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Enhancing Students' Critical Thinking through Case-Based Science Teaching Materials

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Abstract: This study aims to examine the effectiveness of science teaching materials developed using a case-based learning approach in enhancing critical thinking skills. The research employed an experimental method with a pretest–posttest control group design. The sample consisted of 66 first-semester students enrolled in the Elementary School Teacher Education Program at Nusa Cendana University. The findings revealed that the average posttest score of the control group was 59, while the experimental group achieved an average score of 87. The paired-sample t-test results for the posttest scores of the control and experimental groups yielded a significance value of 0.000, indicating a statistically significant difference between the two groups. Furthermore, student responses to the implementation of the teaching materials reached 94%. These results indicate that the use of case-based learning–oriented science teaching materials is effective in improving critical thinking skills, with student responses categorized as very effective.

Keywords: science teaching material, case based learning, critical thinking, science

PRELIMINARY

Critical thinking remains a major challenge among college students (Pradana, Mariana, Anam, 2024; Guest, 2000; Danvers, 2021; Hart, Dacosta, D'Souza, Kimpton, & Ljbusic, 2021). In Indonesia, the overall level of critical thinking among university students is generally low (Rahayu & Bandjarjani, 2021; Umam & Fauziah, 2022; Nawangsari, Pujiastuti, & Gularso, 2022). This condition is influenced by several factors, including the use of learning methods that have not yet integrated problem-based approaches (Fauzi, Ermiana, Nur, Rosyidah, & Sobri, 2023; Hodijah, Hastuti, & Zevaya, 2022), limited student concentration during learning activities (Bellaera, Weinstein-Jones, Ilie, & Baker, 2022; Adeyemi, 2012), insufficient conceptual understanding among college students (Bezanilla, Galindo, & Poblete, 2021), and the lack of appropriate and supportive teaching materials (Virijai, Asrizal, & Festiyed, 2022; Dibyantini & Sulastri, 2022).

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Critical thinking is classified as a complex higher-order thinking skill. Insufficient critical thinking ability constitutes a significant challenge in science learning (Suresman, Febrianti, & Dallyono, 2023). This view is supported by Abdullah, Laily & Masnum (2025), who define critical thinking as an active and disciplined intellectual process involving the application, analysis, synthesis, and evaluation of information. Moreover, the highest levels of Bloom's Taxonomy—analysis, synthesis, and evaluation—are often used to conceptualize critical thinking in educational contexts (Ennis, 1993). Through critical thinking, college students are better able to comprehend concepts deeply and respond thoughtfully to problems.

Meanwhile, the 2022 results of the Programme for International Student Assessment (PISA) reported that the critical thinking performance of Indonesian students was below the international average compared to other participating countries (OECD, 2023). This finding suggests that the Indonesian education system requires improvement, particularly in terms of instructional practices. Lecturers are therefore expected to integrate and apply learning approaches that actively promote critical thinking skills. The development of critical thinking has long been recognized as a fundamental educational objective, as it is widely regarded as one of the essential skills that educators should foster in their students (Sulistyaningrum, Winata & Cacik, 2019).

This condition was further confirmed through interviews with the natural science lecturer team in the Elementary School Teacher Education Program at Nusa Cendana University, which revealed that current learning activities had not yet effectively fostered students' critical thinking skills. The interviews indicated that the Basic Concepts of Natural Science course faced several challenges contributing to the low level of critical thinking among students in the program. Observations showed that only a small number of students demonstrated initiative in responding to lecturers' questions, and most answers were based primarily on memorization rather than a sound understanding of the concepts. Moreover, critical thinking is not limited to cognitive processes alone but also encompasses students' active participation in classroom learning. Students were also found to exhibit low enthusiasm in seeking solutions or exploring answers to the questions posed by their lecturers.

The results of the initial assessment of college students' critical thinking skills in the Basic Concepts of Natural Science for Elementary School course showed an average

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score below 70 (grade B). Based on preliminary observations, the critical thinking test measured three indicators: knowledge construction, reasoning evaluation, and decision-making (Heard et al., 2020b, p. 11). The findings revealed that the overall level of critical thinking among students in the Elementary School Teacher Education Program was low. An analysis of students' responses indicated achievement levels of 41% for knowledge construction, 53.3% for reasoning evaluation, and 50% for decision-making. The overall average critical thinking score was 48.1%, which falls into category E according to Ropii and Fahrurrozi (2017, p. 123). These results indicate that the critical thinking skills of college students require significant improvement.

