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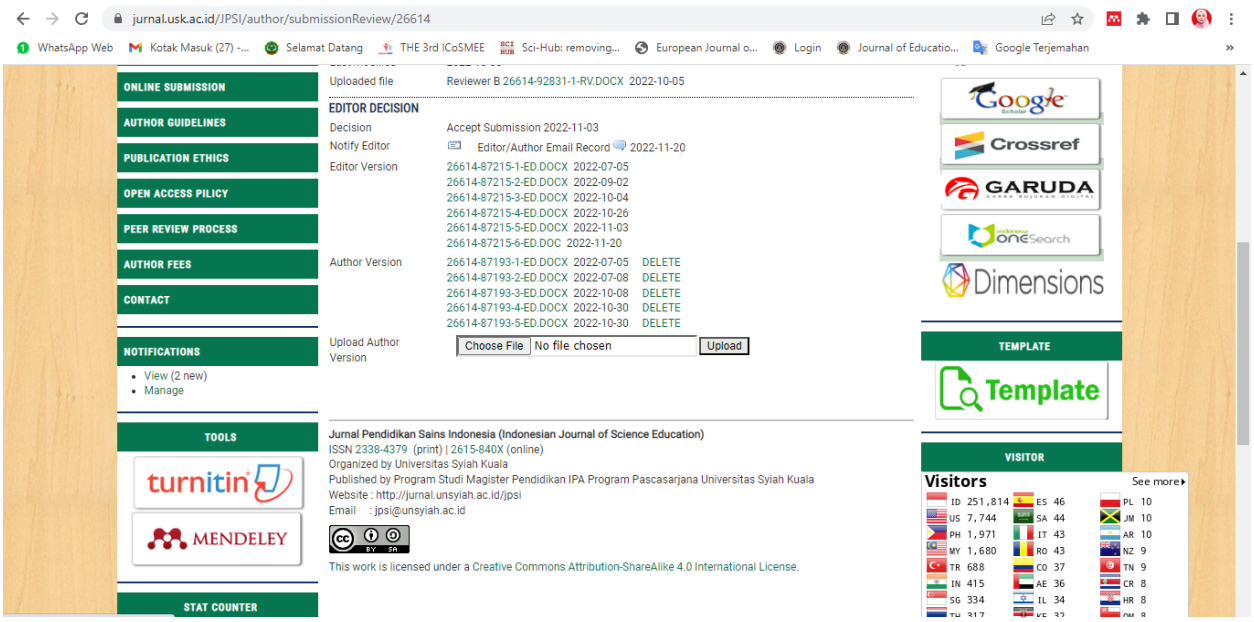
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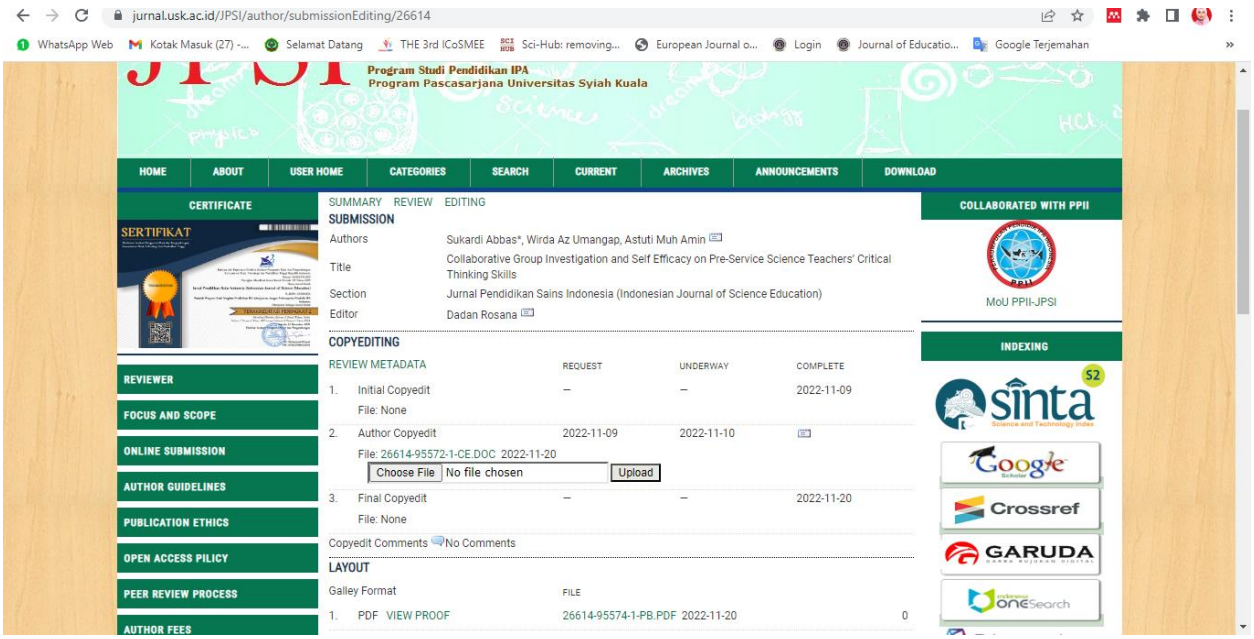
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