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Enhancing problem-solving and critical thinking through contextual learning and TAI integration

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ABSTRACT

Problem solving and critical thinking are essential skills in 21st-century mathematics education. The Team Assisted Individualization (TAI) model promotes both collaborative learning and individual responsibility, while contextual teaching links mathematical concepts to real life, making learning more meaningful. However, combining these two approaches has received limited attention, particularly in enhancing students' problem-solving and critical thinking skills. This study aims to examine the enhancement of these skills through the implementation of the TAI model integrated with a contextual learning approach. A pre-experimental method with a one-group pretest-posttest design was employed. Participants were Grade XI students at a senior high school in Yogyakarta, focusing on the topic of algebraic derivatives. Data were collected using a test designed to assess problem-solving and critical thinking skills, before and after the intervention. Paired sample t-tests were used to analyze the score differences. The findings revealed a significant improvement in students' problem-solving and critical thinking skills following the intervention. This suggests that combining TAI and contextual learning is effective in fostering mathematical thinking competencies. Further research is recommended to explore the roles of group collaboration and individual learning in supporting the development of key 21st-century skills.

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ABSTRAK

Kemampuan pemecahan masalah dan berpikir kritis merupakan keterampilan esensial dalam pembelajaran matematika abad ke 21. Model Team Assisted Individualization (TAI) diketahui dapat mendorong kolaborasi dalam kelompok sekaligus mendukung pembelajaran individu, sedangkan pendekatan kontekstual mengaitkan materi dengan situasi nyata untuk meningkatkan relevansi dan makna pembelajaran. Namun, integrasi keduanya masih jarang dikaji secara mendalam, khususnya dalam konteks pengembangan kemampuan pemecahan masalah dan berpikir kritis. Penelitian ini bertujuan untuk mengetahui peningkatan kedua kemampuan tersebut melalui penerapan model TAI yang terintegrasi dengan pendekatan pembelajaran kontekstual. Metode yang digunakan adalah pra eksperimen dengan desain satu kelompok pretest posttest. Subjek penelitian adalah siswa kelas XI di salah satu SMA di Yogyakarta dengan topik turunan fungsi aljabar. Instrumen yang digunakan berupa tes pemecahan masalah dan berpikir kritis yang diberikan sebelum dan sesudah perlakuan. Analisis data dilakukan dengan uji t berpasangan untuk mengetahui signifikansi perbedaan skor pretest dan posttest. Hasil menunjukkan peningkatan yang signifikan dalam kemampuan pemecahan masalah dan berpikir kritis siswa. Penelitian lanjutan disarankan untuk mengevaluasi kontribusi kerja sama kelompok dan peran individu dalam mendukung pencapaian keterampilan abad ke 21 secara lebih mendalam.

Kata Kunci: *kemampuan berpikir kritis; kemampuan pemecahan masalah; model pembelajaran kooperatif; pendekatan pembelajaran kontekstual; team-assisted individualization*

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INTRODUCTION

Education in the twenty-first century has undergone significant transformations due to the impact of the Fourth Industrial Revolution. This shift has contributed to the rise of Society 5.0, a concept that emphasizes improving overall human well-being. Enhancing the quality of life in Society 5.0 requires equipping students with skills to collaborate effectively in various settings and solve complex problems, as stated by Jazbec in a research titled, *"Steam Education in the Case of Engineering (Empowerment Informatics: Tsukuba University, Japan) and the Art Studies (Interface Cultures: University of Arts and Design Linz, Austria)"*. Furthermore, in this new era, critical thinking, cooperation, creativity, and higher-order thinking skills are essential, especially in the context of mathematics education (Mega, 2022). Problem-solving and critical thinking play a central role in mathematics education and are consistently regarded as fundamental to students' learning development. Problem-solving encompasses a series of cognitive strategies and mental operations, including the construction and manipulation of representations, data analysis, identification of underlying causes, planning, and formulating appropriate solutions, making it a key pathway toward meaningful and effective learning (Lu & Xie, 2024).