Learning materials are one of the key components that determine the effectiveness of the learning process (Yusrina et al., 2021). Research conducted by Ramdani et al. (2021) demonstrated that the implementation of natural science teaching materials based on the 5E learning model and integrated with local wisdom had a positive impact on students' critical thinking skills.

Furthermore, a study by Sofia et al. (2023, p. 54) found that taxation learning materials developed using the 4D model (Define, Design, Develop, and Disseminate) combined with a case-based learning approach were effective in enhancing college students' critical thinking abilities. Similarly, research by Kusumantoro, Jaenudin, and Melati (2022) indicated that interactive digital learning materials incorporating a case-based learning approach were effective for Microeconomics instruction and could be adapted for other courses with appropriate technical modifications. This finding is supported by Syafril et al. (2022), whose case study showed that the development of digital teaching materials contributed to increased student engagement and activeness in higher education learning environments.

Effective teaching materials should be supported by an appropriate learning approach. Research conducted by Andayani et al. (2022) demonstrated that the use of a case-based learning approach was effective in addressing student demotivation, mitigating the learning loss resulting from prolonged online learning, and encouraging students to develop deeper interest in learning the subject matter. This finding is supported by Puri (2022), who reported that case-based learning facilitates students' thinking skills, enhances problem understanding, and leads to more effective problem-solving.

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Furthermore, case-based learning is designed to address students' limited ability to solve real-life and global problems (Sobri et al., 2021). A study by Hysa et al. (2020) also revealed positive student perceptions regarding academic performance and critical thinking development through the implementation of case-based learning. Therefore, the application of a case-based learning approach is expected to enhance college students' critical thinking skills in addressing issues within the Basic Concepts of Natural Science for Elementary School course.

The urgency of this research is motivated by the demands of 21st-century learning, particularly the need to develop critical thinking skills. Science teaching materials designed using a case-based learning approach are intended to equip students with the ability to analyze and solve problems through the cases presented. These cases are expected to stimulate the development of students' critical thinking abilities. By engaging with real or contextual cases, students learn how to approach and resolve problems they may encounter in the future. Moreover, the inclusion of cases in teaching materials within a case-based learning framework trains students to think critically, from problem analysis to informed decision-making

Based on expert perspectives, the critical thinking skills of college students can be enhanced through the use of teaching materials developed with a case-based learning method. Accordingly, this study examined the effects of case-based teaching materials on improving the critical thinking skills of students in the Elementary School Teacher Education Program at Nusa Cendana University, particularly in the Basic Concepts of Natural Science course.

METHOD

This study was classified as development research, specifically focusing on the stage of testing the effectiveness of the teaching materials. The research employed a quantitative pre-experimental method (Ary et al., 2010). A one-group pretest–post test design was used, involving a single experimental group without a control group. This design examined changes resulting from the treatment by comparing participants' pretest and post test scores

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Table 1. Research Design

Group	*Pretest*	Treatment	*Posttest*
Experiment	0_1	X1	0_2
Control	0_3	X2	0_4

The stages of the research were designed as presented in Table 1. In the initial stage of the experiment, a pretest was administered to the college students. Subsequently, the experimental group received the treatment through the implementation of science teaching materials based on a case-based learning approach aimed at improving students' critical thinking skills in the Basic Concepts of Natural Science course. The experimental phase concluded with the administration of a post test and a student response questionnaire to evaluate the implementation of the treatment. In contrast, the control group did not receive any specific treatment.

The variables in this study consisted of an independent variable and a dependent variable. The independent variable was science teaching materials developed using a case-based learning approach, while the dependent variable was students' critical thinking ability. The research population comprised students enrolled in the Primary School Teacher Education Program at Nusa Cendana University. Samples were selected using a cluster random sampling technique. Based on this sampling process, a total of 66 first-semester students were assigned to the control and experimental groups. Each group consisted of two classes, with 33 students in the experimental group and 33 students in the control group. The experimental group was taught using science teaching materials based on case-based learning, whereas the control group received instruction using conventional teaching materials. This study was conducted in 2024.