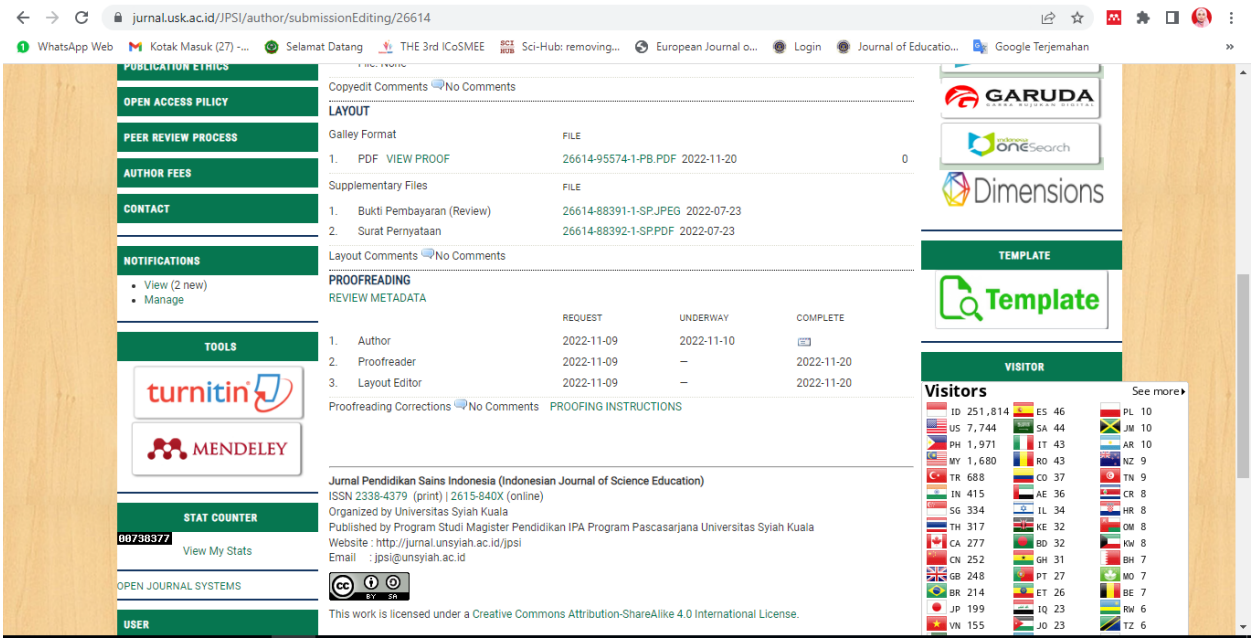
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Collaborative Group Investigation and Self Efficacy on Pre-Service Science Teachers' Critical Thinking Skills

