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Collaborative Problem Solving Oriented Education for Sustainable Development: Its Impact on Critical Thinking Skills and Sustainability Awareness

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Abstract: This study aims to analyze the effect of the Education for Sustainable Development (ESD)-oriented Collaborative Problem Solving (CPS) model on students' critical thinking skills and sustainability awareness in ecosystem material. The study uses a quantitative approach with a non-equivalent control group quasi-experimental design. The research sample consisted of 10th grade students at MAN 1 Metro, with class X-1 as the experimental class and X-2 as the control class, selected using purposive sampling. Data on critical thinking skills were obtained through pretest and posttest, while sustainability awareness was measured using a questionnaire. The results showed that the increase in critical thinking skills of students in the experimental class was in the moderate category with an N-Gain value of 0.70 and was higher than that of the control class. In addition, the sustainability awareness of students in the experimental class reached an average of 84.44, which is in the high category. These findings indicate that the application of the ESD-oriented CPS model is effective in improving critical thinking skills while fostering students' sustainability awareness. Therefore, this learning model is recommended as a relevant contextual learning strategy to support 21st-century education and the achievement of sustainable development goals through education

Keywords: Collaborative Problem Solving. Critical Thinking Skills. Education for Sustainable Development, Sustainability Awareness

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1. Introduction

Society 5.0 is a concept that enables humans to use knowledge based on modern technology to meet needs while also facilitating life (Sakiinah et al., 2022). To face the challenges of the Society 5.0 era, humans will coexist with technologies that can help them address global problems, including those related to the environment. Humans also must ensure that technology is used appropriately to support sustainability without harming the environment. To ensure this, certain skills must be trained in learners, one of which is critical thinking (Harahap et al., 2023).

Critical thinking is a process within thinking skills that can effectively help an individual solve problems and make decisions for themselves (Rauf et al., 2022). In facing the challenges of the Society 5.0 era, this skill can help learners analyze environmental problems, evaluate the impact of technology on the environment, and enable learners to develop innovative and sustainable solutions.

In facing the challenges of the Society 5.0 era, critical thinking needs to be supported by students' understanding of environmental awareness. Environmental awareness is possessed by students to foster a sense of responsibility toward the environment (Maresi & Agastyo, 2024). Environmental awareness must be enhanced to achieve the Sustainable Development Goals; this awareness is commonly known as sustainability awareness or environmental sustainability awareness.

Sustainability awareness is self-awareness that can prepare learners to contribute to sustainable development as an effort to address environmental problems with self-awareness to protect (Zulkarnaen et al., 2023) and to value the surrounding environment by prioritizing the impacts that will occur on the social, economic, and environmental aspects (Rini & Harto, 2022).

Meanwhile, students in Indonesia still have low levels of critical thinking skills and sustainability awareness. The 2022 PISA study, which measured reading literacy, mathematics, and science across 81 countries, shows that Indonesia ranks 68th with scores of 366 in mathematics, 383 in science, and 359 in reading (OECD, 2023). PISA items are designed to assess students' ability to apply their knowledge to their lives, thereby measuring critical thinking skills and sustainability awareness (Katoningsih and Ilham, 2020). In the 2024 Sustainable Development Report, which covered 193 United Nations member states to assess SDG progress, Indonesia ranked 78th out of 167 countries with a score of 69.43. These figures indicate that Indonesia remains weak in SDG achievement, especially in the area of quality education (Sachs et al., 2024).

The low levels of critical thinking skills and sustainability awareness are caused by several factors. One of these factors is the educational approach in Indonesia, which often focuses more on partial textual knowledge rather than integrative and contextual understanding. Teachers still rely on lecture-based teaching or are fixed on a single reading source, causing students to become more passive and to receive information rather than seek it themselves (Agusti et al., 2019).

