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CTL-Deep Learning: Its Influence on Critical Thinking Skills and Self-Confidence in Linear Equation System Material

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Abstract. Many senior high school students have difficulty in understanding Linear Equation Systems (LES). The Contextual Teaching and Learning-Deep Learning (CTL-DL) approach is one of the current solutions. This study aims to describe the effect of the CTL-DL approach on students' critical thinking skills and self-confidence in the material of Linear Equation Systems. This quasi-experimental study with a pretest-posttest control group design used a population of class X students of SMA Negeri 2 Yogyakarta in the 2024/2025 academic year. Sampling was carried out by purposive sampling. Data were collected using observation sheets, critical thinking ability tests, and self-confidence questionnaires, then analyzed using the Multivariate Hotelling's T^2 statistical test and the independent t-test at a significance level of 0.05. The results of the study showed: 1) there was an influence of the CTL-DL approach on students' critical thinking skills and self-confidence, 2) the CTL-DL approach was significantly superior to the expository approach in improving critical thinking skills, and 3) the CTL-DL approach was significantly superior to the expository approach in improving students' self-confidence.

Keywords: CTL-Deep Learning; Critical Thinking; Self-Confidence; Linear Equation System; Learning Approach.

INTRODUCTION

Mathematics is an essential foundation for the development of science and technology, and plays a crucial role in training logical, systematic, and critical thinking skills (N.c.t.m, 2010). In an era that demands adaptability and complex problem solving, critical thinking skills (CTS) are one of the 21st century competencies that students must absolutely master (Sulistiani & Waluya, 2018; Zetriuslita et al., 2018). CTS allows students to objectively analyze information, evaluate arguments, identify assumptions, and draw logical conclusions, all of which are vital not only in academic contexts but also in everyday life (Facione, 2015). Along with cognitive aspects, affective factors such as self-confidence also play an important role in the mathematics learning process (Pečiuliauskienė, 2023). Students with high self-confidence tend to be more persistent in the face of difficulties, more actively involved in learning, and ultimately achieve better learning outcomes (Wulandari & Alyani, 2022).

Learning Linear Equation Systems (LES) is often considered abstract and less meaningful by students. Conventional learning methods are sometimes not optimal in developing critical thinking skills and fostering students' self-confidence (Sarifah et al., 2024). Low critical

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thinking skills hinder students from analyzing problems, evaluating arguments, and drawing logical conclusions. Meanwhile, low self-confidence can cause math anxiety and reluctance to be actively involved in learning (Nugroho et al., 2023). Students' initial critical thinking abilities and their levels of self-confidence before intervention also vary, and these initial differences can affect the final learning outcomes (Hankeln, 2021).

Initial studies show a reality in the field that shows that mathematics learning, especially in fundamental topics such as Linear Equation Systems at the Senior High School (Nurmawanti et al.) level, still faces various challenges. LES is an important material that is the basis for many advanced mathematical concepts and their applications in various fields such as science, engineering, and economics (Herawaty et al., 2021; Trigueros et al., 2009; Widada et al., 2020). However, students often have difficulty in understanding the abstract concept of variables, manipulating equations procedurally, and linking LES to real-world problem contexts (Dwi et al., 2013; Nurmawanti et al., 2021). Traditional teaching methods that tend to be teacher-centered and emphasize memorizing formulas often fail to facilitate the development of CTS optimally. Furthermore, the difficulties experienced by students in understanding the material can have a negative impact on their confidence in their mathematical abilities, creating a negative cycle that hinders learning progress (Widada et al., 2020). The failure to develop CTS and confidence simultaneously in fundamental material such as LES indicates an urgent need for innovative learning approaches.

Responding to these challenges, various learning approaches have been developed and researched. The Contextual Teaching and Learning (CTL-DL) approach has emerged as one of the promising strategies (Bisong, 2019; Boob & Radke, 2024; Calista et al., 2022; Khotimah & Masduki, 2016; Sufianto, 2019). CTL emphasizes the relationship between subject matter and students' real-life contexts, encouraging meaningful learning through its seven main components: constructivism, questioning, inquiry, learning community, modeling, reflection, and authentic assessment (Hobri et al., 2018; Selvianiresa & Prabawanto, 2017; Yudha, 2019). Previous studies have shown that the implementation of CTL in mathematics learning can improve students' conceptual understanding, problem-solving skills, and learning motivation (Nuha et al., 2018). CTL principles, such as inquiry and questioning, inherently have the potential to stimulate CTS (Syamsuddin & Istiyono, 2018).

