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Implementation of Problem-Based STAD Learning to Improve Students' Critical Thinking Skills on Ecosystems

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Abstract: This study investigates whether the Problem-Based Student Teams Achievement Division (STAD) learning model can enhance students' critical thinking skills to a greater extent than conventional lecture-based instruction on the topic of Human Impact on Ecosystems. A quasi-experimental method was employed, using test items as the research instrument. A total of 31 seventh-grade students from class VII I served as the control group, while 30 students from class VII G constituted the experimental group. Descriptive analysis was used to describe the post-test results for each indicator of critical thinking skills. An independent t-test was then conducted to examine the differences in essential thinking abilities between the experimental and control groups. Additionally, an N-gain test was conducted to assess the magnitude of improvement in students' critical thinking skills in the experimental group relative to the control group. The findings indicate that the Problem-Based STAD learning model improved students' critical thinking skills in the experimental group at a moderate level, with an N-gain score of 0.43. In contrast, the conventional learning approach led to a low level of improvement, with an N-gain score of 0.24. This study emphasises the implementation of a problem-based STAD model derived from students' real-life issues, making the learning process more contextual. The topic of Human Impact on Ecosystems was chosen for its strong relevance to students' everyday experiences.

Keywords: STAD Learning Model, Problem-Based Learning, Critical Thinking, 21st Century Skills

INTRODUCTION

Science and technology, in their development, require a strategic role from the educational sector. Moreover, education emphasises different areas of focus (Musahrain et al., 2024). In the 21st century, students are faced with various educational challenges, including: (1) collaborating with others, (2) presenting information clearly, (3) thinking critically and solving problems, and (4) creativity and innovation (Nuraina & Nestiadi, 2025). Therefore, critical thinking skills have become essential competencies to develop. To solve personal and social problems effectively, students need to acquire a range of 21st-century skills (Yulianti et al., 2022).

Critical thinking skills are essential in students' lives. Students need critical thinking as a tool to solve real-world problems (Suradika et al., 2023). These skills are crucial for fostering deep learning, as they enable students to utilise evidence, evaluate presented materials, and reflect on ideas (Chen et al., 2024). Moreover, critical thinking can help students minimise errors when making decisions (Ariadila et al., 2023). Therefore, critical thinking enables students to assess and evaluate events, leading to more thoughtful and informed decision-making.

According to Ennis, critical thinking is the process of logically and deliberately processing information to make informed decisions. It is a skill that involves utilising various objects and concepts to solve problems (Muhibbuddin et al., 2023). Norris and Ennis (1989) identified five components of critical thinking skills, which include: (1) providing a simple explanation, (2) building basic skills, (3) drawing conclusions, (4) offering further clarification, and (5) managing strategies and tactics (Chusni et al., 2020).

Lestari and Annizar (2020) stated that critical thinking skills can be assessed using PISA items, as they require reasoning and strategic problem-solving abilities—skills that define critical thinking. According to the 2022 PISA results, Indonesia ranked 68th out of 81 participating countries (OECD, 2023). The low level of critical thinking skills among Indonesian junior high school students was also highlighted by Nuraina and Nestiadi (2025), who reported that students cannot identify problems and propose ideas or solutions in response to case studies presented during learning activities. These findings indicate that Indonesian students' critical thinking skills remain relatively low compared to those of students in other countries.

The low level of students' critical thinking skills can be attributed to several factors, including the limited use of effective teaching methods and learning models in the classroom. In practice, classroom instruction is still predominantly delivered through teacher-centred lectures, which limits students' active engagement in the learning process. On the other hand, students' understanding is highly influenced by the instructional materials and learning models employed (Nuraina & Nestiadi, 2025). Therefore, to address this issue, alternative solutions are needed—one of which is implementing innovative learning models that foster critical thinking skills. Various efforts have been made to enhance students' critical thinking abilities, including the use of electronic student worksheets (E-LKPD) (Rofik et al., 2025), STEAM-based Project-Based Learning (PjBL)(Rofik et al., 2025, Sari et al., 2025), and E-modules (Amalia et al., 2024).

