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Collaborative Group Investigation and Self Efficacy on Pre-Service Science Teachers' Critical Thinking Skills

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Abstract. In order to teach future generations, preservice science teachers must possess critical thinking skills. However, relatively few studies have examined these skills at the tertiary level, particularly in elementary school science teacher education departments. This study sought to determine the effect of collaborative group investigation (CGI) learning and self-efficacy on the critical thinking skills of students. With a non-equivalent control group design and a 2 x 2 ANOVA inferential statistical test, a quasi-experimental design was implemented. The subjects of this study were forty science teacher candidates who took the Environmental course at a university in Indonesia. A self-efficacy questionnaire and a test of critical thinking skills constituted the research instruments. The results indicated that the collaborative group investigation group received an average score of 62.2, whereas the direct learning group received an average score of 48.8, with an $F_{calculated}$ of 87.626 and a significance value of 0.000. The data analysis revealed substantial differences between the collaborative group inquiry group and the direct learning group in terms of critical thinking skills. The interplay between learning strategies and self-efficacy affects the critical thinking skills of pupils because collaborative learning practices can engage students actively through teamwork, idea exchange, decision making, and shared responsibilities.
Keywords: Collaborative Group Investigation (CGI), Critical Thinking Skills, Self-Efficacy.

Introduction

The twenty-first century has affected all facets of human existence. Education, particularly science education, is essential for adapting to these changes. Preparing students to comprehend change and providing them with opportunity to adapt to change is becoming an increasingly important aspect of science education today. The objectives of contemporary science education must extend beyond reading, writing, and mathematical literacies. Thus, the science teacher is the most significant factor in setting the objectives of science education. To successfully handle future issues and preserve the quality of scientific education for students, aspiring science teachers must be educated with the critical thinking abilities necessary to identify and solve problems based on rapid and precise analysis. (Liu et al., 2020).

Despite several efforts to increase the quality of science educators, the objectives and roles of science education have not been successfully executed. It appears to be instilled in educators that the process of textual learning depends on the knowledge of theory and memorization. This impacts the development of students' learning skills. Prior study has demonstrated that many students struggle to comprehend certain scientific concepts and are unfamiliar with experimental activities that improve scientific skills (Amin, 2022a; Marlina, 2020). The perspectives and ideas of students regarding their issues must be acknowledged, and teaching and learning approaches and strategies must be tailored to students' learning styles and needs (Amin et al., 2022; Falloon, 2019; Kervinen et al., 2020; Prabha, 2020).

We hypothesize that this issue can reduce students' self-efficacy, which in turn impacts their attitudes and critical thinking skills. Therefore, it is considered necessary to apply learning strategies that involve students together in promoting critical thinking attitudes and skills. To address this issue, a collaborative group-based investigational strategy was created to be more effective than conventional teaching methods. Previous studies have demonstrated the efficacy of integrating diverse instructional modalities to enhance students' critical thinking, conceptual comprehension, and interest in science (Hammond et al., 2020; Ku et al., 2014; Raes et al., 2016; Sun et al., 2017). To our knowledge, the strengthening of critical thinking skills by integrating collaborative and investigative teaching approaches has rarely been studied.

Collaborative learning provides students with excellent opportunity to grow during the learning process. Self-development is conducted for personal learning needs and the development of individual skills in constructing knowledge. Moreover, in the context of socio-constructivist theory, collaborative learning might encourage students to acquire in-depth information through group interactions during the execution of a social activity (Ajjawi & Boud, 2015; Deslauriers et al., 2019; Päivi et al., 2017). Intergroup interactions during the performance of experiments can encourage students to acquire information and skills through collaboration and to use experimental results to build knowledge (Amin, 2020; Liu et al., 2020; Zambrano et al., 2019).Preparation of tasks in groups can increase awareness of the importance of cooperation and collaboration to achieve success (Heinimäki et al., 2021; Magnanini et al., 2021; Mende et al., 2021).

The distinctive characteristics of collaborative group investigation are investigation, interaction, interpretation, and intrinsic motivation. Group investigations can encourage students to address challenges together (Sharan et al., 2015). Group work can also encourage pupils to participate actively in the learning process. Students can benefit form group investigations. Individually, they can gain confidence in expressing their opinions, ideas, and questions, and then exchange them with other pupils. Through group investigation, students inspire one another to develop meaningful and enjoyable learning, which ultimately impacts their critical thinking skills. Consequently, the purpose of this study was to determine the influence of collaborative learning practices on the critical thinking skills of students with varying levels of self-efficacy and whether or not the two variables interact.

