to face the world effectively and make skilled contributions to compete in the global market [4].

Students' perceptions about their abilities are called self-efficacy [5] and this concept can influence many aspects of their lives, including problem-solving and decision-making [6], [7]. The perception of their abilities is usually a result of the performance in the learning process [8], [9]. This perception can turn into motivation and confidence to develop their skills further [10], [11].

During the learning process, students can experience various things [12]. Their understanding and performance can be affected by many factors [13], which can sometimes cause a gap between the perceived and actual abilities of the students [14]. Such differences are typical but should be insignificant and crucial for improving the students' abilities [15], [16].

Critical thinking is a rational approach to decision-making that involves evaluating options and adopting the right mindset to solve problems, make choices, and acquire new knowledge [17]. It is an essential skill for lifelong learning as it promotes independent learning and allows for greater flexibility, responsiveness, and practicality [18], [19]. Critical thinking lets base opinions on evidence, distinguish between right and wrong, and maintain consistent beliefs [20], [21].

Critical thinking is a process that requires time, good skills, and motivation from the teacher. Reflective activities in the form of teacher-student discussions are also essential for developing critical thinking [4], [22]. These skills help students face challenges by considering the information they receive, making plans, and evaluating their decisions [23], [24]. Teachers must adapt their teaching methods to students' thinking abilities and provide reflective learning activities so that students can understand their thought processes and know what actions to take [25].

An effective way to enhance students' critical thinking skills is by using the innovative learning model [26]. An innovative learning model offers a unique learning experience that leaves a profound impression on students [27]. According to the study conducted by [28], the learning strategies that can improve students' higher-order thinking skills, including critical thinking skills, are problem-based and inquiry-based learning. The Research Oriented Collaborative Inquiry Learning (REORCILEA) model is an innovative learning model that combines research, collaboration, and inquiry principles based on student's learning experiences [29], [30]. The REORCILEA learning model's syntax includes initiating, hypothesizing, experimenting, writing scientific reports, and evaluating or reflecting on learning [31]. Students must explore what they are learning and have learned to improve their critical thinking skills [32], [33].

Students' perceptions of their abilities directly and positively impact their critical thinking skills while learning [34]. A student's perception of their abilities is a significant factor that can influence and predict their critical thinking skills and interests [35]. Students' perceptions of their abilities can have an inverse or negative relationship with their critical thinking skills [36], [37]. This is because a student's perception of their abilities is just an estimation of their temporary motivations and beliefs, and it may not necessarily reflect their true abilities [38], [39].

Unlike previous studies, which used only one measuring instrument, this study employs two to measure students' perceptions of their skills using research tools. The first instrument used is a questionnaire, while the second is an observation sheet that assesses their actual performance during the learning process. In social science, questionnaires and observation sheets are commonly used to evaluate data. They are straightforward, easy to understand, and can provide insights into the phenomenon being studied [40].

1.1. Questionnaire

A questionnaire is a tool for gathering student data through questions or statements [41]. It is designed to measure affective variables and is used to achieve specific research objectives [42]. Questionnaires can be distributed via mail, email, online, face-to-face, and telephone [43]. Questionnaires are intended to be self-administered by the respondent without direct interaction with the researcher [42]. Respondents can be known or unknown individuals who can provide relevant data on the given topic [44].

Structured questionnaires are commonly associated with quantitative research, which involves analyzing numerical data [42]. The quantitative data from the questionnaires were analyzed using the Excel program and descriptive statistics of frequencies and percentages to answer the research questions [45]. However, as a researcher, it is crucial not to view the data obtained from the questionnaires as the only answer. Instead, it should be considered a tool that can be used to understand a situation. The researcher must be able to interpret the data with a relevant construction of thoughts [46].

