
Effects Science Teaching Material with Case-based Learning Improving Critical Thinking

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Abstract

This research aims to study effectiveness of the science teaching material with a case-based learning approach towards the critical thinking skill. This study belongs to the experimental research with pretest-post test control group design. The research samples were 66 students at semester 1 in the Study Program of Elementary School Teacher Education, Nusa Cendana University. The research showed the average results of post test control at 59 and experiment at 87. The result of the paired sample t-test in post-test control and experiment was Sig. value at 0.000, indicating a significantly average difference between control and experiment class results. Percentage of the student response towards implementation of the teaching material was 94%. Conclusion of this research shows that the use of science teaching material with the case-based learning approach is effective for improving the critical thinking skill while the student response is in a very effective category.

Keywords : Science Teaching Material, Case Based Learning, Critical Thinking



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1. Introduction

Critical thinking becomes a great challenge for the college students (Sulaiman, 2018; Guest, 2000; Danvers, 2021; Hart, Dacosta, D'Souza, Kimpton, & Ljbusic, 2021). Average college students in Indonesia have a low critical thinking level (Rahayu & Bandjarjani, 2021; Umam & Fauziah, 2022; Nawangsari, Pujiastuti, & Gularso, 2022). A low critical thinking level in college students is a result of the learning method which is not yet accompanied with the problem approach (Fauzi, Ermiana, Nur, Rosyidah, & Sobri, 2023; Hodijah, Hastuti, & Zevaya, 2022), the lack of concentration in the class (Bellaera, Weinstein-Jones, Ilie, & Baker, 2022; Adeyemi, 2012), the limited learning concept in college students (Bezanilla, Galindo, & Poblete, 2021), and an absence of the adequate teaching material (Virijai, Asrizal, & Festiyed, 2022; Dibyantini & Sulastri, 2022).

Critical thinking belongs to a complex thinking skill. Low critical thinking skills are a crucial problem in science learning (Suresman, Febrianti, & Dallyono, 2023). This statement was supported with an opinion from Snyder & Snyder (2008) in which critical thinking is a disciplinary intellectual process which is active and the conceptualized skill, in applying, analyzing, synthesizing, and/or evaluating information. Furthermore, three highest levels of Bloom's Taxonomy in the educational purposes (analysis, synthesis, and evaluation) are frequently offered as a definition of critical thought (Ennis, 1993). Critical thinking facilitates the college students to understand concept and to be sensible towards problems.

On the other hand, 2022 PISA (Programme for International Student Assessment) published that the critical thinking level in Indonesian college students was below average, compared with other nations (OECD, 2023). It indicates that the education system in Indonesia requires some adjustments, particularly in the learning process. Lecturers must be capable of integrating or utilizing the learning approach which encourages the critical thinking. The ability to think critically is generally considered to be one of the skills teachers should attempt to develop in their students (Wallen & Shirts, 1966).

This condition is also confirmed by interview with lecturer team of natural science subject in Study Program of Elementary School Teacher Education, Nusa Cendana University, in which their learning activities did not yet develop the critical thinking. This interview revealed a fact that a course, Basic Concept of Natural Science, had several issues leading to the low critical thinking in the students of Study Program of Elementary School Teacher Education, Nusa Cendana University. The condition showed that only few students had initiative to answer questions from their lecturers and they only responded to the questions based on their memory, despite the limited understanding on concept. Critical thinking is not limited to the cognitive thinking skill only, but also involves the activeness of students in class. Students also seemed less enthusiastic in searching answer for every question asked by their lecturers.

Result of an initial test for the critical thinking skill in college students showed average value at <70 (B) in a course, Basic Concept of Natural Science for Elementary School. Based on the initial observation, the critical thinking test used three critical thinking indicators, namely knowledge construction, reasoning evaluation, and decision-making (Heard, et al., 2020b: 11), while the result of critical thinking in students of the Study Program of Elementary School Teacher Education was low. An analysis was carried out on the answers from college students, while the results were knowledge construction indicator at 41%, reasoning evaluation at 53.3% and decision making at 50%. Average result of the critical thinking skill in college students was 48.1%, which can be put in category E (Ropii & Fahrurrozi, 2017: 123). It indicates that critical thinking in the college students requires improvement.

The learning material is one of important aspects determining effectiveness in the learning process (Yusrina et al., 2021). A research conducted by (Ramdani et al., 2021) explained that implementation of the natural science teaching material with 5E model, integrated with the local wisdom, had a positive effect towards the critical thinking skill. Result of the analysis from a research by Sofia, et.al. (2023: 54) showed that the learning material on taxation, developed

with the 4D (Define, Design, Develop, and Disseminate) model and the case-based learning, can improve the critical thinking skill in college students. Another research from Kusumantoro, Jaenudin, A., & Melati, I. S (2022) showed the result that an interactive digital material with the case-based learning approach was effective to be used in learning Microeconomics and can be developed for other courses with some technical adjustments. It was also confirmed by another research by Syafril, et. al., (2022) in a case study, in which the development of digital teaching material can improve the activeness of college students.