Methods

The current study employed a quasi-experimental method because variables assumed to affect treatment are extremely difficult to regulate. In this study, the variables included two independent variables (collaborative group investigation and direct learning), a moderator variable (self-efficacy), and a dependent variable (critical thinking skills). The design employed is a 2 x 2 factorial non-equivalent control group design based on these variables. Table 1 depicts the research design.

Table 1. 2 x 2 Factorial Design

Moderator Variable		Independent Variables	
		Colaborative Group Investigation (X1)	Direct Learning (X2)
Self-efficacy (Y)	high (Y1)	X1Y1	X2Y1
	low (Y2)	X1Y2	X2Y2

This study's population consisted of fifty sixth-semester biology students who programmed the *Environment* course. Cluster sampling technique was employed for sampling, with two classes chosen directly as sample classes (single stage cluster pattern). In this study, the research participants comprised of 50 individuals. In the experimental procedure, however, 10 individuals were eliminated from the sample because they did not attend all eight study meetings. Thus, forty students were separated into two treatment groups: the experimental group and the control group. Each group consisted of 20 individuals, for a total of 40 participants in the study. Based on the identification results of each group's learning outcomes, it was presumed that both groups have the same level of academic capacity.

The research instruments were comprised of two instruments: one to assess self-efficacy and one to assess critical thinking skills. The self-efficacy instrument was designed as a questionnaire with a Likert scale (0–5). The dependent variable instrument, which was used to assess students' critical thinking skills, is a test.

We started the study in coordination with the head of the institution and the lecturer who taught the Environment course. This was done to get approval while ensuring that all learning instruments and accompanying facilities were already available. The researchers then met with students to collect biographical information and distribute a self-efficacy questionnaire. This questionnaire was designed to classify students into two categories: those with strong self-efficacy and those with low self-efficacy.

The second step was to administer a pretest to students by distributing questions on critical thinking skills. After receiving the results of the preliminary test, the treatment phase of the study commenced. Each treatment group (experimental and control) participated in the study for eight meetings, beginning with the pretest and concluding with the posttest. The pretest was administered during the initial meeting, whereas the posttest was administered at the last meeting. The test outcomes were entered and descriptively and quantitatively assessed.

In this study, descriptive and inferential data analysis methods were employed. The data were collected, arranged, and processed descriptively with no effort to generalize through the use of unambiguous descriptions. To test the research hypothesis, inferential analysis was employed. The statistical analysis used in this study is a factorial 2 x 2 multivariate analysis of variance (MANOVA). This study employed the MANOVA technique because it investigated the differences between two independent variables and between two dependent variables.

Before evaluating the hypothesis, the assumption tests, consisting of the normality test of the data distribution for all groups and the homogeneity test of the variance between groups, were conducted. These examinations were performed using the SPSS Windows Version 20 application. The Kolmogorov-Smirnov Lilliefors Significance Correction test was utilized to determine the data normality, while the Levene test was utilized to determine the homogeneity of variance. The normality of the distribution of the research group data, or the homogeneity of the variance between groups was determined based on 5% level of significance or $\alpha = 0.05$. At the significance level of more than 5% ($\alpha = 0.05$), the data distribution was normal and the variance between groups was homogeneous.

Results and Discussion

The Results of Descriptive Analysis on Students' Critical Thinking Skills

Data on critical thinking skills were obtained from the pre-test and post-test results. The datasets were then scoured for differences and used in the analysis. Descriptive statistics were used to aid in the presentation and description of data presented for further analysis, particularly hypothesis testing. Inference statistics were used to help with hypothesis testing. Inference statistics were used to help with hypothesis testing.

The Critical Thinking Skills of Students in the Collaborative and Direct Learning Classes

The results of a descriptive statistical examination of the critical thinking skills of students are presented in Table 2.

Table 2. Descriptive Analysis of Students' Critical Thinking Skills (M ± SD)

Treatment	Self Efficacy		Total
	High Self Efficacy	Low Self Efficacy	
Collaborative	67.5 ± 5.60	56.9 ± 4.28	62.2 ± 7.29
Direct	57.1 ± 3.48	39.7 ± 5.01	48.4 ± 9.86
Total	62.3 ± 7.01	48.3 ± 9.92	55.3 ± 11.1

The descriptive analysis of students' critical thinking skills yielded the mean, standard deviation, and number of students as outputs. The collaborative group, which consisted of 20 students or participants, gained a mean (M) of 62.2 and a standard deviation (SD) of 7.29. In contrast, the direct learning group, comprised of 20 individuals, recorded a mean of 48.4 and a standard deviation of 9.86.