In the context of mathematics, this capacity refers to a person's ability to solve a variety of complex mathematical problems (Sinaga et al., 2023). On the other hand, critical thinking refers to the essential ability to analyze information, assess evidence, and scrutinize arguments in order to judge their credibility and relevance (Karimi-Ghartemani et al., 2020; Song et al., 2024). Critical thinking involves interpretation, analysis, evaluation, inference, explanation, and self-regulation, as well as personal dispositions such as inquisitiveness, self-confidence, open-mindedness, and prudence, all of which contribute to intellectual progress (Dong et al., 2023; Khaira et al., 2023). Furthermore, studies have demonstrated a positive correlation between problem-solving ability and critical thinking ability (Song et al., 2022; Tasgin & Dilek, 2023). This close relationship suggests that understanding and fostering both skills in the context of learning is essential.

A survey conducted by the Program for International Student Assessment (PISA) in 2022 found that Indonesian pupils' math scores have declined since the previous PISA test in 2015, when the PISA math score was 386. In 2018, it fell to 379, and in 2022, it further declined to 366. This puts Indonesia's score below the OECD country average of 472. According to these findings, the highest level obtained by Indonesian students in mathematics is level 1a. Students at this level can only answer mathematical questions in simple contexts where questions and information are clearly defined with simple problem-solving formulas or algorithms. They are unable to solve complex mathematical problems at the level of problem-solving and critical thinking, as stated in PISA 2022 Results (Volume I) by the Organisation for Economic Co-operation and Development (OECD). These findings highlight the importance of instructors in Indonesia providing targeted interventions to enhance students' problem-solving and critical thinking skills in mathematics.

In response to the twenty-first-century necessities of collaboration and cooperation, as well as the emphasis on individual abilities, cooperative learning should be implemented to facilitate collaboration while also focusing on individual traits. Cooperative learning, particularly with the Team Assisted Individualization (TAI) approach, is well-suited to meeting this demand. TAI is a cooperative learning model that blends cooperative and individualized learning, as stated by Slavin in a book titled *"Team-Assisted Individualization"*. Slavin pioneered this type of TAI in the field of mathematical education. According to research, using TAI can help students improve their problem-solving skills in mathematics (Taguinod & Ching, 2023; Tinungki et al., 2022; Tinungki et al., 2024). Other studies on the use of TAI have found that this type of cooperative learning is beneficial in enhancing students' critical-thinking skills in mathematics (Andari et al., 2023; Marasabessy et al., 2021).

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In addition to TAI from the cooperative learning model, research shows that studying through a contextual approach enhances students' problem-solving and critical thinking skills in mathematics (Amalia et al., 2024; Rohimatunisa & Sudianto, 2022; Winarso & Haqq, 2020). This improvement is supported by the characteristics of both skills, which align closely with the principles of contextual learning. Specifically, contextual learning emphasizes organizing information within real-world contexts, thereby making learning more meaningful and relevant. This contextual approach, when combined with problem-solving strategies, has been shown to significantly enhance students' ability to solve problems and foster their critical thinking in mathematics (Azizah & Winarti, 2020).

Previous research has demonstrated that combining the TAI-type cooperative learning model with a contextual approach holds promise for enhancing students' mathematical problem-solving and critical thinking skills. Studies have shown that such integration promotes collaboration and enables students to relate mathematical concepts to real-world situations, thereby improving their problem-solving abilities (Cahyanti et al., 2024). Additionally, this combination is effective in improving mathematics learning outcomes across different levels of student attitudes toward the subject (Letunggamu et al., 2024; Ratnasari et al., 2020). However, most existing studies have focused on either cooperative or contextual learning independently, with limited attention given to the specific integration of the TAI model and contextual approach, particularly concerning both problem-solving and critical thinking skills in mathematics. While some studies have integrated TAI and contextual approaches, reporting improvements in learning outcomes and problem-solving abilities, none have explicitly examined their combined effect on students' critical thinking skills. Therefore, this study aims to apply a TAI model integrated with a contextual approach to examine its effectiveness in improving students' mathematical problem-solving and critical thinking abilities. Furthermore, this research aims to evaluate the consistency of the integrated model in fostering these essential skills within the context of mathematics learning.