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Abstract. This study sought to determine the effect of collaborative group investigation (CGI) learning and self-efficacy on the critical thinking skills of students enrolled in the Environment course. 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. Students with high self-efficacy and those with low self-efficacy demonstrated significantly different self-efficacy, as the mean test score of students with high self-efficacy (62.3) was higher than that of students with low self-efficacy (48.3), with an $F_{calculated}$ value of 90,184 and a significance value of 0.000. 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.

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Introduction

Education is a coordinated endeavor aimed at guiding students in a better direction. Therefore, the best approach for students to accomplish this objective is to adhere to the learning principles of the transfer of values and the transfer of knowledge or skills. As a major determinant, the role and objectives of education remain connected to these two factors. The goals of science education are to link scientific endeavors with life's values and to introduce students to scientific activities through observation and exploration of natural phenomena and the search for solutions to life's problems. Through science education, students acquire scientific knowledge and assume responsibility for addressing issues in life. The role of science education must extend beyond the comprehension of concepts and their applications.

Comment [H2]: Jangan menarasikan terlalu umum dan tak ilmiah juga diawal dengan tulisan definisi atau pengertiannya! Mulaii saja menjelas permasalahannya yang didukung data dan sejuml referensi primer yang mutakhir!

The objective and role of science education have not been adequately implemented. Educators appear to be ingrained in the practice of relying solely on mastery of theory and memorization for textual learning processes. This affects the growth of students' learning capabilities. Past research has demonstrated that many students struggle to comprehend certain scientific concepts and are unfamiliar with experimental activities that enhance scientific skills (Bostan Sarioglan et al., 2021; Marlina, 2020). Students' views and ideas about their difficulties should be respected and teaching-learning

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approaches and strategies should be adapted to the learning needs and learning styles of students (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 Häkkinen 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; Mende et al., 2021); (Magnanini 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

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

The population in this study were all sixth semester biology students who program environmental courses. Their total number is 50 people. Cluster sampling technique was used for sampling. As a result, 40 people were sampled in this study. They were divided into two groups, namely the experimental group and the control group. Each group consists of 20 people so that the total number is 40 people. Both groups are assumed to have the same ability based on the results of the identification of learning outcomes.

The study was done across eight meetings in the odd semester and included a pre-test, treatment sessions, and a post-test. 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.

The pre-test activity was conducted during the first week, with students completing assesment for self-efficacy and critical thinking skills. Following that, treatment was administered to both the experimental and control groups. The data obtained in the study were arranged and analyzed descriptively to determine the mean, standard deviation, normality and homogeneity. Furthermore, it is analyzed using inferential statistics to test the hypotheses that have been formulated if the assumption tests such as normality and homogeneity are met. All testing techniques use the help of SPSS software.

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.

Comment [H6]: Sajikan dulu datanya, baru dibahas langsung secara mendalam didukung sitasinya kepada artikel jurnal yang relevan!

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

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 (M) of 48.4 and a standard deviation (SD) of 9.86. The results of a descriptive statistical examination of the critical thinking skills of students are presented in Table 2.

Comment [H7]: Kurang ilmiah tulisannya, jika istilahnya diulang-ulang penulisan nama dan simbolnya!

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

Sumber: Data Penelitian Diolah (2019)

Comment [H8]: Jika data ini merupakan hasil penelitian sendiri tak perlu ditulis sumbernya!

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

The descriptive analysis of students' critical thinking skills based on their self-efficacy yielded the mean, standard deviation, and number of students as outputs. Twenty (N) students with high self-efficacy reported a mean (M) of 62.3 and a standard deviation (SD) of 7.01. Meanwhile, twenty students with low self-efficacy obtained a mean (M) of 48.3 and a standard deviation (SD) 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 for critical thinking skills in the group with low self-efficacy. Table 1 provides an overview of the outcomes of data interpretation.

Comment [H9]: Idem!

The Results of the Assumption Tests

Normality Testing

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. The findings of the Levene's homogeneity test are displayed in Table 4.

Table 4. The Result of Levene's Test of Variance Homogeneity

Variable	F	Sig.	Remarks
Critical Thinking Skills	0.869	0.466	Homogeneous

Comment [H10]: Penyajian data ini kurang ilmiah, karena datanya sangat sederhana! Cukup dinarasi saja !

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 5 contains the results of the hypothesis testing in this study.

Table 5. 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 (CGI) 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 (CGI) 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

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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, 2022).

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, 2022).

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. (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. For instance, Pesouta and John Nietfeld's (2020) research indicates that learners who engage in cooperative learning demonstrate a high level of awareness. The study further concludes that the social setting of the classroom and self-efficacy, particularly motivation, influence the acquisition of high-level abilities. 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,

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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 (CGI) 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, the higher the positive effect on critical thinking skills. 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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