Roger and Johnson (1994) stated that cooperative learning can promote higher-order thinking skills in students by encouraging the exchange of ideas and collaborative problem-solving with peers through group discussions (Qismullah Yusuf et al., 2015). The Student Teams Achievement Divisions (STAD) model is a cooperative learning approach that provides students with opportunities to engage in the learning process actively. STAD organises students into small groups of four to five members with heterogeneous composition in terms of academic ability, gender, and ethnicity (Yusuf et al., 2015). According to Sinaga et al (2022), STAD is considered an effective model for fostering creativity, coordination skills, critical thinking, and the ability to support others.

In addition, students can develop their critical thinking skills as they are increasingly exposed to complex problems. Such problems train students to solve them by making maximum efforts to analyse and express opinions, categorise information, provide justification, reflect, interpret the meaning of judgments, and draw conclusions from problem-solving processes (Afifah & Nurfalah, 2019). To effectively solve a problem, individuals need critical thinking skills, as these skills encourage them not to settle for a single answer but to explore alternative solutions based on analysis and information derived from the problem itself (Sholihah & Lastariwati, 2020). Therefore, problem-based learning models can be considered a viable approach to fostering students' analytical problem-solving abilities.

The topic Human Impact on Ecosystems was selected because it reflects real-world problems encountered in students' daily lives. For example, activities such as dumping waste into rivers or clearing land can lead to declines in biodiversity within ecosystems. This content is closely related to critical thinking skills, as it allows students to observe environmental issues in their surroundings directly and stimulates their curiosity (Nuraina & Nestiadi, 2025). By studying the material contextually, students are expected to develop their critical thinking skills by investigating the causes of environmental problems and exploring potential solutions.

The STAD learning model can be integrated with a problem-based learning approach, resulting in the Problem-Based STAD model. This instructional model emphasises student collaboration within groups to understand and solve real-world problems, thereby achieving learning objectives and constructing understanding based on students' cognitive processes (Rianti et al., 2021). The integration of Problem-Based Learning (PBL) and STAD provides students with opportunities to examine, respond to, and collaborate critically. Students are also trained to confront problems, think critically to find solutions, and are challenged to resolve both academic and real-life issues (Andriyati & Noviani, 2023). The syntax of the Problem-Based STAD model, as implemented by Dwi Anjani et al. (2023), illustrates the integration of PBL stages into cooperative STAD learning, as follows: (1) the phase of presenting objectives, motivation, and information aligns with orienting students to the problem; (2) the group formation phase aligns with organizing students for learning; (3) the discussion phase corresponds with guiding individual or group investigations; (4) the phase involving presentations, quizzes, and rewards aligns with presenting students' work; and (5) the evaluation and conclusion phase corresponds with analyzing and evaluating the problem-solving process.

In the Problem-Based STAD learning model, during the phase of presenting objectives, motivation, and information, students listen to the teacher's presentation on environmental issues in their surroundings. In the second phase, group formation, students are organised into groups consisting of 4–5 members. The third phase, discussion, involves students engaging in dialogue about the causes and impacts of environmental problems and exploring possible solutions and preventive measures. During the presentation phase, students present the results of their group work and receive feedback from other groups, which further promotes peer discussion. This phase is followed by a quiz and the distribution of rewards, aimed at developing students' individual competencies. In the final phase, evaluation and conclusion, students summarise what they have learned throughout the lesson. Based on these student activities within the Problem-Based STAD learning syntax, students are trained to provide explanations and arguments to their peers, engage in deeper thinking during discussions, and develop strategic approaches to address environmental problems. Therefore, this learning model is expected to foster and enhance students' critical thinking skills effectively.

A study conducted by Sulistyani and Pratama (2024) demonstrated that the integration of Problem-Based Learning and STAD effectively enhances students' critical and mathematical thinking skills. Similar findings were reported by Karma et al. (2023) (Karma et al., 2023), who found a positive impact on students' critical thinking abilities following the implementation of Problem-Based Learning within an STAD framework. Based on these findings, it is expected that students' critical thinking skills can also be improved through the application of the Problem-Based STAD model compared to conventional lecture-based instruction, particularly on the topic of Human Impact on Ecosystems.

Based on the aforementioned explanation, problem-based learning can cultivate students' critical-thinking skills, while the STAD learning model can facilitate students' ability to work collaboratively in teams. These models are appropriate for efforts to improve students' critical-thinking skills in Indonesia, which remain relatively low. This study examines the statistical differences in students' critical-thinking abilities before and after learning through the Problem-Based STAD model. The purpose of this study is to determine the improvement in students' critical-thinking skills regarding human impacts on ecosystems following the implementation of the Problem-Based STAD learning model.