Instrument used in this research was test instrument Test instruments for measuring the critical thinking skill in college students were pre-test and post-test, while this test had 45 essay questions. Questionnaire instrument was used for identifying student response related to the use of a teaching material of science concept with the case-based learning approach. Indicators in questionnaire were compiled to identify the implementation and usefulness levels from the teaching material used as free variables. Questionnaire had 15 questions related to readability, presentation, and usefulness. Instrument used the Likert scale with the value range as follows: (1) score 4 for SA (strongly agree); (2) score 3 for A (Agree); score 2 for DA (disagree); and score 1 for

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SDA (strongly disagree). Questionnaire also provided comment and suggestion columns, concerning implementation from free variable treatment. Hypothesis test on the effect of free variable on bound variable was conducted using the Paired Sample T-Test.

This test was conducted to examine the effectiveness of the teaching materials used in the lecture by comparing students' pretest and post test results. Prior to conducting the hypothesis testing, an assumption test in the form of a normality test was performed using the Kolmogorov–Smirnov method. The paired-sample t-test was applied when the data met the assumption of normal distribution. Both the assumption tests and hypothesis testing were carried out using SPSS version 23 software. The null hypothesis (H_0) of this study stated that there was no significant difference in the average mathematics literacy skills between the pretest and post test scores. The effectiveness level of the teaching materials was further evaluated using the N-gain test.

Effectiveness test can be seen from some aspects, namely the response of college students after using the science teaching material with the case-based learning approach. Data analysis technique on the result of questionnaire was descriptive analysis. Data analysis was applied for identifying effectiveness of the learning material. Result of this analysis was a percentage of overall responses from every student related to free variable treatment. Formula to calculate the percentage score is shown in Formula 2.

$$P = \frac{\sum \text{all of questionnaire answers}}{(\text{number of questionnaire items} \times \text{the highest score} \times \text{number of respondents})}$$

RESULTS

This study aimed to examine the effect of science teaching materials developed with a case-based learning approach on students' critical thinking skills. All research instruments used in the experiment were first tested for validity prior to implementation. The science teaching materials were designed in an engaging manner and were equipped with case presentations in each chapter to support the development of students' critical thinking abilities. The cases included in the teaching materials were intended to stimulate students to analyze problems and propose solutions after learning the relevant concepts. In addition, the teaching materials incorporated critical thinking test items to assess students' levels of critical thinking.

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Science teaching materials developed using a case-based learning approach possess several key characteristics: (a) the integration of cases in each chapter, (b) the inclusion of group discussion sheets for collaborative learning, (c) worksheets that encourage student brainstorming, (d) materials designed to guide students in solving case-based problems, (e) self-assignment activities to strengthen students' conceptual understanding, and (f) critical thinking assessment tests. These science teaching materials were developed in accordance with the competencies of the Basic Concepts of Elementary Science course. The competencies addressed include explaining measurement and material changes, analyzing motion and simple machines, identifying vibrations and waves, analyzing energy and work, and analyzing basic electrical concepts.

Test effectiveness, students were administered critical thinking skill questions related to the science teaching materials developed with the case-based learning approach. These questions were designed to measure students' critical thinking skills before and after the treatment using the case-based teaching materials. The data were analyzed using both descriptive and inferential statistical techniques to evaluate the effectiveness of the teaching materials.

A. Effectiveness Science Teaching Material with case-based learning

This experimental study began with a pretest and concluded with a post test, both of which employed a 45-item objective critical thinking test. The assessment of critical thinking was based on nine indicators: identifying gaps in knowledge, discriminating among information, identifying patterns and making connections, applying logic, identifying assumptions and motivations, justifying arguments, identifying criteria for decision-making, evaluating alternatives, and testing and monitoring implementation. The results of both tests were analyzed using descriptive and inferential statistical methods to determine the effect of the independent variable on the dependent variable. The data presented in Table 2 represent the results of the descriptive statistical analysis of posttest scores from both the control and experimental groups.