LITERATURE REVIEW

Team-Assisted Individualization represents one form of cooperative learning that enables students to engage in group-based learning while simultaneously providing opportunities for each individual to internalize their understanding, as stated by Slavin (1985) in a book titled "Team-Assisted Individualization". This dual mechanism allows students to benefit from diverse perspectives during the learning process. Meanwhile, the Contextual Learning Approach emphasizes the presentation of material through real-world and personally relevant contexts, as stated by Johnson (2002) in a research titled "Contextual teaching and learning: what it is and why it is here to stay", which can facilitate students' comprehension and foster the improvement of mathematical critical thinking and problem-solving ability. When integrated, these two approaches offer complementary strengths. TAI promotes collaborative and individualized learning processes, whereas contextual learning enhances content delivery through meaningful and applicable contexts.

Team-Assisted Individualization in Terms of Problem-Solving Ability and Critical Thinking

Based on previous research, the use of the cooperative learning model TAI is effective in fostering students' mathematical critical thinking abilities (Tinungki et al., 2022). In a follow-up study, this improvement is attributed to the integration of group learning with individual learning, which enriches students' problem-solving abilities (Tinungki et al., 2024). Likewise, TAI encourages students to be more active and responsive in group discussions through peer questioning, while still being guided by the teacher and remaining accountable for their group's performance (Putri & Fitria, 2022). These studies

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suggest that TAI can be a beneficial instructional strategy for enhancing students' problem-solving skills. In addition, research found that the experimental group's ability to solve mathematical problems was significantly enhanced by the TAI strategy of learning, in contrast to the control group (Najoan et al., 2024). The model promotes active student engagement in group settings, maintains the teacher's role as a facilitator, and emphasizes the internalization of individual learning. Furthermore, the TAI cooperative model also contributes to improving students' critical thinking in mathematics (Marasabessy et al., 2021). Instructional designs based on the TAI model are also effective in enhancing critical thinking because they support deeper levels of analytical reasoning (Suprayitno et al., 2023).

This collection of studies suggests that TAI is effective not only in supporting general learning outcomes but also in developing essential twenty-first-century skills, particularly critical thinking and problem-solving abilities. The strength of this model lies in its combination of collaborative learning and individual responsibility, which enables students to construct their understanding through social interaction and personal reflection actively. Within the context of mathematics education that demands high levels of cognitive involvement and complex reasoning, TAI is regarded as a suitable and beneficial approach. Moreover, integrating TAI with a contextual learning approach is likely to improve learning effectiveness by enabling students to connect abstract mathematical concepts to real-life situations. Therefore, the use of TAI in mathematics learning should be considered a comprehensive and adaptive instructional approach that addresses students' educational needs in the current era.

Contextual Learning Approach in Terms of Problem-Solving Ability and Critical Thinking

The contextual learning approach emphasizes presenting material within real-world contexts, allowing students to feel more connected to the subject matter and thereby enhancing their understanding of it. A study suggests that this approach holds significant potential for improving learning outcomes (Adilah et al., 2024; Sudirman et al., 2024). This suggests that contextual learning can positively contribute to students' academic achievement. Moreover, much research has demonstrated that the contextual learning strategy can augment students' critical thinking abilities (Ali & Julaihah, 2023; Nurzulianti et al., 2024). These findings suggest that context-based learning can be an effective strategy for developing students' critical thinking skills during the learning process.

Another notable cognitive advantage of contextual learning lies in its ability to strengthen students' problem-solving capabilities. Research has demonstrated that incorporating contextual approaches into mathematics instruction can lead to substantial improvements in students' problem-solving performance (Hayati et al., 2022). Consistently, contextual learning has also been found to support students' conceptual comprehension and promote the use of problem-solving techniques in practical, everyday scenarios (Hariyati & Purwanto, 2023). These results highlight the effectiveness of context-based learning environments in enhancing students' mathematical problem-solving skills by situating abstract concepts within familiar and relevant real-life situations.