The Critical Thinking Skills of Students with High and Low Self-Efficacy

The descriptive analysis of students' critical thinking skills based on their yielded the mean, standard deviation, and number of students as outputs. Twenty (N) students with reported a mean of 62.3 and a standard deviation (SD) of 7.01; a mean of 48.3 and a standard deviation of 9.92. These results indicate that the mean score for critical thinking skills in the group with high self-efficacy is greater than the mean score with low self-efficacy.

The Results of the Assumption Tests

The Saphiro Wilk test with a significance level of 0.05 was used to examine the normality of the data on critical thinking skills and self-efficacy. This test was predicated on the null hypothesis (Ho) derived from the population's normal distribution. If the significance value (sig) is less than or equal to 0.05, the data distribution is deemed abnormal. Alternatively, if the significance value (sig.) exceeds 0.05, then the data distribution is deemed normal.

Table 3 summarizes the results of the normality assumption test on critical thinking skills in terms of the learning strategies employed and the students' self-efficacy levels.

Table 3. The Results of the Saphiro Wilk Normality Test

Variable	Z	Sig.	Remarks
Critical Thinking Skills			
Collaborative Learning	0.939	0.232	Normal
Direct Learning	0.907	0.055	Normal
High Self Efficacy	0.944	0.279	Normal
Low Self Efficacy	0.956	0.462	Normal

The results of the Sapiro Wilk test conducted with SPSS to determine the normality of data on critical thinking skills and self-efficacy indicated that the significance value of critical thinking skills for groups of students taught using the collaborative learning strategy (0.232) was greater than 0.05 (0.232>0.05). This finding suggested that the data on critical thinking skills followed a normal distribution. In addition, the significant value for the normality of critical thinking skills data in the direct learning group (0.055) was greater than 0.05. This result implied that the data on the critical thinking skills of students taught through direct instruction likewise followed a normal distribution.

The significance value of the critical thinking skills of students with high self-efficacy (0.279) was greater than 0.05, as determined by the Sapiro Wilk normality test. The critical thinking skills of students with poor self-efficacy also had a significant value (0.462) that was more than 0.05 (0.462>0.05). These results showed that the data from both groups were normally distributed.

Levene's Test of Variance Homogeneity

Levene's test was conducted using data on students' critical thinking abilities from the collaborative learning group, direct learning group, and students with high and low self-efficacy. Based on the homogeneity of variance test, data on the students' critical thinking skills based on the classroom learning strategy and self-efficacy indicated a significance level more than 0.05 ($p > 0.05$). Therefore, the data between treatment groups had a homogeneous variance.

Hypothesis Testing

Table 4 contains the results of the hypothesis testing in this study.

Table 4. Hypothesis Testing Results

No	Hypothesis	F	Sig	Remarks
1	There is a significant difference in critical thinking skills between the collaborative learning group and the direct learning group.	87.626	0.000	Hypothesis accepted
2	There is a significant difference in critical thinking skills between students with high and low self-efficacy.	90.184	0.000	Hypothesis accepted
3	The interaction between the learning strategy and self-efficacy had an effect on students' critical thinking skills.	5.319	0.027	Hypothesis accepted

The data in the Table 5 shows that the results of the first hypothesis test prove that there is a significant difference in critical thinking skills between students who are taught collaborative group investigation and direct learning. The results of the test indicated an F-calculated of 87.626 and a significance level of 0.000. This number showed a statistically significant difference between the two groups (p 0.05). Consequently,

hypothesis 1 was supported, indicating that the critical thinking skills of students in the collaborative investigation group differed considerably from those of students in the direct learning group. This result is in accordance with prior research which indicates that the involvement of students in teamwork affects their learning achievement. Students with low abilities can get maximum achievements if they apply the processes of research adequately when working in groups (Zorlu & Sezek, 2020).

Students participate in collaborative group investigation by investigating topics, exchanging perspectives, and assessing experiences to enhance their knowledge and critical thinking skills (Rosiani et al., 2020). Critical thinking enables pupils to rationally analyze knowledge and prepare for independent study (Amin et al., 2020). Students with critical thinking skills can distinguish between material that is significant, irrelevant, or unimportant (Amin et al., 2017). Individual factors, such as motivation and achievement needs, can also influence students' critical thinking skills (Tamam et al., 2021). Students' self-confidence can rise with CGI because they collaborate, assist one another, and build awareness. Students with high self-esteem assist students with low self-esteem.