Table 2. Result of Descriptive Test

		N	Minimum	Maximum	Mean	Std. Deviation
Control	Pretest	33	41.11	74.44	55.319	9.27372
	Posttest	33	50	80	63.1718	8.40548
experiment	Pretest	33	45.56	78.89	59.158	9.91090
	Posttest	33	76.67	100.00	86.962	6.38405
Valid N (list-wise)		66				

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Table 3 indicates that the average pretest score was lower than the average posttest score. Descriptively, this finding suggests a difference in students' critical thinking scores before and after the implementation of science teaching materials using a case-based learning approach. However, descriptive analysis alone does not demonstrate a statistically significant effect of the teaching material implementation on the critical thinking skills of students in the Elementary School Teacher Education Program at Nusa Cendana University. Therefore, to determine the significance of the effect between these two variables, a hypothesis test was conducted using a paired-sample t-test on the pretest and post test results. Non-independent t-test was utilized to confirm pretest and post-test results. T-test was conducted with the aid of SPSS-23 software. Result of t-test in SPSS is summarized in Table 3.

Table 3. Result of Normality Pretest

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Category	Statistic	df	Sig.	Statistic	df	Sig.
Criticalthinking_value	control	.100	33	.200*	.947	33	.111
	experiment	.146	33	.072	.939	33	.061

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 4 shows that data from the result of pre-test on the critical thinking skill had normal distribution. For data normality test in control and experiment, Kolmogorov–Smirnov test was utilized as shown in Table 5. Result of normality test in pre-test had a significance level at 0.200. Significance level in control was 0,200 > 0.05, meaning that control data had normal distribution. H_0 = accepted . Result of the normality test in experiment had a significance level at 0.072. Significance level in post-test was 0.072 > 0.05, meaning that experiment data had normal distribution. H_0 = accepted Thus, control and experiment data on pretest critical thinking had normal distribution. Result of homogeneity test with Levene's test analysis is shown in Table 4.

Table 4. Result of Homogeneity Test

Test of Homogeneity of Variances
Criticalthinking_value

Levene Statistic	df1	df2	Sig.
.438	1	64	.511

In Table 5, significance level of homogeneity test in pretest control and experiment was 0.511. Significance level in homogeneity test was 0.511 > 0.05, which

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indicated that pretest control and experiment data were homogeneous H_0 = accepted, Normality and homogeneity tests are the prerequisite for non-parametric test. Result of t-test using SPSS-23 is presented in Table 5.

Table 5. Result of non-parametric t-test for balance test

Paired Sample Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pre-test control – experiment	-3.83909	2.36277	0.92832	-8.55966	.88148	1.625	64	0.109

In Table 5, significance level of the result from non-independent t-test was 0.000. Significance level of hypothesis test was 0.109 < 0.05, indicating a not difference of average scores in the critical thinking skills in pre-test and post-test, H_0 = accepted. This means that the experimental and control classes have balanced critical thinking abilities.

After carrying out the balance test, a hypothesis test is carried out. Student test result data is in table 4. Post test data was analyzed using the t test hypothesis test. Hypothesis testing aims to determine the effectiveness of the saints teaching material with case based learning learning. Testing the effectiveness of the experimental and control groups begins with prerequisite tests, namely normality and homogeneity tests. Non-independent t-test was utilized to confirm post-test control and experiment results. T-test was conducted with the aid of SPSS-23 software. Result of t-test in SPSS is summarized in Table 5.

Table 6. Result of Normality Post Test

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Category	Statistic	df	Sig.	Statistic	df	Sig.
Criticalthinking_value	control	.133	33	.145	.951	33	.145
	experiment	.140	33	.102	.937	33	.057

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 6 shows that data from the result of post test on the critical thinking skill had normal distribution. For data normality test in control and experiment, Kolmogorov–Smirnov test was utilized as shown in Table 5. Result of normality test in pre-test had a

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significance level at 0.145. Significance level in control was 0,145 > 0.05, meaning that control data had normal distribution. H_0 = accepted . Result of the normality test in experiment had a significance level at 0.102. Significance level in post-test was 0.102 > 0.05, meaning that experiment data had normal distribution. H_0 = accepted Thus, control and experiment data on pretest critical thinking had normal distribution.

Table 7. Result of Homogeneity Test

Test of Homogeneity of Variances			
Criticalthinking_value			
Levene Statistic	df1	df2	Sig.
3.363	1	64	.071

In Tabel 7, significance level of homogeneity test in post-test control and experiment was 0.71. Significance level in homogeneity test was 0.071 > 0.05, which indicated that pretest control and experiment data were homogeneous H_0 = accepted, Normality and homogeneity tests are the prerequisite for non-parametric test. Pre-test and post-test control experiment data with normal and homogeneous distribution were hypothesis tested using the non-parametric paired sample t-test (Ary et al., 2010). Result of t-test using SPSS-23 is presented in Table 8.