Recent findings from various studies indicate that contextual learning effectively supports the development of students' problem-solving and critical thinking skills. One of the key factors contributing to the success of this approach is the presentation of subject matter within meaningful, real-life contexts. By engaging students in learning activities that are relevant to their everyday experiences, contextual learning supports a more profound understanding of mathematical concepts, facilitates structured problem-solving processes, and develops the capacity to interpret and critically judge information as essential components of critical thinking.

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The Potential of Contextual Learning Approach Integrated Team-Assisted Individualization

The integration of the TAI model and the contextual learning approach represents an appropriate instructional strategy to optimize student achievement in mathematics learning. Combining the TAI cooperative learning model with a contextual learning method has been shown to improve student learning outcomes (Letunggamu et al., 2024; Ratnasari et al., 2020). Both TAI and the contextual learning approach have been reported and recognized as effective cooperative learning models for enhancing students' problem-solving and critical thinking skills. While each approach has demonstrated its potential, their integration is expected to yield more optimal learning outcomes. TAI primarily contributes to the structuring of the learning process, whereas the contextual learning approach enhances the relevance and presentation of the subject matter. Several studies have emphasized that combining these two approaches can foster collaborative learning environments and help students enhance their problem-solving capabilities (Cahyanti et al., 2024). This potential may also extend to other areas of mathematical competence. These findings support the idea that integrating the TAI model with the contextual learning approach is effective in fostering mathematical learning outcomes and are expected to enhance further students' problem-solving and critical thinking abilities in mathematics learning.

These findings suggest that integrating the TAI model with the contextual learning approach harnesses its potential from the collaborative and interactive nature of the learning environment, which reinforces students' analytical thinking and structured problem-solving processes (Najoan et al., 2024). In addition to its impact on problem-solving, this integration also provides an opportunity to enhance students' critical thinking abilities, as analytical reasoning is a core element of critical thinking, as stated by Facione in a book titled *"Think Critically".* Therefore, the synergy between TAI and contextual learning holds strong potential for enhancing students' mathematical problem-solving and critical thinking abilities.

METHODS

This research uses an experimental method with a pre-experimental design. The pre-experimental design aims to study a specific group and apply a predetermined intervention during the experiment, eliminating the need for a control class to compare with the experimental class. The treatment was only carried out in one class designated as the experimental class using pre-test and post-test scores to get the impact of the treatment. Therefore, the pre-experiment design employed in this study is a one-group pretest-posttest design. The pretest data were collected prior to the treatment, while the posttest data were collected after the treatment. As a result, the outcomes of the treatment can be known with certainty because they can be compared to the pre-treatment scenario. The flowchart for this research is presented in **Figure 1**.