Some advantages of using questionnaires in research are that it is a time-efficient way to collect data, it can collect information on sensitive issues, and it is economical [47]. Additionally, questionnaires can be collected quickly and easily from many respondents, even if dispersed or in remote locations. The obtained data can be compared, contrasted, and combined with qualitative data collection techniques like open-ended questions, participant observation, and interviews [48].

However, there are a few downsides to using questionnaires in research. The response rate to questionnaires may be low; Questionnaires usually provide only a brief overview of the topic being studied; Questionnaires often elicit socially desirable responses [47]. One of the significant limitations of questionnaires is that it takes more work to ensure that respondents fully understand the questions and will take the time to provide accurate information. This could be due to various reasons, such as boredom, lack of time, unwillingness to provide certain information, lack of knowledge, or difficulty understanding the question [44].

1.2. Observation Sheet

Observation analyzes and records behavior by directly observing individuals or groups based on predetermined aspects [41]. In education, observation sheets are checklists and notes that document the level of student activity based on observations made during the classroom learning process [49].

The data obtained through observation during the learning process in the classroom includes descriptive notes and a checklist table of statements that have been executed accordingly [50].

Observation sheets containing notes and checklists of classroom activities are used before, during, and after the learning activities [51]. Everything observed, heard, and experienced during classroom observation is carefully recorded in detail on the observation sheet [45]. The observer's observations provide an overview of each student's behavior in the classroom. The observer observes each activity in the classroom directly and provides a representative and systematic description of each student's behavior in turn [52].

The individual observing the classroom activities is an experienced researcher with expertise in assessing such activities. They can explain the research and reassure both teachers and students. The primary goal is to avoid excessive assessment and to utilize the schedule appropriately. Before observing, the observers undergo pre-training using an observation guide that includes categories, conventions, and procedures developed by the researcher [53]. To perform observational assessment, a multilevel statistical model is required to describe and detail clustered observational data in classroom learning [54].

There is a need for more research using systematic observation sheets to objectively study the relationship between teaching practices and students' attitudes, behaviors, and skills [55]. However, one of the challenges of using observation sheets is the tool's validity. Some research questions require data on behaviors that may be easy for some people to observe but difficult for others, even with an assessment category sheet [56].

This study aimed to determine students' perceptions of their critical thinking skills and actual learning performance through the REORCILEA model. Based on these research objectives, the research questions are as follows: What is the correlation between students' perceptions of their critical thinking skills based on the questionnaires and actual performances in the learning process based on the observation sheets?

2. Methodology

To achieve the aims of this study, a descriptive quantitative research method was used with SPCTQ and CTOS as research instruments. 82 students in grade IX of a secondary school in Yogyakarta, Indonesia participated in this study. The data were analyzed using correlation test analysis. with the specific description as follows.

2.1. Research Design and Sample

The present research employed a descriptive quantitative method with a comparative approach study. Purposive sampling was used as the sampling technique. The research was carried out in a secondary school in Yogyakarta, and 82 class IX secondary students, comprising 29 male students and 53 female students, participated in this study.

2.2. Research Instrument and Data Collection

This research study employed two research instruments to examine critical thinking skills. The first instrument used was a modified version of the critical thinking skills questionnaire conducted by [57]. The second instrument used was a modified version of the critical thinking skills observation sheet conducted by [58], [59]. Both instruments consisted of 5 aspects and a total of 11 items. These items were rated using a dichotomous scale, with "yes" receiving a score of 1 and "no" receiving a score of 0. The students completed the SPCTQ electronically using a Google form that included statements about something they had done in class and self-measurements of a statement. Additionally, four observers evaluated the students' CSOS during the learning process in two class sessions.

2.3. Data Collection

Before conducting the research, students who participated were informed that their personal information would be kept confidential. The data collected was solely for research purposes and did not affect their teacher's evaluation. Students completed the SPCTQ before taking the CTOS, which was administered over two sessions. The first session consisted of group discussion activities, while the second consisted of results presentation activities. Although the evaluation was conducted in groups, each student was evaluated individually.