Table 8. Result of non-parametric t-test for hypotesis

Paired Sample Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	Sig. (2-tailed)
Pair 1	Pre-test – Post-test	-23.79091	1.83739	0.92832	-27.46152	-20.12030	-12.94864		0.000

In Table 8, significance level of the result from non-independent t-test was 0.000. Significance level of hypothesis test was 0.000< 0.05, indicating a difference of average scores in the critical thinking skills in pretest and post-test, H_0 = rejected. It means that the science teaching material with a case-based learning approach affected the critical thinking skill in students of Study Program of Elementary School Teacher Education, Nusa Cendana University.

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B. **Effectiveness Test on the College Student Response**

The effectiveness of the implementation of the case-based learning teaching materials was assessed through a student response questionnaire administered after the posttest. The questionnaire was designed to capture students' perceptions of the science teaching materials used during the experimental phase. The resulting data were descriptive in nature and reflected students' views on the implementation and usefulness of the science teaching materials developed with a case-based learning approach.

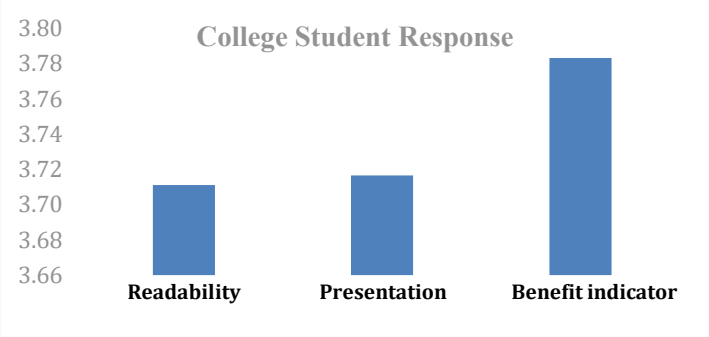

Figure 1. Chart of College Student Response.

This chart illustrates students' responses after using case-based learning materials in experiment class. Result from the response questionnaire based on readability, presentation, and benefit indicators.

Figure 1 presents a summary of the descriptive analysis of student responses based on the indicators of readability, presentation, and usefulness. The mean score for readability was 3.71, while the presentation and usefulness indicators recorded mean scores of 3.72 and 3.78, respectively. Using Formula 2, these results correspond to a percentage value of 94%. In general, the overall percentage of student responses was classified within the very effective category.

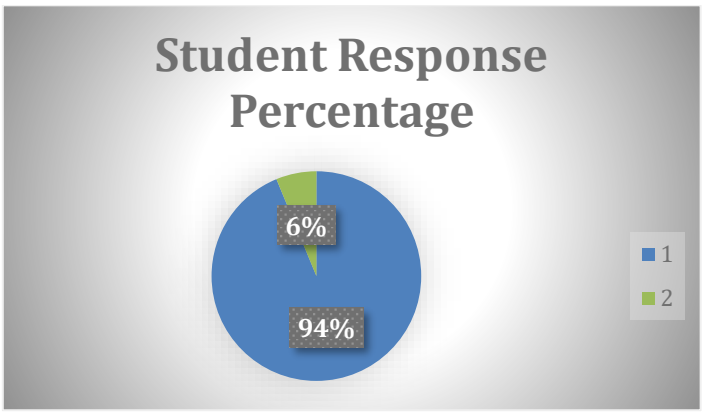

Figure 2. Percentage of Student Response.

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Result from the response questionnaire based on readability, presentation, and benefit indicators. The Value presented resulted was 94%. Response from most of the students on implementation of the teaching material about science concept with the case-based learning approach was very effective. It indicated that the teaching material has been implemented well, in accordance with its stages. Besides, the teaching material had excellent presentation and usefulness for the college students. This learning activity created an exciting class atmosphere, thus improving the motivation of students to learn (Fajriyah, 2018). It was also followed with the increase in post-test score for the critical thinking skill in college students.

DISCUSSION

The interview results indicated that the implementation of science teaching materials using a case-based learning approach was well executed among students in the Elementary School Teacher Education Program at Nusa Cendana University. This finding was supported by classroom observations comparing the experimental group, which applied case-based learning materials, with the control group, which did not use this approach. The control group demonstrated lower achievement levels than the experimental group.