Preliminary research conducted at MAN 1 Metro shows that students' critical thinking skills and sustainability awareness remain low. This is evidenced by test results measuring critical thinking skills, which have an average score of 31 percent,

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categorized as low. For sustainability awareness, the questionnaire results show an average of 49.52 percent, also in the low category. This is because students have not yet provided accurate and relevant explanations for the questions asked. The low levels of critical thinking skills and sustainability awareness are also supported by interview results conducted with teachers at MAN 1 Metro. Based on interviews with educators, it was found that in teaching activities, teachers have not yet implemented models that can enhance students' critical thinking skills and sustainability awareness. Teachers also have not connected the learning to sustainability awareness. Additionally, interviews with students revealed that learning activities were not linked to daily life applications and remained anchored to a single textbook source. As a result, students tend to be less active in learning activities.

Efforts to improve critical thinking skills and sustainability awareness include, among other things, the role of teachers who provide opportunities for students to be active in learning (Parinduri & Nursyam, 2023). To support active student participation, collaboration is needed among teachers and students, among students themselves, and between students and the environment, so that a conducive and active learning process is created (Wibawa et al., 2019). To make this learning process possible, teachers can implement learning models that require students to be active and to discover themselves how to face or solve problems in learning (Agusti et al., 2019). One learning model that involves students actively in learning is a problem-solving oriented learning model (Redhana, 2019). One such problem-solving oriented learning model that can be implemented by teachers is the Collaborative Problem Solving learning model.

The Collaborative Problem Solving learning model actively involves group participation to coordinate and collaborate in planning, implementing, and testing solutions to achieve problem-solving goals (Wibawa et al., 2019). In its implementation, the Collaborative Problem Solving model can increase students' participation in learning through problem solving (Johari et al., 2018). In addition to active participation, schools must also cultivate sustainability awareness in learning to support sustainable development (SDG Education for Sustainable Development, ESD) (Agusti et al., 2019). The concept of ESD equips learners with knowledge, skills, values, and attitudes to process information, take responsible actions, and make decisions that are accountable for the sustainability of the environment, economy, and a just society for future generations (Purnamasari & Aldila, 2021). ESD can be integrated into the curriculum and daily learning activities, thereby creating a learning environment that encourages students to think critically, collaborate, and take responsibility for global and environmental issues (Malua & Olvitt, 2024).

Previous research indicates that the Collaborative Problem Solving (CPS) model can enhance students' cognitive outcomes and critical thinking skills, while Education for Sustainable Development (ESD) has been widely discussed as a means to promote sustainability awareness and attitudes. However, empirical studies that explicitly integrate CPS with ESD principles into a coherent instructional design remain limited. Moreover, existing studies often focus on a single outcome—either critical thinking skills or sustainability awareness—rather than examining their combined or simultaneous development within one learning intervention. This gap is particularly evident in biology education, especially in teaching ecosystem topics in Madrasah Aliyah, where learning should be contextual and closely connected to sustainability challenges in the Society 5.0 context.

Research on Collaborative Problem Solving (CPS) to date has focused more on improving cognitive learning outcomes and collaborative skills, but has not commonly integrated CPS explicitly with the concept of Education for Sustainable Development (ESD) to foster sustainability awareness. Thus, this study offers a new learning strategy that not only trains learners to solve problems collaboratively but also instills sustainability values relevant to global and local environmental issues. Furthermore, previous research generally emphasized the development of critical thinking skills, whereas this study adds a new dimension in the form of sustainability awareness as an important indicator in modern science learning. With this combination, the study is expected to make theoretical and practical contributions to designing biology learning strategies that are more effective.

The main novelty of this study lies in the systematic integration of the Collaborative Problem Solving model with the principles of Education for Sustainable Development into a comprehensive learning strategy design. This study integrates collaborative problem-solving activities with contextual environmental sustainability issues, while simultaneously measuring improvements in critical thinking skills and sustainability awareness. Furthermore, this research was conducted in the context of Madrasah Aliyah with ecosystem material, which is still rarely the focus of ESD-based Collaborative Problem Solving research. Thus, this research provides theoretical and practical contributions to the development of relevant biology learning strategies to shape students who think critically and have sustainability awareness to support the achievement of sustainable development goals through education.