On the other hand, the concept of deep learning in a pedagogical context emphasizes achieving deep understanding, not just surface learning (Boob & Radke, 2024). Deep learning involves students' ability to connect ideas, see patterns, apply knowledge in new situations, and reflect critically on their own learning processes – aspects that are highly relevant to the development of CTS (Syam et al., 2020). Strategies that encourage deep learning aim for students to know not only the 'what' but also the 'why' and 'how', building a solid and flexible understanding (Hawkes, 2023). Research indicates that approaches that encourage deep understanding are positively correlated with higher-order thinking skills (Nugraheni & Sukestiyarno, 2022).

Although CTL has been shown to be effective in linking learning to context and enhancing understanding, and deep learning strategies are effective in promoting deep understanding and higher-order thinking (Priliawati et al., 2019), the explicit integration of the two as a “CTL-Deep Learning” learning approach to simultaneously enhance CTS and self-confidence in specific topics such as LES is still rarely explored (Apriyanti et al., 2019). Existing studies tend to focus on one approach (CTL or deep learning strategies) or measure different dependent variables (Khotimah & Masduki, 2016). There is a gap in the literature on how the synergy between meaningful contextual learning (through CTL) with an emphasis on depth of understanding and critical reflection (through deep learning principles) can be specifically designed and implemented to address LES learning difficulties while simultaneously fostering CTS and self-confidence in high school students.

Therefore, this study proposes and investigates the "CTL-Deep Learning" learning approach specifically designed for LES material at the high school level (Khoirudin et al., 2020; Kumari et al., 2023; Putra et al., 2024; Rad & Davis, 2024). The uniqueness (*novelty*) of this study lies in: (1) Development and implementation of an integrated learning approach that synergizes the core principles of CTL with strategies that explicitly encourage deep learning in the context of LES learning. (2) Empirical investigation of the influence of this CTL-Deep Learning model simultaneously on two crucial variables: students' critical thinking skills (cognitive aspect) and self-confidence (affective aspect). (3) Focus on fundamental but often considered difficult LES topics, at the high school level. This study aims to provide empirical evidence regarding the effectiveness of the CTL-Deep Learning model as an alternative solution to improve the quality of mathematics learning, especially in preparing students with the critical thinking skills and self-confidence needed in the 21st century. This study examines the effect of implementing a learning approach that integrates Contextual Teaching and Learning (CTL-DL) with Deep Learning strategies on students' critical thinking skills and self-confidence in the Linear Equation System (LES) material. This theoretical framework is based on relevant learning theories that explain how context, deep understanding, critical thinking, and self-confidence are interrelated in mathematics learning.

The basis of CTL is the constructivist view, which states that students actively construct their own knowledge through interactions with their environment and experiences (Sari & Putri, 2023). CTL emphasizes meaningful learning by linking academic material to students' real-life contexts (Gravemeijer, 2008; Purwanti & Waluya, 2019). This approach involves seven main components: constructivism, questioning, inquiry, learning community, modeling, reflection, and authentic assessment. In the context of LES, CTL is expected to help students understand the relevance and application of mathematical concepts in real situations, thus encouraging understanding that is more than just procedural (Istiqomah & Mariani, 2020). This connection to the real world is assumed to motivate students and make learning more meaningful.

Deep Learning in a pedagogical context (different from deep learning in AI) refers to a learning approach in which students aim to deeply understand the meaning of the material, relate it to existing knowledge, and apply it in context (Rad & Davis, 2024). This is in contrast to surface learning which only focuses on memorizing facts without deep understanding. Deep Learning strategies involve high-level cognitive processes such as analyzing, synthesizing, and evaluating information. The application of this strategy in LES learning is expected to encourage students to not only memorize formulas or solution steps, but also understand basic concepts, relationships between variables, and the logic behind the solution method (Nurmawanti et al., 2021). The combination of CTL that provides context with encouragement for Deep Learning is expected to create a strong conceptual understanding.