The data in the table 5 shows that the results of the second hypothesis test prove that there are difference in critical thinking skills between students with high and low self-efficacy.The results of the test indicated an an F-calculated of 90.184 and a significance level of 0.000. This value suggested a significant difference (p 0.05), thus supporting the acceptance of hypothesis 2. Therefore, it was inferred that there was a considerable difference between students with high self-efficacy and students with low self-efficacy in terms of critical thinking skills. Self-confidence plays a crucial part in learning activities because it enables pupils to believe in their ability to accomplish learning objectives (Amin et al., 2016). This provides a response to the second formulation of the problem, demonstrating that self-efficacy greatly enhances students' critical thinking processes. Analysis of the data demonstrates that pupils with high self-efficacy have superior critical thinking skills compared to those with low self-efficacy. This study's findings are consistent with the findings of Nuraisyah and Izzati, who found a correlation between self-efficacy and student learning outcomes (Nuraisyah & Izzati, 2020). Students with high self-efficacy tend to demonstrate superior abilities and skills, whilst those with low self-efficacy frequently experience feelings of insecurity. Self-efficacy can boost students' comfort and confidence when participating in classroom discussions (Amin, 2022b).

Self-confidence plays a crucial part in learning activities because it enables pupils to believe in their ability to accomplish learning objectives (Amin et al., 2016). This provides a response to the second formulation of the problem, demonstrating that self-efficacy greatly enhances students' critical thinking processes. Analysis of the data demonstrates that pupils with high self-efficacy have superior critical thinking skills compared to those with low self-efficacy. This study's findings are consistent with the findings of Nuraisyah and Izzati, who found a correlation between self-efficacy and student learning outcomes (Nuraisyah & Izzati, 2020). Students with high self-efficacy tend to demonstrate superior abilities and skills, whilst those with low self-efficacy frequently experience feelings of insecurity. Self-efficacy can boost students' comfort and confidence when participating in classroom discussions (Amin, 2022b). Self-efficacy can affect students' self-regulation such as goal setting, thinking skills, and self-assessment (Nurulwati et al., 2022). Science process skills are an important element that plays a role in stimulating critical thinking skills (Darmaji et al., 2021). The ability to think critically is more in receiving information by studying sources of information circulating can be accounted for or not, read information from various sources which are summarized into a conclusion (Purwanti et al., 2022; Rezkillah & Haryanto, 2020).

F-test was conducted to investigate the third problem formulation about the effect of the interaction between collaborative learning and self-efficacy on the critical thinking

skills of students. The results of the test indicated an F-calculated value of 5.319 and a significance value of 0.027 <0.05. This indicates that the interplay between collaborative learning in groups and self-efficacy has an effect on students' critical thinking skills. Introducing discussion during elaboration and collaboration enables students to delve deeper into scientific concepts (Ping et al., 2020). From a constructivist perspective, educators are not responsible for imparting knowledge, but rather for facilitating it. Educators present students with practical projects and provide appropriate direction, questions, and answers to enhance student involvement and encourage further thinking. (Amin, 2017; Kim et al., 2014).

This finding contrasts a recent study by Dini Farera that found no connection between learning models and self-efficacy in mathematical problem-solving. Numerous recent studies, however, have demonstrated that self-efficacy is a trait that can influence learning outcomes. This underscores the concept that intrinsic motivation as a component of self-efficacy must be considered to generate pupils with high levels of awareness and skills (Pintrich, 2000). Improving pupils' critical thinking skills is crucial because, with critical thinking, they will be able to solve a variety of challenges throughout their life and use these skills in future scenarios (Mahanal et al., 2016). Self-efficacy can be utilized to enhance collaborative group investigation procedures and students' critical thinking skills. Self-efficacy behavior improves the effectiveness of the CGI and direct learning implementation in the classroom. This study's findings reveal that there is a substantial association between CGI strategy and self-efficacy, which has a major impact on students' critical thinking skills; the stronger the link between learning strategies and self-efficacy. In contrast, the negligible relationship between learning strategies and self-efficacy has no effect on critical thinking skills. Shared ownership of high and low self-efficacy behaviors and learning strategies (CGI and direct learning) will alter students' critical thinking skills. Therefore, learners should consider their level of self-efficacy while managing their learning process. Through the implementation of relevant learning models, students' critical thinking skills can be enhanced (Azizah et al., 2020).

Conclusion

The results of the data analysis showed that: (1) there was a significant difference in critical thinking skills between the collaborative learning group and the direct learning group, where students taught with the collaborative group investigation strategy achieved higher than those taught with the direct learning strategy; (2) there was a significant difference in critical thinking skills between students with high and low self-efficacy, where the students with high self-efficacy demonstrated higher critical thinking skills than those with low self-efficacy; (3) the interaction between the learning strategy and self-efficacy had an effect on students' critical thinking skills.

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