Sufficient teaching material is supported by the suitable learning approach. A research conducted by (Andayani et al., 2022) explained that the learning with a case-based learning approach was effective in solving the demotivate in college students, anticipating the effects of losing learning process due to online learning implementation which took a long time, and inspiring students to get motivated in learning a material further. It was confirmed by (Puri, 2022) in which the case-based learning facilitated the thinking skill in college students, developed better understanding of a problem, and achieved better solution. Learning with the case-based learning approach sought to respond to a low skill in solving life problem and global issues (Sobri et al., 2021). A research by (Hysa, et al., 2020) found a positive perception towards the performance of college students and critical thinking through the case-based learning. A case-based learning is expected to improve the critical thinking skill in college students to solve issues in a course, Basic Concept of Natural Science for Elementary School.

The urgency in this research is driven to fulfil the demands of 21st century learning development, one of which is critical thinking. Teaching materials for science concepts with a case-based learning approach prepare students to learn to solve problems from the cases presented. The case is expected to encourage the growth of students' critical thinking skills. Students learn from cases to be able to solve problems in the future. Cases in teaching materials with a case-based

learning approach train students to think critically from analysing to making decisions.

Based on an expert opinion, the critical thinking skill in college students can be improved through a teaching material with a case-based method. Therefore, this research investigated effects of the teaching material with a case-based method to improve the critical thinking skill in college students of Study Program of Elementary School Teacher Education, Nusa Cendana University, particularly in a course, Basic Concept of Natural Science.

2. Method

This study belonged to the development research, particularly on a stage of testing the teaching material's effectiveness. Method used was the pre-experimental quantitative research (Ary et al., 2010). Research used the one-group pretest-post test design which involved only one experiment class without control class. This design compared conditions before and after treatment, by comparing pretest and post-test scores.

Table 1. Research Design

Group	<i>Pretest</i>	Treatment	<i>Posttest</i>
Experiment	O_1	X1	O_2
Control	O_3	X2	O_4

Stages of research were designed as presented in Table 1. For the first stage of this experiment, pre-test was given to the college students. The next posttest was treatment on these students in experiment group, by applying the teaching material with a case-based learning for improving their critical thinking skill on a material, Basic Concept of Natural Science. This stage of experiment was ended by giving post-test and response questionnaire on the treatment implementation. But control group don't have treatment special.

Variables in this research were free variables and bound variables. Free variable was the teaching material with a case-based learning, while its dependent variable was the critical thinking capability. Population in this research were students of the Study Program of Primary School Teacher Education, Nusa

Cendana University. Samples were taken using a technique, cluster random sampling. Based on the sample-taking, 66 students at 1 semester were samples for control and experiment group. The experimental class and control class each consisted of 2 classes. Students in experiment classes consisted of 33 people, while students in control classes also consisted of 33 people. The experiment class learned using science teaching materials with case based learning, while the control class learned using conventional teaching materials. This research 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 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 used to study effectiveness in the use of a teaching material in the lecture, by comparing post-test and pretest results. Assumption test required before implementing the hypothesis test was normality test, using the Kolmogorov Smirnov test. Hypothesis test on the Paired Sample T-Test can be carried out when data are normally distributed. Hypothesis test and its assumption tests were conducted with the aid of SPSS 23 software. For H0 of this research, there is no significantly average difference between skills of mathematics literacy during pretest and

post-test. Effectiveness level of the teaching material was viewed from 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.

$$P = \frac{\sum \text{all of questionnaire answers}}{(\text{number of questionnaire items} \times \text{the highest score} \times \text{number of respondents})} [2]$$

3. Result and Discussion

Result

This study was conducted to find the effect of science teaching material with case based learning toward critical thinking skills. All instruments used in the experiment were first tested for validity before being used in the experiment. Science teaching materials will be arranged attractively, equipped with the presentation of cases in each chapter and able to improve students' critical thinking skill. The cases presented in the teaching materials are designed to provoke students to analyse cases, solve them after learning the material. This teaching material is equipped with critical thinking test questions to measure the level of critical thinking of students.

The characteristics of science teaching materials developed with case based learning are (a) teaching materials utilizing cases in each chapter, (b) there is a group discussion sheet for students to work on, (c) worksheets invite students to brainstorm, (d) materials are prepared for students to be able to solve cases, (e) self-assignment to sharpen students' knowledge, and (f) Critical thinking test.