2. Method

This study uses a quasi-experimental design with a non-equivalent control group. Sampling was conducted using purposive sampling with the characteristic that the students had never studied ecosystem material. Class X-1, with 35 students, served as the experimental group that used a Collaborative Problem Solving learning model oriented toward Education for Sustainable Development, while Class X-2, with 35 students, served as the control group that used the Discovery Learning learning model. The data type used in this study is quantitative data. The data collected are critical thinking skills obtained from pretest and posttest scores, and sustainability awareness data obtained from the students' sustainability awareness survey during the learning process.

The item analysis was conducted using the analysis of student score data, followed by a *N*-Gain analysis with the following formula.

$$N - Gain = \frac{X - Y}{Z - Y}$$

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The average *N*-Gain score obtained is then interpreted according to Table 1.

Table 1. Categories of *N*-Gain Calculation Results

N-Gain Score	Category
N Gain > 0,7	High
0,3-0,7	Medium
N Gain < 0,3	Low

(Hake, 2002)

The *N*-Gain scores obtained from the experimental class and the control class are used as data to compare the improvement in students' critical thinking skills. Subsequently, an analysis of critical thinking indicators was conducted using the following formula.

$$Score = \frac{Total\ score}{Maximum\ score} \times 100\%$$

The percentage score obtained is then interpreted according to Table 2.

Table 2. Percentage of Critical Thinking Indicators

Percentage Scale	Criteria
21%-40%	Poor
41%-60%	Adequate
61%-80%	Good
81%-100%	Very Good

(Riduan, 2012)

Subsequently, an analysis of the survey data on sustainability awareness was conducted using the following formula.

$$\frac{\text{Total score obtained}}{\text{Total maximum score}} \times 100\%$$

Subsequent interpretations are based on Table 3.

Table 3. Interpretations of Sustainability Awareness

Response percentage (%)	Response Criteria
0,0 – 39.9	Practices performed infrequently or never.
40,0 – 69,9	Practices performed at a moderate frequency.
70,0 – 100	Practices performed at a moderate frequency or always

(Hassan et al., 2010)

Subsequently, an analysis of student respondents survey data was conducted using the following formula.

$$P = \frac{F}{N} \times 100\%$$

The results were interpreted based on Table 4.

Table 4. Student Response Categories

Score	Category
81-100	Very Good
61-80	Good
41-60	Adequate
21-40	Poor
0-20	Very Poor

(Kartini & Putra, 2020)

3. Result and Discussion

This study assesses the improvement in students' critical thinking skills, as reflected by pretest and posttest scores derived from a 16-item instrument. The critical thinking skills encompass five aspects: 1) basic clarification, 2) bases for a decision, 3) inference, 4) advanced clarification, and 5) strategic and tactical thinking (Ennis, 2011). The results indicate improvements in both the experimental and control classes, compared with pretest scores. Data from the experimental and control classes served as the source for computing the N-Gain scores. The statistical test results are presented in Table 4.

Table 5 shows an increase in the experimental class relative to the pretest, and likewise for the control class.

Table 5. Statistical Tests for Pretest and Posttest Data on Critical Thinking Skills

Class		$\bar{x} \pm sd$	N Gain	Interpretation	Kategori
Experiment	*Pretest*	40,86 ± 8,04	0,70	*N Gain* > 0,7	Sedang
	Posttest	82,57 ± 6,46			
Control	*Pretest*	37,69 ± 7,04	0,44	0,3-0,7	Sedang
	Posttest	66,23 ± 4,98			

X= Nilai rata-rata; Sd= Standard Deviation

Enhancements in critical thinking skills and sustainability awareness were influenced by students' enthusiasm and active participation. In the LKPD, there is discourse relating to ecosystem issues; students formulate problem statements, analyze the problems that arise, implement learning, and become aware of

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environmental issues, thereby increasing environmental consciousness, environmentally responsible attitudes, and the ability to propose solutions to environmental problems.

After examining the *N*-Gain data for pretest and posttest scores in critical thinking skills, the following presents the improvements in critical thinking skills by aspect for the experimental and control classes.