METHOD

This study employed a quasi-experimental approach using a pre-test post-test non-equivalent control group design (Cohen, 2007). It involved two class groups, designated as the experimental and control groups. The experimental group received instruction through a Problem-Based STAD learning model, hereafter referred to as the PB-STAD class (Problem-Based Student Teams Achievement Divisions). In contrast, the control group did not receive this instructional model. Instead, the control group was taught using a lecture-based method and is hereafter referred to as the lecture class.

One of the junior high schools in Nganjuk Regency served as the research site for this study, involving 30 seventh-grade students from class VII G—16, male and 14 female students, comprising the PB-STAD group. Additionally, 31 students from class VII I—16 male and 15 female—participated as the lecture group. In this study, the implementation of the Problem-Based STAD model functioned as the independent variable. At the same time, students' critical thinking skills on the topic of Human Impact on Ecosystems served as the dependent variable.

The PB-STAD class participated in lessons and completed student worksheets (LKPD) aligned with the Problem-Based STAD model's syntax. This alignment enabled observation of students' adherence to the PB-STAD learning steps through their responses on the prepared worksheets. The cultivation of students' critical thinking skills was not limited to the PB-STAD class; it was also implemented in the lecture class. In the lecture group, students' critical thinking skills were fostered through teacher-led prompts and completion of student worksheets.

This study employed a critical thinking assessment instrument comprising five open-ended questions, administered as both pre- and post-tests. The pre-test was administered before the instructional intervention to assess students' initial essential thinking skills. The post-test was administered after the instructional intervention had been delivered. Both the experimental and control groups completed these assessments to identify differences in students' critical thinking performance following the implementation of different instructional models. Before its implementation, the student worksheet (LKPD) instrument underwent validation, including validity and reliability testing using the percentage-of-agreement method.

Table 1. Percentage of Similarity in LKPD Validation Using the Percentage of Agreement Method

Aspect		Average	Criteria
Learning and Materials	**Readability and Visual Design**		
100%	94%	97%	Almost Perfect

In addition, the test instrument also underwent the same validation procedures, with the results presented in Table 2. The validation results showed that the LKPD achieved a percentage of agreement of 97%, while the test items reached 98.4%. These results indicate that both the test instrument and the LKPD are valid and reliable for use with students, as supported by Borich (1994) in Widiawati et al. (2022), who stated that an instrument is considered valid when it achieves a percentage of agreement (PA) of 75% or higher (≥75%).

Table 2. Percentage of Similarity in Pre-test and Post-test Validation Using the Percentage of Agreement Method

Aspect			Average	Criteria
Item Feasibility	**Language Appropriateness**	**Item Appropriateness**		
99,3%	98,6%	97,3%	98,4%	Almost Perfect

The data analysis in this study employed a descriptive approach by outlining students' post-test results based on the critical thinking skill indicators proposed by Norris and Ennis (1989), which include: (1) providing simple explanations, (2) building basic skills, (3) drawing conclusions, (4) offering further clarification, and (5) managing strategies and tactics. Before analysis, the data were subjected to normality testing (Shapiro-Wilk) and homogeneity testing (Levene's Test). An independent t-test was used to compare students' critical thinking skills between the PB-STAD class and the lecture class. Additionally, an N-Gain analysis was conducted to determine the magnitude of improvement in students' critical thinking skills in both groups. The level of improvement is classified as high if the gain score exceeds 0.7 ($g > 0.7$), moderate if it falls between 0.3 and 0.7 ($0.3 < g \leq 0.7$), and low if it is less than or equal to 0.3 ($g \leq 0.3$), as suggested by (Meltzer, 2002). Furthermore, students' critical thinking skills were categorised into levels as defined by Ramdani et al. (2020), using the criteria in Table 3.