Self-confidence in academic contexts is often associated with Bandura's concept of self-confidence, which is an individual's belief in their ability to succeed in a particular task (Bai, 2023; Jayasundera & Allam, 2024). Self-confidence is influenced by mastery experiences, experiences of others, social persuasion, and physiological/emotional states. The CTL-Deep Learning learning approach has the potential to increase students' self-confidence in several ways. By understanding LES material in depth (deep learning results) and being able to apply it in real contexts (facilitated by CTL), students tend to experience success, which is the strongest source of self-confidence. Understanding the relevance of LES in real life (through CTL) can reduce math anxiety and increase feelings of competence (Khoirudin et al., 2020; Selvianiresa & Prabawanto, 2017; Zulyadaini, 2017). The learning community component in CTL allows students to learn together and support each other, which can provide positive experiences and social persuasion. This means that the application of the CTL-Deep Learning approach in LES learning will create a more interesting, relevant, and adaptive learning environment compared to conventional learning approaches (in this study is expository). Students in the CTL-Deep Learning group will be involved in contextual problem-solving activities, discussions, and possibly interactions with technology-based learning systems that support deep understanding. Therefore, this study proposes an intervention of learning approaches in the form of CTL integration and Deep Learning strategies to create a conducive learning environment for abstract materials such as LES. CTL provides context and relevance, while Deep Learning encourages deep understanding and high-level cognitive engagement. This combination can theoretically improve students' critical thinking skills by confronting them with authentic problems that require analysis, evaluation, and logical reasoning to be understood and solved in depth; and increase students' self-confidence through meaningful material mastery experiences and strong conceptual understanding, as well as through a learning environment that is supportive and relevant to their lives.

Based on this rationality, this study hypothesizes that the application of the CTL-Deep Learning model will provide a significant positive influence on students' critical thinking skills and self-confidence in the Linear Equation System material compared to conventional learning methods.

METHOD

The type of research used in this study is quasi-experimental research with Pretest-Postest Control Group Design. The population in this study were all students of class X of SMA Negeri 2 Yogyakarta, academic year 2024/2025. The sample was selected using purposive sampling technique. Data collection methods used to obtain research data are test and non-test methods. Data collection instruments include observation sheets, critical thinking ability test instruments and self-confidence questionnaires. The study was conducted from August 19, 2024 to September 17, 2024.

The learning intervention in this study is the CTL-Deep Learning learning approach proposed as an innovation to overcome these problems. This approach integrates two approaches: Contextual Teaching and Learning: Connecting LES material with students' real-world contexts, encouraging meaningful learning, constructivism, and collaborative work. The CTL approach is expected to facilitate understanding of concepts and relevance of the material, which has the potential to improve critical thinking skills. Deep Learning (in a pedagogical context): Utilizing technology (e.g., adaptive platforms, learning data analysis, or AI-based simulations) to facilitate deep understanding, provide personalized feedback, and present challenges that are appropriate to students' ability levels. This "Deep Learning" aspect can help students identify complex patterns in LES, encourage in-depth analysis (critical thinking), and provide a more personalized and supportive learning experience (potentially increasing self-confidence).

Research Variables and Measurement: Independent Variable: Learning approach (Experimental Group: CTL-Deep Learning; Control Group: Conventional Approach). Dependent Variable: (1) Critical Thinking Ability; (2) Self-Confidence. Covariates: (1) Critical Thinking Ability Pre-test Score; (2) Self-Confidence Pre-test Score. The use of these covariates is important because students' initial ability and initial self-confidence can affect post-test results, regardless of the learning approach applied. Data Analysis (ANCOVA): To test the effect of the CTL-Deep Learning model more accurately, the analysis will be used. ANCOVA allows comparison of the mean post-test scores of critical thinking ability and self-confidence between the experimental and control groups, while statistically controlling (adjusting) for initial differences in pre-test scores (covariates). Thus, significant differences in adjusted means post-test scores can be attributed to the effect of the learning approach applied, not to differences in initial ability between groups (Field, 2023). Inferential analysis is used to test the hypothesis by showing statistical results on samples that can be used to conclude the research population. The research data analyzed in this study include pretest and posttest data on students' critical thinking ability and self-confidence scores. The data analyzed were calculated using the R program (R Core Team, 2024)and the RStudio program (RStudio Team, 2020).

RESULTS AND DISCUSSION

In this study, observations were conducted by observers during learning using the CTL-DL approach in the experimental class and the expository approach in the control class. Based on the results of observations, both the experimental class (using CTL) and the control class (using the expository approach) showed a very good level of learning implementation, with an average percentage of teacher and student activity above 90%. In teacher activities in the CTL-DL and expository classes, the average percentage was 96% (very good). In student activities in the CTL-DL class, it was 94% (very good) while the expository class was 93% (very good). This indicates that both learning methods have been implemented according to plan.

Critical thinking skills were measured using a descriptive test consisting of 4 questions, both in the experimental class using the Contextual Teaching and Learning approach and using the expository approach. The test was given to students before and after being given treatment.