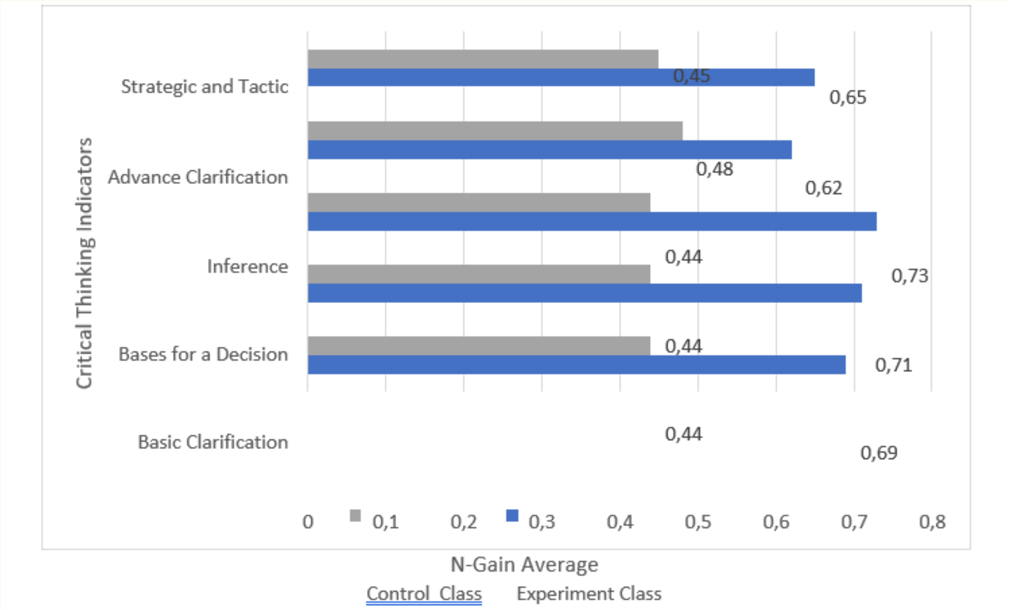

Figure 1. Improvements by Aspect of Critical Thinking Skills

Based on the data obtained from Figure 1, it is evident that the *N*-Gain values for each indicator of critical thinking relatively increased compared to the pretest values, in both the experimental and control classes. The analysis of the average scores for each aspect of critical thinking shows an increase in the inference and bases for a decision aspects, which have higher mean N-Gain than the other aspects. The Inference aspect has a mean *N*-Gain of 0.73 with a high interpretation. To develop this aspect in students, in the LKPD the researcher provided a discourse containing problems related to issues in the terrestrial ecosystem and gave students an opportunity to infer what they had learned from the discourse. In the questions, the researcher presented a diagram illustrating a problem in a paddy field ecosystem; students then identified the problems, their impacts, and appropriate solutions based on the data obtained.

Based on the data for the aspect "bases for a decision," the mean *N*-Gain is 0.71. This result is attributed to the LKPD in which the researcher provided questions related to the impacts of damage to one of the ecosystems around the students' environment. Students sought the correctness of the given answers by observing their surroundings or consulting reading sources. Additionally, the improvement in this aspect is evidenced by the students' responses to the posttest questions administered by the researcher. Students were asked to state the causes and impacts of illegal mining, considering social, economic, and environmental dimensions, and they did so by seeking information from reliable sources and verifying the accuracy of the information.

Table 6. Improvements in the Sustainability Awareness Questionnaire

Indicator	Eksperiment		Control	
	%	Criteria	%	Criteria
Sustainability practices	98,10	High	21,90	Low
Behaviors and attitudes	96,19	High	89,52	High
Emotional	59,05	Medium	63,33	Medium
Avarage	84,44	High	58,25	Medium

In the category of sustainability awareness, there are three subcategories: sustainability emotional awareness, behavior and attitude awareness, and sustainability practice awareness (Alissa et al., 2022). The increase in students' Sustainability Awareness, as observed from the overall percentage of students attaining high scores across indicators in both the experimental and control groups, is highest for the behavior and attitude awareness indicator, with a mean score of 96.19 for the experimental group and 89.52 for the control group. This outcome is attributed to the teaching approach, in which the researcher presents environmental issues that encourage students to discuss environmental topics with peers and with people around them.