2.4. Data Analysis

Questionnaire data and observation sheets collected are processed using Microsoft Excel. Below is the formula for calculating scores [60] from a questionnaire completed by students and an observation sheet completed by observers regarding students' critical thinking skills:

$$R = \frac{f}{n} \times 100\%$$

Information:

- R = Percentage score
- F = Total score obtained
- N = Maximum score obtained

Table 1 shows that the results are adjusted to the assessment criteria [61].

Table 1. Criteria percentage of critical thinking skills

Percentage (%)	Criteria
0.00-29.99	Very Low
30.00-55.99	Low
56.00-79.99	Moderate
80.00-89.99	High
90.00-100	Very High

The validity of all research instruments was tested using SPSS Statistics 25. All items used in the instruments were found to be valid. The analysis revealed that Cronbach alpha values of SPCTQ and CTOS were 0.678 and 0.608, respectively, indicating that the total is more significant than 0.2172 and the data is reliable. Correlation analyses were conducted to describe the results, assuming the data was regular and homogeneous. in Table 2 below.

Table 2. Critical thinking skills questionnaire

Aspects	Items	Percentage (%)	Criteria
Induce and consider the results of induction	I can summarize learning material after understanding it repeatedly.	87.80	High
	I have participated in activities where I gave my considerations and suggestions.	69.51	Moderate
	I have used my knowledge to solve problems in certain situations.	95.12	Very High
Aspect average 1		84.14	High
Consider whether the source can be trusted or not	I have participated in activities that made me a tutor or mentor.	41.46	Low
	I love poetry and songs.	85.36	High
	I am responding to a problem I found on social media.	43.90	Low
Aspect average 2		56.90	Moderate
Ask and answer questions	I participate in class discussions even though it is outside the discussion of learning materials.	80.48	High
	I can describe things from my point of view.	89.02	High
Aspect average 3		84.75	High
Do practicum and consider the results of practicum	I once designed simple, practical activities in class or at home.	74.39	Moderate
Define terms and consider a definition	To help answer the question, I need an example discussion before working on the problem.	97.56	Very High
	I checked the answers to the questions I was working on before submitting them.	93.90	Very High
Aspect average 5		95.73	High
Aspect overall average		78.04	Moderate

3. Results

To answer the questions in this study, a detailed and clear description of the results is needed. How students' critical thinking skills are based on their thinking, how students' critical thinking skills are based on actual performances in the learning process, so that the relationship between the two is obtained.

3.1. Students' Critical Thinking Skills are Based on Their Thinking

The results of processing the questionnaire data completed by the students showed that the average percentage of the SPCTQ was 78.04% in the moderate category. The maximum percentage in the very high category is 97.56% in aspect 5. Define terms and consider a definition, item 10, "To help answer the questions, I need an example discussion before working on the problem,". The minimum percentage in the low category is 41.46% in aspects 2. Consider whether the source can be trusted, item 4 "I have participated in activities that made me a tutor or mentor." The following details of the SPCTQ are shown

3.2. Students' Critical Thinking Skills are Based on Actual performances in The Learning Process

The observation sheet data processed by the observer showed that the average percentage of the student's CTOS is 62.52% in the moderate category. The maximum percentage in the high category is 82.92% in aspect 5.

Define terms and consider a definition, item 10 "Fill in the table of observations of practical results on the student's worksheet,". The minimum percentage in the low category is 39.02% in aspect 2. Consider whether the source can be trusted, item 5, "Find information from various sources". The following details of the CTOS are shown in Table 3 below.