Teaching materials for science concepts with a case-based learning approach are developed according to competence of the Elementary Science Basic Concepts. Competence developed in this teaching material are explain

about Measurement and Material Change, analyse motion and simple planes, identify vibrations and waves, analyse energy and effort, and analyse simple electricity.

For effectiveness test, students were asked questions on the critical thinking skill, concerning science teaching material with case based learning. These questions about critical thinking skill aimed to measure their critical thinking skill before and after treatment, using the teaching material with a case-based learning. Data were processed using the descriptive and inferential statistical tests for investigating effectiveness in the use of a teaching material.

Effectiveness Science Teaching Material with case based learning

This experimental research was started with the pretest activities and ended with the post-test, using 45 objective questions critical thinking test. Critical thinking with 9 indicator there are identifies gaps in knowledge, discriminates amongst information, identifies patterns and makes connections, applies logic, identifies assumptions and motivation, justifies arguments, identifies criteria for decision-making, evaluates options, tests and monitors implementation. Result of these two tests was processed using the descriptive and inferential statistics to identify effects of free variable towards its bound variable. Data in Table 2 was the result of descriptive statistical calculation from the results of post test control and experiment scores.

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				

Table 2 shows that average pretest was lower than average post-test. It descriptively indicates a difference in average scores of critical thinking skill in pretest and post-test after implementing a science teaching material with the case-based learning approach. However, it cannot show any significant effect

from the teaching material implementation on the critical thinking skill in students of the Study Program of Elementary School Teacher Education, Nusa Cendana University. Furthermore to identify significant effects between these two variables, hypothesis test was conducted with the paired sample t-test on 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 3 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 3. 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 4, significance level of homogeneity test in pretest control and experiment was 0.511. Significance level in homogeneity test was $0.511 > 0.05$,

which indicated that pretest control and experiment data were homogeneous H_0 =accepted, Normality and homogeneity tests are the prerequisite for non-parametric test. 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								
			95% Confidence					
			Interval of the					
			Difference					
	Mean	Std. Deviation	Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1: Pre-test – control	-3.83909	2.36277	0.92832	-8.55966	6.88148	1.625	64	0.109
experiment								

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 5. Posttest data was analyzed using the t test hypothesis test. Hypothesis testing aims to determine the effectiveness of the sains 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 significance level at 0.145. Significance level in control was $0.145 > 0.05$, meaning that control data had normal distribution. $H_0 = \text{accepted}$. 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. $H_0 = \text{accepted}$. 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 Table 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. $H_0 = \text{accepted}$. 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								
		Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference		t	Sig. (2-tailed)
					Lower	Upper		
Pair 1	Pre-test – Post-test	23.79091	1.83739	0.92832	-27.46152	20.12030	-12.948	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.

Effectiveness Test on the College Student Response

Effectiveness in application of the teaching material with a case-based learning was measured from the questionnaire of student response. Response questionnaires were given to the students after completing post-test. This questionnaire aimed to identify their responses toward the science teaching material applied during the experiment. Data resulted were descriptive data concerning implementation and usefulness of the science teaching material with the case-based learning approach.

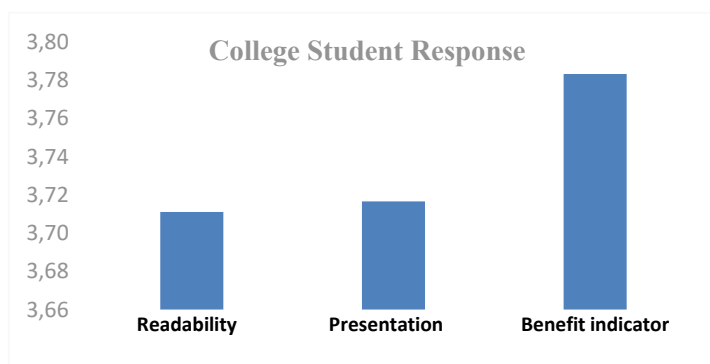


Figure 1. Chart of College Student Response. This chart illustrates students' responses after using case-based learning materials in experiment class. Result from the response questionnaire based on readability, presentation, and benefit indicators.

Summary of the descriptive analysis result from the response questionnaire, based on readability, presentation, and benefit indicators, is shown in figure 1. Average questionnaire score for the readability indicator was 3.71. Average questionnaire score for presentation indicator was 3.72. Average questionnaire score for usefulness indicator was 3.78. When presented using

Formula 2, the value resulted was 94%. The average percentage of response questionnaire score from all students belonged to the very effective criteria.