The implementation of case-based learning teaching materials emphasized a Student-Centered Learning (SCL) approach, which encouraged greater student engagement during the learning process. This was evident during classroom activities, where students actively participated in discussions to solve the cases presented. Case-based learning serves as an instructional innovation that facilitates deeper understanding of subject matter while promoting active learning. Furthermore, through case-solving activities, students were able to connect theoretical concepts with real-life situations, making the learning experience more meaningful and relevant.

The results of the effectiveness test demonstrated that science teaching materials developed using a case-based learning approach had a significant effect on the critical thinking skills of students in the Elementary School Teacher Education Program at Nusa Cendana University. The development of critical thinking has long been recognized as a fundamental goal of education (Hudgins & Edelman, 1988). The hypothesis testing yielded a significance value of 0.000, which is less than 0.05, indicating a statistically

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significant difference in the average posttest scores of critical thinking skills between the control and experimental groups. These findings confirm that the implementation of science teaching materials based on case-based learning was effective in enhancing critical thinking skills in the experimental group.

These results are consistent with previous studies. Fauzi et al. (2023, p. 15) reported that the application of case-based learning demonstrated high effectiveness in improving college students' critical thinking skills, with an N-gain score of 0.713, categorized as high. Similarly, Cotugno (2018, p. 22) found that case-based learning developed around real events within local communities had a substantial impact on college students' learning outcomes. Mahdi, Nassar, and Almuslamani (2020, p. 297) also emphasized that case-based learning plays an important role in enhancing critical thinking skills when integrated into teaching practices. Furthermore, Hodijah, Hastuti, and Zevaya (2022, p. 477) noted that case-based learning effectively encourages students to develop critical thinking skills by analyzing cases from multiple perspectives to identify optimal solutions.

Student responses to the case-based learning teaching materials were highly positive, with an overall questionnaire score of 94%, which falls within the very effective category. This finding aligns with Wulandari et al. (2019), who reported consistently positive student attitudes, as reflected in satisfaction questionnaires, where most students in the experimental group felt motivated by their learning experiences. In addition, Hysa et al. (2020, p. 188) identified positive effects of case-based learning on students' academic performance and critical thinking skills. In this study, case-based learning served as the foundation for the development of science teaching materials and demonstrated strong potential to enhance critical thinking skills among college students. Thus, teaching materials based on case-based learning represent an innovative approach to fostering critical thinking and creating a more dynamic and engaging learning environment in higher education.

Critical thinking skills are essential in the context of 21st-century learning (Rosidin, Kadaritna, & Hasnunidah, 2019). The differences in critical thinking skills observed between students in the control and experimental groups can be attributed to the use of different teaching materials. The implementation of science teaching materials based on a case-based learning approach in the experimental group was shown to

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effectively enhance students' critical thinking skills by encouraging greater activeness and independence in solving cases related to real-life situations. In addition, students became more confident in expressing their ideas and drawing conclusions.

Critical thinking is categorized as a higher-order thinking skill that involves making decisions through reasonable, reflective, responsible, and skillful thinking processes. Furthermore, case-based learning contributes to the development of analytical and decision-making skills, as students work independently and collaboratively in small groups to resolve presented cases. This finding is consistent with Astawa (2021), who identified several strengths of case-based learning, including: (1) the ability to develop analytical skills by encouraging learners to question the essence of issues, (2) the capacity to apply theoretical concepts to real-world contexts, (3) the promotion of learner independence through problem-solving activities, and (4) the enhancement of confidence, motivation, collaboration, and oral communication skills, particularly during group discussions and presentations.

CONCLUSION

Based on the research findings and data analysis, it can be concluded that the implementation of science teaching materials using a case-based learning approach has a significant effect on college students' critical thinking skills. The hypothesis test yielded a significance value of 0.000, which is less than 0.05, indicating a statistically significant difference in the average posttest scores of critical thinking skills between the control and experimental groups. In addition, the effectiveness level, as reflected by the percentage of students' responses to the implementation of the teaching materials, was categorized as very effective. Based on these findings, it is recommended that lecturers incorporate a case-based learning approach when teaching science-related materials, particularly those concerning the basic concepts of natural science. For future researchers, it is suggested that the study be extended by including a control group as a comparison to further strengthen the evaluation of this learning approach.

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