Table 3. Critical thinking skills observation sheet

Aspects	Items	Percentage (%)	Criteria
Induce and consider the results of induction	Make simple hypotheses or guesses in their language from a question on the student's worksheet	54.87	Low
	Conclusions from practical results	69.51	Moderate
Aspect average 1		62.19	Moderate
Consider whether the source can be trusted or not	Prepare tools and materials	73.17	Moderate
	Have a discussion before practicum	71.95	Moderate
	Find information from various sources	39.02	Low
	Making experimental procedures or practical work steps	79.26	Moderate
Aspect average 2		65.85	Moderate
Ask and answer questions	Analyzing argument questions, namely students provide simple explanations by looking at facts that exist in everyday life	42.68	Low
	Asking and answering questions, that is, students can ask and answer questions about an explanation of the questions in the practicum	40.24	Low
Aspect average 3		41.46	Low
Do practicum and consider the results of practicum	Caution in practice	80.48	High
Define terms and consider a definition	Fill in the table of observations of practical results on the student's worksheet	82.92	High
	Presenting practical results	53.65	Low
Aspect average 5		68.28	Moderate
Aspect overall average		62.52	Moderate

3.3. The Relationship Between Student's Perceptions of Their Critical Thinking Skills and Actual Performances in the Learning Proces

Figure 1 is a comparison chart of students' SPCTQ and CTOS data.

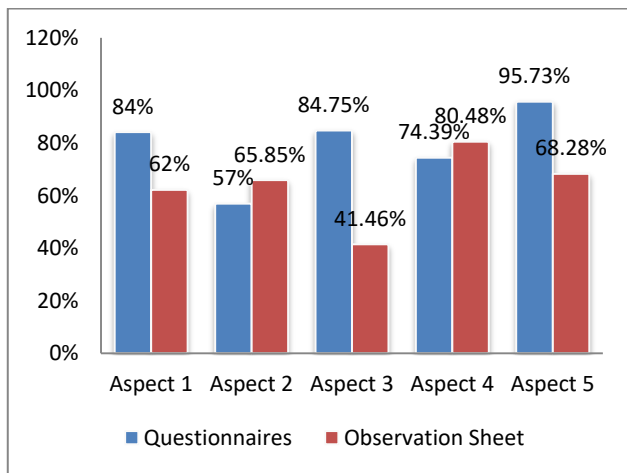


Figure 1. Result of critical thinking skills questionnaire and observation sheet

Based on the comparison above, of the 5 existing aspects, 3 aspects, 1, 3, and 5 of the SPCTQ, are higher than the CTOS with a significant difference. At the same time, aspects 2 and 4 CTOS are higher than SPCTQ with insignificant differences. This shows that there are differences between SPCTQ and CTOS. There is a side where what they think about their abilities is too optimistic or confident, even though this is not their low reality, and there is a side where what they feel about their abilities tends to be harmful when they are much better. To see if the observers completed a relationship between the SPCTQ completed by the students and the CTOS, a correlation test was performed with the results shown in Table 4.

Table 4. Correlation test of critical thinking skills questionnaire and observation sheet

Correlations			
		Observation Sheet	Questionnaires
Sig. (1-tailed)	Observation Sheet	0.000	0.137
	Questionnaires	0.137	0.000
N	Observation Sheet	11	11
	Questionnaires	11	11

It is evident from the table that the significance value in the correlation test between SPCTQ and CTOS is 0.137, which is greater than 0.05.

This implies that there is no correlation between them, indicating no association between the students' perceptions of their critical thinking skills and actual performance in the learning process.

4. Discussion

This study evaluates students' critical thinking skills from two perspectives - the students' perceptions and the ratings their teachers give. It is essential to measure this aspect to ensure a match between what the students think and what is happening in reality. Three possible scenarios arise: first, the student's perception of their critical thinking skills aligns with the situation. Second, the students' perception of their critical thinking skills is better than the reality. Third, the situation is better than the students' perceived critical thinking skills. Ideally, the first scenario is the best as it means that what the students think is the same as the reality, and there is no gap between the two. However, in general situations, the second and third scenarios are more common and can significantly impact the sustainability of students' critical thinking skills over time (Willingham, 2021) [62]. The study also found that these factors significantly affect students' ability to think critically at a higher level [63].