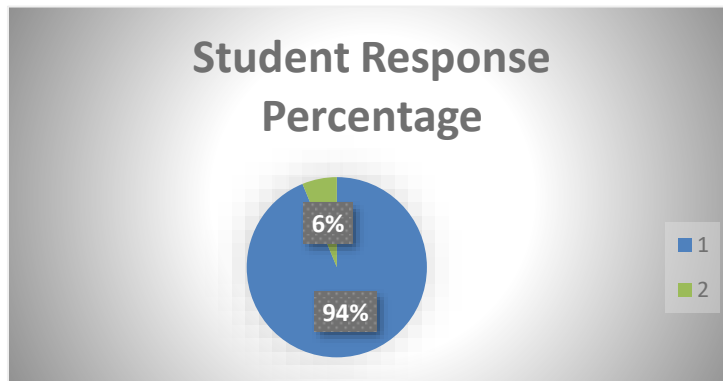


Figure 2. Percentage of Student Response. Result from the response questionnaire based on readability, presentation, and benefit indicators. The Value presented resulted was 94%.

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 result of interview shows good implementation of the teaching material with the case-based learning approach in students of the Study Program of Elementary School Teacher Education in Nusa Cendana University. It was proven by the result of observation on the experiment class which applied the teaching material with the case-based learning approach and control class without this model. However, this control class had a lower score, compared with the experiment class.

Implementation of the teaching material with a case-based learning approach tended to emphasize the Student-Centered Learning (SCL), making students more active in the learning. This statement was proven by teachers

when applying the case-based learning, which made students more active in having discussion for solving a case given in the learning. Case-based learning is a learning innovation to understand a material better and to train students to be more active in the learning. Besides, in solving a case, college students were capable of linking the learned concept with daily cases which were more realistic.

Result of the effectiveness test showed 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. Educators have long regarded the development of "critical thinking" as an important objective of education (Hudgins & Edelman, 1988). Significance level of hypothesis test was $0.000 < 0.05$, indicating a difference of average scores in the critical thinking skills in post-test control experiment. Science teaching material with case based learning was effective when implemented in learning for improving the critical thinking in experiment class. In a research conducted by Fauzi, et al., (2023: 15), implementation of the case-based learning had a high effectiveness level on the critical thinking skill in college students, with N-Gain score at 0.713 and in a high category. In the result of a research by Cotugno, (2018: 22), the case-based learning, developed with an event in local community, had a considerable effect on college students. Mahdi, Nassar, & Almuslamani, (2020: 297) explained that the case-based learning was used in teaching, so it played important role in improving the critical thinking skill in college students. As stated in a research by Hodijah, Hastuti, & Zevaya, (2022: 477), the case-based learning was capable of encouraging the critical thinking skill in college students for solving cases, viewed from different perspectives, for bringing the best solution.

Response of students on the teaching material with a case-based learning was positive. Value resulted was 94% of response questionnaire score from all students belonged to the very effective criteria. A research by (Wulandari, et al., 2019) stated that attitude of the students was always very positive, as reflected in the satisfaction questionnaire, in which most of the students in experiment

group felt motivated by the experience during their learning process. A research by Hysa, et al. (2020: 188) discovered a positive performance on the students' performance and critical thinking skill through the case-based learning. The case-based learning was the basis in this research and implemented in developing a teaching material on the science concept, which potentially improved the critical thinking in college students. A teaching material with the case-based learning is a new innovation to develop the critical thinking in college students and create a dynamic learning atmosphere.

Critical thinking skills are important in the context of 21st-century learning (Rosidin, Kadaritna & Hasnunidah., 2019). Difference of the critical thinking skill in college students from control and experiment classes were caused by the use of different teaching material. The use of a teaching material with the case-based learning approach in experiment class was proven capable to improve the critical thinking in college students because they were encouraged to be more active and independent in the case-based learning for solving cases related to daily activities. Besides, students were more confident in conveying their idea and conclusion. Critical thinking is a high-order thinking skill which is implemented in making a decision using reasonable, reflective, responsible, and skilful thinking. Besides, the case-based learning affects analysis skill and decision making in college students for solving cases independently with small group. This statement is in line with Astawa (2021), in which strengths of the case-based learning are (1) the capability to develop analysis skill (to question the essence of something), (2) a skill to apply context (theory) and reality in the field, (3) independence in searching and solving task through a problem-solving training, (4) improvement of confidence, spirit, and cooperation in group, oral skill (in presentation).

4. Conclusion

Based on the results of research and data analysis, it can be concluded that implementation of the science teaching material with the case-based learning approach has a significant effect on the critical thinking skill in college

students. Significance level of hypothesis test was $0.000 < 0.05$, indicating a difference of average scores in the critical thinking skills in post test control experiment. Effectiveness level based on the percentage of college students' response on the teaching material implementation is very effective. Based on the result of this research, the suggestion is that the case-based learning approach is used by lecturers of the science teaching material in their learning activities, particularly for a material related to the basic concept of natural science. For other researchers, it is suggested to improve the research by adding a control class as comparison of this learning mode.

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