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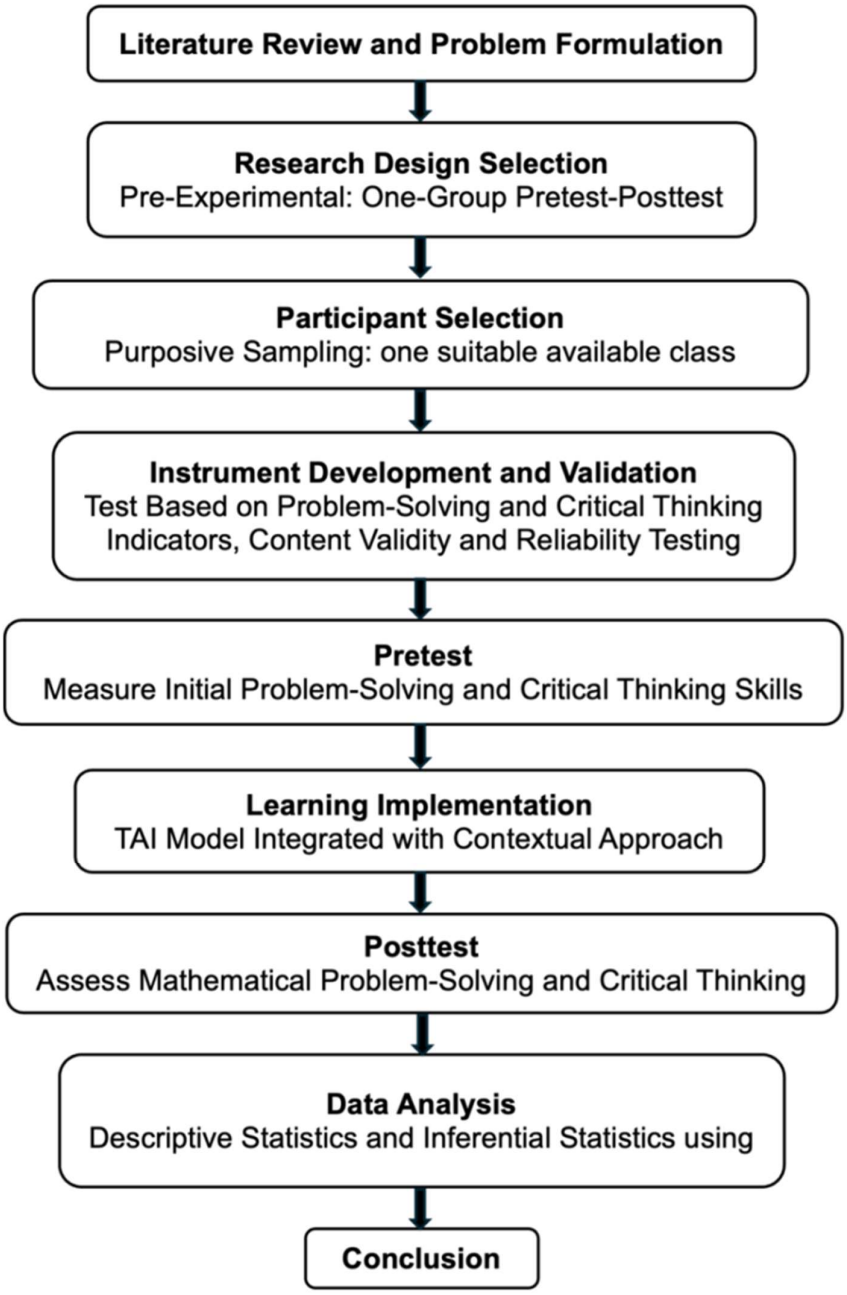

Figure 1. Research Flow Chart
Source: Research conducted by the author, 2024

This study was carried out at a high school in Yogyakarta. As shown in **Figure 1**, this study employed purposive sampling, where students were selected based on the relevance of the material to their studies. The experimental group received learning with a TAI-type cooperative model integrated with a contextual learning approach for five meetings. The first session was dedicated to conducting pre-tests and diagnostic tests to assess students' initial abilities and to form heterogeneous groups in preparation for the implementation of the learning. The second, third, and fourth sessions were learning activities that implemented TAI in a contextual approach. Finally, the fifth session included the implementation of the post-test to assess the ability. The steps of cooperative learning-type TAI used in this study are:

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1. **Step 1**: Placement Test: Giving a pretest of diagnostic material of algebraic function derivative material. Additionally, the previous value is used for comparison.
2. **Step 2**: Teams: Students are divided into heterogeneous groups based on their ability as determined by the diagnostic test and previous grades.
3. **Step 3**: Curriculum Materials: Before students join groups, they are taught the materials individually, and then, through exercises, they try to understand the materials. The materials are organized using a contextual approach, where the materials and questions are related to real-world contexts.
4. **Step 4**: Team Study Method - Students join in groups and work on the provided questions.
5. **Step 5**: Team Score and Team Recognition: Group representatives present their group work to the class, offer praise for each student's correct answers, and provide feedback on student work that needs improvement.
6. **Step 6**: Group-Paced Unit: The teacher conducts a debriefing at the end of the lesson to ensure the whole class understands the material.
7. **Step 7**: Fact Test: After all the materials are completed, the teacher conducts a post-test to assess individual success.