Table 3. Criteria for Critical Thinking Skills

Gain Score	Category
81,25 < x ≤ 100	Very High
71,50 < x ≤ 81,25	High
62,50 < x ≤ 71,50	Moderate
43,75 < x ≤ 62,5	Low
0 < x ≤ 43,75	Very Low

RESULTS AND DISCUSSION

The collected pretest and posttest data were initially subjected to prerequisite analyses, namely the Shapiro–Wilk normality test and Levene's homogeneity test. The results showed that the data were normally distributed and homogeneous, as indicated by significance values greater than 0.05, thereby allowing the analysis to proceed to the subsequent tests. The results of the normality and homogeneity tests are presented in the table below:

Table 4. Normality Test Results

Class		Shapiro-Wilk Statistic	p-value	Note
PB-STAD	Pretest	0,969	0,512	Normal
	Posttest	0,936	0,069	Normal
Lecture-based	Pretest	0,956	0,233	Normal
	Posttest	0,979	0,782	Normal

The analysis of students' pre-test responses indicated that the initial critical thinking abilities of students in both the PB-STAD class and the lecture class were relatively equivalent, with average pre-test scores of 37.8 and 39.1, respectively. The equivalence of initial critical thinking skills between the two groups was confirmed through an Independent T-test, which showed no significant difference. This result supports the comparability of the two classes. The pre-test data for both the PB-STAD and the lecture classes are presented in Table 6.

Table 5. Homogeneity Test Results

Test	Levene's Statistic	p-value	Note
Pretest	0,629	0,413	Homogeneous
Posttest	0,145	0,705	Homogeneous

The PB-STAD class engaged in learning activities designed to develop critical thinking skills through the Problem-Based STAD model, guided by structured student worksheets (LKPD). Students began by identifying ecosystem-related problems presented in the LKPD, with guidance from the teacher. They then formed pre-assigned groups to discuss the issues and complete the additional questions in the worksheet. Each group presented the results of their discussion, followed by individual quizzes to evaluate students' understanding. In contrast, the lecture class focused on teacher-centred instruction. The teacher explained the topic of human impact on ecosystems while intermittently posing questions to stimulate students' critical thinking. This was followed by students working on pre-prepared worksheets designed to reinforce the material.

Table 6. Average Pre-test Scores of the PB-STAD Class and the Lecture Class

Class	Mean Pretest Score	Category
PB-STAD	37,8	Very Low
Lecture-based	39,1	Very Low

Following the implementation of the Problem-Based STAD learning model, post-test scores increased in the PB-STAD class. The improvement in scores, based on the comparison of pre-test and post-test results, is presented in the table below:

Table 7. Comparison of Students' Critical Thinking Skills in the PB-STAD Class and the Lecture Class

Class	Pretest Results		Posttest Results		Score Improvement
	Score	Category	Score	Category	
PB-STAD	37,8	Very low	64,2	Moderate	26,4
Lecture-based	39,1	Very low	54,0	Low	14,9

Following the implementation of the Problem-Based STAD learning model, differences in students' critical thinking levels between the PB-STAD class and the lecture class were observed. This can be seen in the percentage distribution of students' essential levels of thinking based on their post-test scores, which shows that a higher proportion of students in the PB-STAD class fell into the "very high" and "high" categories than those in the lecture class. The detailed data are presented in Table 8.

Table 8. Distribution of Students' Critical Thinking Skills in the PB-STAD Class and the Lecture Class.

Criteria for Critical Thinking Skills	PB-STAD Class	Lecture Class
Very high	10%	3,2%
High	26,7%	6,5%
Moderate	23,3%	25,8%
Low	26,7%	41,9%
Very low	13,3%	22,6%

For the first critical thinking indicator, providing a simple explanation, 67% of students in the PB-STAD class achieved high scores, compared to only 16% in the lecture class. This finding indicates that the PB-STAD class had more students demonstrating high-level critical thinking skills on this indicator than the lecture class. An example of a high-scoring student response from the PB-STAD class on a question related to this indicator—regarding the impact of burning waste—is as follows "(1) Air pollution occurs because the smoke from burning waste releases ash into the air, leading to pollution; (2) When plastic waste is burned, the chemical substances from the plastic can seep into the soil, causing soil contamination; (3) It can cause respiratory and skin diseases; the smoke, which contains ash, may lead to breathing difficulties when inhaled and can cause skin irritation when it comes into contact with the skin".