Moreover, during the instruction, the researcher provides opportunities for students to observe their surrounding environment and identifies one example of ecosystem damage—litter around the irrigation area. From these observations, students analyze the impacts of continuing such behavior. The ensuing discussions lead students to realize that indiscriminate waste disposal can cause persistent, long-term damage to ecosystems. Through these activities, students develop practical skills in decision-making by analyzing, evaluating, and first consulting information from reliable sources. Thus, based on the above, there appears to be a linkage between the enhancement of critical thinking and students' sustainability awareness.

Table 7. Students' Responses to the Use of the Collaborative Problem Solving Model Oriented toward Education for Sustainable Development

No	Indicator	Percentage	Category
1.	Students' responses to the learning process.	85%	Very Good
2.	Students' responses to the implementation of sustainability-oriented learning and daily life applications.	88%	Very Good
3.	Students' responses to environmental awareness and responsibility.	85%	Very Good
4.	Students' responses to participation and engagement in learning.	84%	Very Good
Avarage		86%	Very Good

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The enhancement of critical thinking skills and sustainability awareness is influenced by students' enthusiasm and active participation. This is reflected in the results of the Student Response Questionnaire presented in Table 7, which indicates that 88% of students report increased participation and engagement in learning. Active student involvement in the learning process can improve conceptual understanding. In the LKPD, scenarios related to ecosystem issues were provided, prompting students to formulate research questions and analyze the problems. The teacher first explained these issues and guided students to develop solutions, enabling them to discuss and identify solutions with sustainable impacts. This aligns with the findings in Table 7, where 88% of students reported implementing learning and heightened environmental awareness, along with a sense of responsibility toward the environment, and the ability to propose sustainable solutions to environmental problems.

This study produced several key findings. First, the application of the Collaborative Problem Solving (CPS) model oriented towards Education for Sustainable Development (ESD) was proven to significantly improve students' critical thinking skills compared to conventional learning. This was demonstrated by the N-Gain score for critical thinking skills in the experimental class, which was 0.70, placing it in the moderate category and higher than the control class. This finding is in line with previous studies which state that collaborative problem-solving-based learning is effective in training students' analytical, inferential, and decision-making skills (Redhana, 2019; Wibawa et al., 2019).

This study also found that the application of ESD-oriented CPS was able to increase students' sustainability awareness to a high level, with an average score of 84.44. The highest increase was in the aspect of sustainability attitudes and behavior, which shows that student involvement in discussions and analysis of contextual ecosystem issues can foster concern and responsibility for the environment. These results reinforce previous findings that the integration of ESD in science education plays an important role in building students' sustainability awareness (Agusti et al., 2019; Purnamasari & Aldila, 2021).

The results of this study indicate a correlation between improved critical thinking skills and students' sustainability awareness. Collaborative problem-solving activities focused on ecosystem issues encourage students to think critically while considering the social, economic, and environmental impacts of proposed solutions. These findings support the view that the development of critical thinking skills through contextual learning can go hand in hand with the formation of sustainability awareness within the framework of ESD (Zulkarnaen et al., 2023).

4. Conclusion

Based on the results of the study, it can be concluded that the application of the Collaborative Problem Solving (CPS) model oriented towards Education for Sustainable Development (ESD) has proven to be effective in improving students' critical thinking skills and sustainability awareness. This is demonstrated by the increase in the N-Gain value of critical thinking skills in the experimental class, which is higher than that of the control class, as well as the achievement of sustainability awareness in the high category. The active involvement of students in solving contextual problems related to ecosystem issues encourages students to analyze, evaluate, and formulate sustainable solutions, while fostering environmentally conscious attitudes and behaviors. Thus, the ESD-oriented CPS model is relevant and recommended as a 21st-century learning strategy to develop students who think critically and have sustainability awareness.

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