This study collected data through a descriptive test consisting of three items to measure students' problem-solving and critical thinking skills, which included indicators related to the material of algebraic function derivatives, particularly the concept of algebraic functions and their derivatives. This test was designed to assess students' mathematical problem-solving and critical thinking abilities. The four main steps in problem-solving include understanding the problem, devising a plan, carrying out the plan, and looking back, as stated by Polya in a book titled *'How to Solve It: A New Aspect of Mathematical Method'.* This method facilitates the formation of a systematic approach to thinking and problem-solving in pupils, which is crucial for their mathematical advancement (Gulam & Arenas, 2024). Reasonable interpretation, explanation, analysis, assessment, inference, and self-regulation are essential components of critical thinking, as stated by Facione in a book titled *"Critical Thinking : What it is and Why it Counts"*. This study focuses on measuring critical thinking skills in the areas of interpretation, analysis, evaluation, and inference.

The test instruments used will be evaluated for validity and reliability prior to their use. The validity of the test instrument's content is analyzed using Aiken's formula (Aiken, 1985). The test instrument is considered valid when the Aiken coefficient is equal to or greater than 0.6. The results of the calculation of Aiken's coefficient on the test instrument were ≥ 0.6, indicating that the content of the test instrument used was deemed valid. The reliability of the test and questionnaire in this instrument is assessed using Cronbach's Alpha formula. The alpha coefficient calculated for the test employed was 0.6, indicating that the test was reliable (Rasmuin et al., 2021). Therefore, the instrument is deemed valid and reliable and is suitable for use in the study.

Data analysis in the study began with descriptive analysis and progressed to statistical analysis. The research data is described in terms of average, standard deviation, theoretical maximum score, and theoretical minimum score. For the inferential statistical analysis, assumption tests were first conducted to ensure the normality of the data. Subsequently, a paired sample t-test was used for each skill, namely mathematical problem-solving and critical thinking.

RESULTS AND DISCUSSION

Exploration of Students' Abilities in Mathematical Problem-Solving

A descriptive examination of students' problem-solving skills was conducted by comparing pre-test and post-test data, which were analyzed using specific indicators. **Table 1** below presents the results of the descriptive analysis of students' problem-solving abilities.

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Table 1. Descriptive Analysis of Students' Problem-Solving Ability

Variations	Pre-test	Post-t est
Average Score	15.38	75.78
Standard Deviation	7.25	23.19
Maximum Score	30.77	100
Minimum Score	5.13	30.77

Source: Research conducted by the author, 2024

Table 1 shows that students' problem-solving skills on the topic of the derivative of algebraic functions improve after learning with the TAI-type cooperative learning model combined with a contextual approach. This improvement is reflected in the increase in students' average problem-solving test scores. Descriptively, an improvement in students' problem-solving ability is observable. Furthermore, the standard deviation data demonstrate that students' scores are nearly identical or not very diverse before treatment, but become more diverse following treatment. This standard deviation demonstrates that students' problem-solving abilities are nearly uniform before treatment and become more diverse after treatment, indicating a change in students' problem-solving abilities. This change is evident in the difference between the average pre-test and post-test scores. For further clarification, **Table 2** presents the results of the statistical analysis conducted using a paired t-test.

The following stage is to use hypothesis testing to discover significant differences in student learning outcomes (paired sample t-test). The following hypotheses were employed in this study:

H_0: Students' problem-solving performance does not differ significantly before and after the test.

H_1: Students' problem-solving performance shows a significant difference between the pre-test and post-test phases.

Table 2. Paired t-Test Analysis of Problem-Solving Ability

Mean	Std. Deviations	Std. Error Mean	t	df	Sig. (2 Tailed)
60.399	18.874	3.632	16.628	26	<0,001

Source: Research conducted by the author, 2024

Table 2 shows that the p-value for students' mathematical problem-solving ability is less than 0.001, which is below the significance level of 0.05. Since there is a substantial difference between the pre-test and post-test scores, the null hypothesis (H_0) is rejected. These results suggest that teaching students about algebraic function derivatives using the TAI cooperative model in conjunction with a contextual learning approach effectively enhances their problem-solving skills. These results align with previous studies, which indicate that integrating TAI and the contextual approach can enhance students' problem-solving abilities (Cahyanti et al., 2024). In addition, the findings also support reports that combining these two instructional models can improve students' achievement in mathematics (Letunggamu et al., 2024; Ratnasari et al., 2020). This consistency is evident in the context of derivative material for algebraic functions.