The second critical thinking indicator, building basic skills, included a question about activities that can lead to river pollution. The data show that 30% of students in the PB-STAD class achieved high scores, compared with 26% in the lecture class. This finding suggests that a greater proportion of students in the PB-STAD class demonstrated high-level critical thinking skills for this indicator than those in the lecture class. An example of a high-scoring student response from the PB-STAD class regarding activities that may cause river pollution is as follows "(1) Disposing of waste and sewage: carelessly throwing waste into rivers can lead to accumulation of garbage, potentially causing floods due to blocked water flow; (2) Dumping chemicals into rivers: this can harm aquatic life, as the chemicals may be toxic to organisms living in the river; (3) Fishing using explosives: the use of bombs can kill aquatic animals due to the force of the explosion".

The third critical thinking indicator, concluding, showed that more students in the PB-STAD class demonstrated high-level critical thinking skills than those in the lecture class. Specifically, 47% of students in the PB-STAD class achieved high scores on this indicator, compared with only 22% in the control group. The question for this indicator asked students to conclude an article discussing the causes and impacts of marine waste issues. An example of a high-scoring response from the experimental class is as follows: "The causes include the continued use of plastic by many industries in their products, as well as the public's reliance on single-use plastics in daily life. The impacts include soil, water, and air pollution. For example, marine animals may ingest plastic waste, mistaking it for food, leading to their death. Additionally, harmful chemicals from plastics can seep into the soil and contaminate sources of clean water".

For the fourth critical thinking indicator, providing further clarification, the data similarly showed that more students in the PB-STAD class demonstrated higher levels of critical thinking than those in the lecture class. Specifically, 43% of students in the PB-STAD class scored in the high category for this indicator, while 38% of students in the lecture class did so. The question for this indicator involved analysing the potential consequences for deer populations if mining activities in the Kalimantan forests continue to expand. One example of a high-scoring response from a student in the PB-STAD class is as follows: "The deer population could face extinction by 2024 due to the continued expansion of mining areas and the resulting reduction of forest habitats. As their habitats become increasingly restricted, both deer and tigers lose their natural habitats and are forced to migrate to other areas. In these smaller areas, the likelihood of encounters between deer and tigers increases significantly. Since tigers prey on deer, this could lead to a sharp decline in the deer population. Moreover, with limited habitat, deer may struggle to find food, potentially leading to starvation and, ultimately, extinction".

Meanwhile, the percentage of students who achieved high scores on the fifth critical thinking indicator, managing strategies and tactics, was relatively similar between the PB-STAD and lecture classes. A total of 83% of students in the PB-STAD class and 84% in the lecture class attained high scores on this indicator. This finding reflects that students in both groups demonstrated comparable proficiency in handling strategy and tactics. However, students in the PB-STAD class received more structured training in critical thinking related to this indicator. In PB-STAD learning, students were presented with two alternative solutions to address a problem and were asked to select or design the most appropriate strategy to resolve the issue. This approach encouraged students to make thoughtful decisions by considering various perspectives. Moreover, classroom observations revealed that the PB-STAD class was more actively engaged, as students were required to express their opinions on the most suitable strategies and tactics for addressing environmental problems. This suggests that the PB-STAD model is more effective in enhancing student engagement.

Table 9. N-Gain of Pretest and Posttest

Class	N-Gain	Note
PB-STAD	0,43	Moderate
Lecture-based	0,24	Low

Students in the PB-STAD class generally demonstrated higher levels of critical thinking achievement compared to those in the lecture class. This suggests that implementing the Problem-Based STAD learning model contributes more to enhancing students' critical thinking skills than the conventional lecture-based method. This indication is supported by the post-test data, which show an average score of 64.0 in the PB-STAD class and 54.3 in the lecture class. The results of the Independent T-test further support this finding, revealing a Sig. (2-tailed) value of 0.015. Since the Sig. (2-tailed) The value 0.015 is less than 0.050; therefore, there is a statistically significant difference between the PB-STAD and lecture classes. An N-Gain test was subsequently conducted to determine the extent of the impact of the Problem-Based STAD model. The results of the N-Gain analysis for both the PB-STAD and lecture classes are presented in Table 9.