Table 1Descriptive Statistics of Critical Thinking Ability Test

Descriptive	Experimental Class (CTL-DL)		Control Class (Expository)	
	Pretest	Posttest	Pretest	Posttest
Average	12.31 (18%)	48.31 (71%)	11.58 (17%)	42.69 (63%)
Standard Deviation	4.54	10.54	4.52	10.51
Ideal Minimum Value	0	0	0	0
Ideal Maximum Value	68.00	68.00	68.00	68.00
Minimum Student Score	5.00	30.00	3.00	24.00
Student Maximum Score	20.00	66.00	21.00	59.00

Based on Table 19, it can be seen that the average critical thinking ability in the experimental class (CTL-DL) at the pretest and posttest was higher than the control class (Expository). In the experimental class (CTL-DL), the average pretest score was 12.31 with a percentage of 18% then at the posttest it became 48.31 with a percentage of 71% so it can be concluded that there was an increase of 36 points with a percentage of 53%. While in the control class (Expository) the initial average at the pretest was 11.58 with a percentage of 17% then became 42.69 with a percentage (63%) at the posttest with an increase of 31.11 points with a percentage of 46%. Based on the results obtained, it can be concluded that there is a significant difference in the average in the experimental class (CTL-DL) and the control class (Expository). However, the average increase in the experimental class (CTL-DL) and control class (Expository) has not reached a moderate score of ≥ 75 to meet the criteria for critical thinking skills. Visually average students' critical thinking ability, see Figure 1.

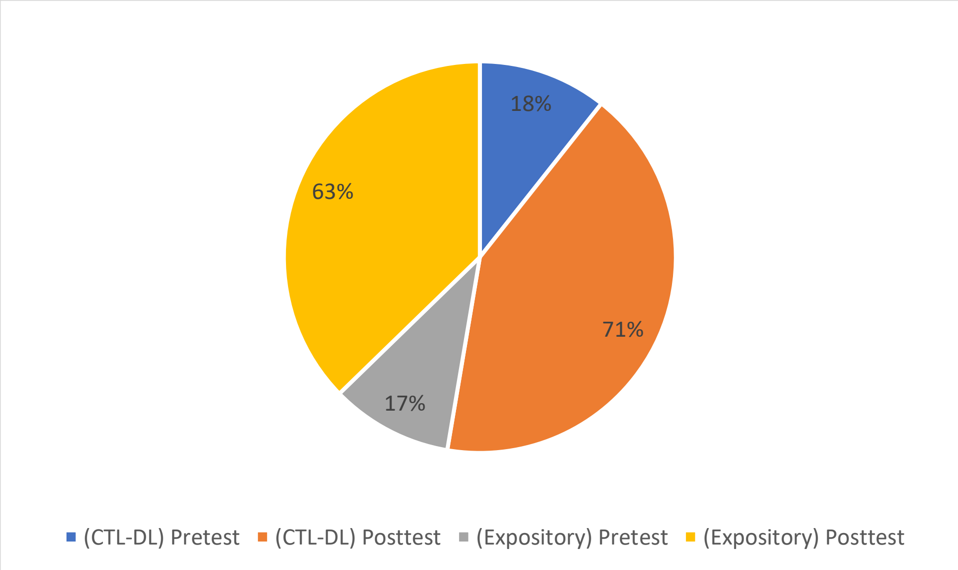

Figure 1. Average Students' Critical Thinking Ability

Based on the average percentage of each indicator of critical thinking ability after being given treatment in both classes, there was an increase in each indicator of critical thinking ability. The total average and total percentage of critical thinking ability indicators after being given treatment in the experiment (CTL-DL) became 6.90 (57%) and in the control class (Expository) became 6.10 (50%). In addition, the posttest results of the experimental and control classes experienced the highest average increase in the second indicator, namely the ability to provide reasons based on relevant facts/evidence at each stage with an increase in the experimental class reaching 9.75 points while the control class was 7.55 points.

In the experimental (CTL-DL) and control (Expository) classes, there was an indicator that achieved the lowest increase, namely the sixth indicator which measures the ability to check or re-check the results of solving problems as a whole with an increase value of only 2.03 points, while in the control class (Expository) the increase value reached 1.81 points.

Self-confidence data were obtained from the results of the initial and final questionnaires totaling 24 statements, both in the experimental class using the Contextual Teaching and Learning approach and using the expository approach. The results of the descriptive statistics of self-confidence are as follows.