Aspect 1, "Induce and consider the results of induction," has a higher score on the SPCTQ than on the CTOS. Induction involves inferring specific things to produce general things [64]. Although students feel they already possess this ability, it must be optimally applied in classroom applications. A positive perception of the possessed skills is fundamental to understanding the given learning quickly [65]. However, in the observations made in this study, students still need to use their knowledge to determine hypotheses and draw conclusions. They are limited to writing without understanding it repeatedly.

Aspect 2, "Consider whether the source is reliable or not," has a higher score on the CTOS than on the SPCTQ. The material and information used for learning must come from reliable sources [66]. Although teachers have provided and facilitated access to appropriate materials and knowledge, students need to improve their skills in finding reliable sources of information. However, students are better in this aspect of learning than they think, which shows their curiosity and interest in understanding the teaching materials the teacher provides [67], [68]. This is because the available teaching materials or resources are adaptive in increasing students' learning motivation [69].

Aspect 3, "Asking and answering questions." has a higher score on the SPCTQ than on the CTOS.

In the learning process, a student's ability to ask and answer questions is significantly influenced by the context of the questions. This often requires explanations that relate to everyday life [62]. A positive classroom atmosphere directly impacts student engagement and vice versa [71]. In the study's observations, students only went through the process of asking and answering questions. However, without effective feedback and further analysis, discussions about the questions tend to be brief and lacking depth, the answers need to be corrected.

Aspect 4, "Do practicum and consider the results of practicum," has a higher score on the CTOS than on the SPCTQ. Practicum is a prevalent and highly appreciated method among students [72]. Participating in psychomotor activities helps students improve their skills more than they realize, making hands-on learning valuable. Students tend to prefer learning based on practical experience related to the concepts and theories they have studied [73]. This approach helps improve student and teacher relationships [74].

Aspect 5, "Define terms and consider a definition," has a higher score on the SPCTQ than on the CTOS. Introducing new and innovative ideas to students can be challenging [75], [76]. Though students may like these new ideas, applying them optimally in the classroom is important to ensure meaningful learning. Critical thinking skills are cognitive processes that prioritize self-regulation and depend on the learning process. In any learning activity, students must take responsibility for their understanding and position [77], [78].

The results of the SPCTQ and CTOS correlation tests suggest that various factors can impact students' critical thinking skills. These factors include students' overconfidence [75], incomplete readiness to learn [79], lack of seriousness in participating in learning [80], and inadequate learning independence [70].

5. Conclusion

Students' perceptions of their abilities and the actual learning process can sometimes differ. Based on the research conducted, it was found that the highest scoring items on the SPCTQ and CTOS are found in the same aspect, namely aspect 5 "Defining terms and consider a definition", with the SPCTQ item "To help answer the questions, I need an example discussion before working on the problem" and the CTOS item "Fill in the table of observations of practical results on the student's worksheet".

While the lowest scoring items on SPCTQ and CTOS are also found in the same aspect, namely aspect 2 "Consider whether the source can be trusted or not", with the SPCTQ item "I have participated in activities that made me a tutor or mentor" and the CTOS item "Find information from various sources."

The research found that the average SPCTQ score of 78.04% was considerably higher than the average CTOS score of 62.52%. This suggests that no direct relationship exists between students' perceptions of their critical thinking skills and what happens in the learning process. However, when students can reconcile their perceptions of their abilities with the activities that take place in the classroom, there can be a relationship between their SPCTQ and CTOS scores. To facilitate this, the environmental role of teachers and parents is crucial. The comparison of SPCTQ and CTOS scores can help teachers understand their students' perceptions of their abilities and adjust their teaching methods accordingly. However, it is important to note that the SPCTQ and CTOS statement items are different, although they convey the same meaning. For future research, it is recommended that the statement items for both tests should be identical to ensure accuracy.

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