Table 10. Comparison of N-Gain Scores for Each Indicator

Indicator	N-Gain of PB-STAD Class	Category	N-Gain of Lecture Class	Category
Provide a simple explanation	0,44	Moderate	0,15	Low
Developing Basic Skills	0,23	Low	0,20	Low
Drawing a Conclusion	0,31	Moderate	0,02	Low
Provide further clarification	0,49	Moderate	0,34	Moderate
Managing Strategies and Tactics	0,74	High	0,63	Moderate

Based on the table above, the overall N-Gain score for the PB-STAD class was 0.43, indicating a moderate level of improvement. In contrast, the lecture class had an N-

Gain score of 0.24, indicating a low level of improvement. It was also observed that the N-Gain for each indicator in the PB-STAD class was consistently higher than that of the lecture class. The N-Gain score of 0.43 in the PB-STAD class indicates that the Problem-Based STAD learning model effectively improved students' critical thinking skills at a moderate level, in contrast to the conventional lecture-based approach, which achieved a lower N-Gain score of 0.24, indicating a low level of improvement. Furthermore, the research data revealed that students' critical thinking skills in the PB-STAD class improved to a moderate category across four essential indicators of thinking: providing simple explanations, concluding, offering further clarification, and managing strategies and tactics. The percentage data on students' critical thinking levels in both the PB-STAD and lecture classes also showed that more students in the PB-STAD class fell into the "very high" and "high" categories than in the lecture class. These findings support the notion that students' critical thinking skills can be developed through the implementation of the Problem-Based STAD learning model. This indication is consistent with the findings of Karma et al. (2023), who demonstrated that integrating the cooperative STAD learning model with a problem-based learning approach can enhance students' critical thinking skills. Similarly, the study by Sulistyani and Pratama (2024) reported an increase in students' critical thinking abilities following the application of problem-based STAD instruction. These outcomes can be attributed to the numerous benefits offered by both the STAD cooperative learning approach and problem-based learning.

The STAD learning model, which emphasises collaborative group work, provides ample opportunities for students to interact, share ideas, and exchange feedback. Through this type of learning, students can evaluate their ideas, make informed decisions, and draw thoughtful conclusions. Moreover, it also allows students to communicate their learning outcomes within the classroom (Ermin & Marsaoly, 2021). The ability to organise and analyse problems effectively, as well as to think mathematically, can further contribute to the development of critical thinking skills (Anderson & Krathwohl, 2001).

Problem-based learning (PBL) also offers a range of advantages. This approach enables students to connect their existing knowledge with real-world situations, making the learning process more contextual and meaningful (Lusmianingtyas & Sriyanto, 2022). In PBL, students take a central role in the learning process, which helps them develop critical thinking and problem-solving skills (Hidayatussakinah et al., 2021). Additionally, this model equips students with the ability to solve problems, present logical arguments, identify issues from multiple perspectives, and propose appropriate solutions to the problems they encounter (Adilah & Rosyida, 2024).

Although students' critical thinking skills have improved, as shown in the table above, the overall essential levels of thinking in both the PB-STAD and lecture classes are not yet considered high. Students in the PB-STAD class still demonstrated moderate levels of critical thinking, while students in the lecture class remained in the low category (Ramdani et al., 2020). This may be attributed to students' lack of motivation to engage in critical thinking. As noted by Chusni et al. (2020) Students are often not motivated to learn or practice critical thinking because they perceive the learning process as ineffective. Moreover, the development of critical thinking skills requires consistent and sufficient practice over time (Ermin & Marsaoly, 2021). The limited duration of this study may have hindered the full development of students' critical thinking abilities, resulting in outcomes that still fall within the moderate category. In addition, students' critical thinking abilities varied significantly, as reflected in the diverse range of post-test scores. This variation may be due to differences in intellectual development levels among students, which can be influenced by age. As Purwanto (1998) explains, individuals' capacity for mature thinking tends to increase as they grow older.

CONCLUSIONS

The results of this study indicate that implementing the Problem-Based STAD learning model on the topic of human impact on ecosystems contributed moderately to improvements in students' critical thinking skills. This is evidenced by post-test results following the application of different instructional models in the PB-STAD and lecture classes, as well as by N-Gain scores, which showed a 0.43 score in the PB-STAD class, indicating a moderate increase, and a 0.24 score in the lecture class, indicating a low increase. The Problem-Based STAD learning model may be considered a viable alternative instructional strategy for fostering students' critical thinking skills. This study was limited to two classes within a single school, and therefore the data may not fully represent the general condition of seventh-grade students' critical thinking abilities. Future studies are expected to implement Problem-Based STAD learning on a broader scale, involving multiple classes and schools, so that the resulting data can more accurately reflect students' critical thinking abilities after implementation.

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