These results demonstrate the consistent effectiveness of the TAI learning model in terms of students' problem-solving ability, as well as the effectiveness of the contextual approach in enhancing students' mathematical problem-solving skills (Hayati et al., 2022; Najoan et al., 2024; Putri & Fitria, 2022; Tinungki et al., 2024). The combination of both approaches offers structured peer collaboration, teacher guidance, and contextualized tasks, which collectively contribute to a deeper understanding and more effective solution strategies. This suggests that integrating TAI with a contextual learning approach not only

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supports the development of procedural knowledge but also promotes meaningful engagement with mathematical concepts.

Exploration of Students' Abilities in Mathematical Critical Thinking

The development of students' mathematical critical thinking skills throughout the learning process was examined through a descriptive analysis based on their test performance. By comparing pre-test and post-test data evaluated using mathematical critical thinking skills markers, as indicated in Table 3 below, a descriptive study of students' mathematical critical thinking abilities was conducted.

Table 3. Descriptive Analysis of Students' Critical Thinking Skills

Variations	Pre-test	Post-t est
Average Score	14.58	75.77
Standard Deviation	8.09	23,25
Maximum Score	31.25	100
Minimum Score	4.17	31.25

Source: Research conducted by the author, 2024

Table 3 shows that students' mathematical critical thinking skills on the derivative of algebraic functions improve after being taught using the TAI-type cooperative learning model combined with a contextual approach. Furthermore, the standard deviation data demonstrate that students' scores were almost identical or not diverse before treatment and became more diverse post-treatment. This implies an improvement in students' critical thinking skills, as evidenced by the increase in average scores on both the pretest and posttest results. The improvement is also reflected in the rise of both minimum and maximum scores, indicating that students generally achieved higher levels of performance. This suggests that not only did the overall ability improve, but more students reached higher levels of critical thinking performance than before.

Additionally, a paired sample t-test will be performed to determine whether the pre-test and post-test scores differ significantly, evaluating whether there is a significant difference in the learning outcomes of students in critical thinking skills. The findings of the statistical analysis, which was performed using a paired t-test, are shown in **Table 4**. In this study, the following theories were used.

H_0: There is no meaningful difference between students' critical thinking scores on the pretest and posttest.
H_1: Students' critical thinking scores differ significantly between the pretest and posttest phases.

Table 4. Paired Samples t-Test Results for Critical Thinking Skills

Mean	Std. Deviations	Std. Error Mean	t	df	Sig. (2 Tailed)
61.189	18.044	3.472	17.621	26	<0,001

Source: Research conducted by the author, 2024

According to Table 4, the students' mathematical critical thinking skills have a p-value of less than 0.001, which is significantly below the 0.05 significance level. Since there is a substantial difference between the pre-test and post-test scores, the null hypothesis (H_0) is rejected. These findings suggest that students' critical thinking abilities in the subject of algebraic function derivatives can be enhanced by integrating the TAI cooperative learning model with a contextual learning approach.

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The inclusion of critical thinking as part of the learning outcomes aligns this study with previous research, which has shown that integrating the TAI model with a contextual approach can enhance students' mathematics learning achievement (Letunggamu et al., 2024; Ratnasari et al., 2020). Moreover, these findings also support earlier studies reporting that each of these learning models, when implemented independently, has the potential to improve students' critical thinking skills (Ali & Julaihah, 2023; Marasabessy et al., 2021; Nurzulianti et al., 2024; Tinungki et al., 2022). This result strengthens the evidence that the combined approach can effectively foster students' critical thinking in learning the derivatives of algebraic functions.

Discussion

This study shows that combining the TAI cooperative learning model with a contextual learning approach can effectively enhance students' problem-solving and critical thinking skills. These findings are consistent with research that has found the integration of TAI-type cooperative learning with a contextual approach to lead to improved student learning outcomes, particularly about problem-solving and critical thinking abilities (Letunggamu et al., 2024; Ratnasari et al., 2020). However, their study primarily focused on students' overall academic performance as reflected by general achievement scores, without addressing specific mathematical competencies. In contrast, the present study offers a new contribution by explicitly focusing on the development of students' problem-solving and critical thinking skills as distinct and measurable outcomes in the context of mathematics learning. This result is supported by previous findings indicating that students' active engagement in TAI-based learning, combined with the use of real-world problems, significantly contributes to improved learning outcomes (Ratnasari et al., 2020). The current study similarly observed that students became more actively involved in group activities when given opportunities to internalize the material independently, which in turn increased their confidence when participating in collaborative work. Furthermore, presenting the content within real-life contexts helped students better grasp the concept of algebraic function derivatives, making it more concrete and accessible rather than abstract and challenging to understand.

Additionally, previous studies have highlighted the importance of integrating TAI with contextual learning in enhancing students' problem-solving abilities (Cahyanti et al., 2024). These studies emphasize the importance of integrating structured collaboration with authentic, real-world learning contexts to foster mathematical understanding. The findings of the present study further confirm and strengthen the consistency of this approach with earlier research, highlighting its effectiveness in fostering essential cognitive skills in mathematics education. Through group learning, students not only receive support from their peers but also have the opportunity to actively construct their understanding. This combination of peer-assisted learning and independent processing helps train students to become more proficient problem solvers. Moreover, presenting the material in ways that are relevant to students' daily lives makes it easier for them to comprehend the problems, thus optimizing the overall problem-solving process.

Cooperative learning, which emphasizes teamwork, allows students who struggle with mathematics to learn from their classmates who have mastered the subject. Students, particularly in the TAI type, are allowed to grasp the content individually, which will ultimately assist everyone in internalizing the concepts learned. This is consistent with the initial development of the TAI cooperative concept. This type of TAI tries to combine cooperative incentives with individualized learning customized to students' mathematical aptitude and speed, as well as to create the social impacts of cooperative learning while satisfying students' various learning requirements, as stated by Slavin in a book titled *"Team-Assisted Individualization"*. In addition, the TAI model fosters active engagement and responsiveness during group

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interactions by encouraging peer questioning under teacher supervision, while also maintaining individual and group accountability (Putri & Fitria, 2022). These theoretical characteristics help explain the improvements in problem-solving and critical thinking skills observed in this study.

Aside from the benefits offered by TAI, contextual learning plays a significant role in deepening students' understanding, enhancing their problem-solving abilities, and fostering the development of individual mathematical critical thinking skills. This aligns with findings from previous studies that highlight the positive impact of contextual learning on mathematical competence (Amalia et al., 2024; Rohimatunisa & Sudianto, 2022; Winarso & Haqq, 2020). By allowing students to connect abstract mathematical concepts with real-life contexts, contextual learning makes the learning process more meaningful and easier to internalize. When integrated with cooperative learning structures such as TAI, this approach not only promotes group collaboration but also strengthens individual accountability and engagement in the learning process. Given these advantages, further research is recommended to explore more deeply how collaborative learning strategies contribute to improvements in individual student performance.

Overall, this study highlights the connection between collaborative learning and the presentation of content within real-world contexts. Further research is needed to explore the effects of integrating the TAI model and the contextual approach on other mathematical competencies, as well as how each method might be combined with alternative forms of collaborative instruction. It is also important to examine how both group interaction and individual engagement contribute to achieving current educational objectives. These directions may provide deeper insights into how integrated learning models can be adapted to foster broader mathematical and cognitive development. Ultimately, such efforts are crucial in supporting the development of 21st-century skills, including critical thinking, collaboration, communication, and problem-solving.

CONCLUSION

Based on the statistical findings, the implementation of TAI-type cooperative learning, integrated with a contextual approach, directly improved students' mathematical problem-solving and critical thinking skills, particularly in the topic of algebraic function derivatives. TAI, rooted in collaborative learning, is effectively integrated with contextual approaches to nurture skills in addressing mathematical challenges and making logical evaluations, which hold significant relevance in contemporary 21st-century education. Further investigation is recommended to assess the impact of both group collaboration and individual contributions on supporting modern educational goals.

AUTHOR'S NOTE

The author affirms that there is no conflict of interest regarding the publication of this article. Additionally, the author ensures that all data and content presented are original and have not been subjected to plagiarism.

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