Table 2Descriptive Statistics of Self-Confidence Questionnaire

Descriptive	Experimental Class (CTL-DL)		Control Class (Expository)	
	Pretest	Posttest	Pretest	Posttest
Average	80.58 (67%)	91.25 (76%)	78.44 (65%)	84.36 (70%)
Standard Deviation	10.39	10.31	9.81	10.11
Ideal Minimum Value	24.00	24.00	24.00	24.00
Ideal Maximum Value	120.00	120.00	120.00	120.00
Minimum Student Score	61.00	74.00	59.00	63.00
Student Maximum Score	101.00	110.00	99.00	101.00

Based on Table 2, it can be seen that the average self-confidence ability in the experimental class during the pretest and posttest was higher than the control class. In the experimental class, the average pretest score was 80.58 with a percentage of 67% then at the posttest it became 91.25 with a percentage of 76% so it can be concluded that there was an increase of 10.67 points with a percentage of 9%. While in the control class, the initial average at the pretest was 78.44 with a percentage of 65% then became 84.36 with a percentage of 70% at the posttest with an increase of 5.92 points with a percentage of 5%. Based on the results obtained, it is concluded that the average achievement of self-confidence in the experimental class (CTL-DL) reached more than 90 in the moderate category that has been set in the self-confidence criteria. Visually average students' self-confidence, see Figure 2.

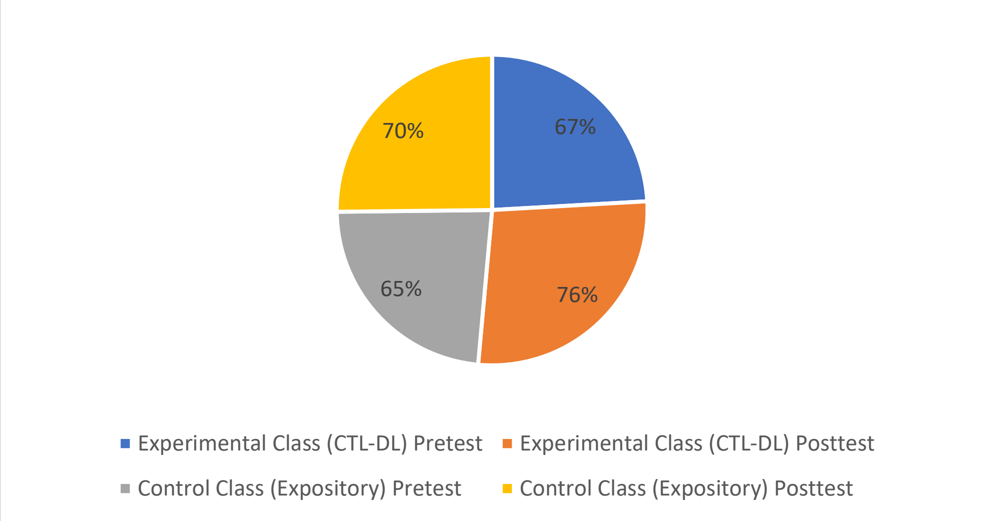

Figure 2. Average Students' Self-Confidence

Based on the average percentage of each self-confidence indicator after being given treatment in both classes, there was an increase in each self-confidence indicator. The total average and total percentage of self-confidence ability indicators after being given treatment in the experiment (CTL-DL) became 15.21 (77%) and in the control class (Expository) became 14.06 (70%). In addition, the posttest results of the experimental class (CTL-DL) and the control class (Expository) experienced the highest average increase in the same indicator, namely the first indicator that measures the ability to be serious in understanding mathematical material with one's own abilities. The increase in the experimental class (CTL-DL) reached 2.67 points and in the control class (Expository) reached 1.58 points for the first indicator.

Furthermore, Table 2 also shows the lowest self-confidence indicator achieved in both classes. In the experimental class (CTL-DL) and the control class, the lowest indicator achieved was the second indicator which measures the ability to have a positive view of learning outcomes with one's own abilities. In the experimental class (CTL-DL), the lowest increase in the second indicator was 1.14 points, while in the control class (Expository) it was 1.11 points.

Multivariate data analysis begins by detecting the existence of outliers in the data. Outliers in the data in this study were detected using boxplots and Mahalanobis distance calculations. Data analysis shows that there are no extreme values or outliers in the data on students' critical thinking skills and self-confidence, both before and after treatment. This applies to both univariate analysis and multivariate analysis using Mahalanobis distance. Thus, the data used in this study can be considered clean and suitable for further analysis.

In this study, the Henze-Zikler test statistic was used to test the multivariate normality assumption with a significance level $\alpha = 0{,}05$. The Henze-Zikler test in this study was calculated with the help of the R program in the Multivariate Normality (MVN) library. Based on the analysis, it was obtained that the data on critical thinking skills and self-confidence before and after treatment for each class were distributed normally multivariately. This is based on the p-value which is greater than $\alpha = 0{,}05$for each class.

Univariate normality test is used to determine whether the pretest and posttest data on each variable come from a normally distributed population. The univariate normality test in this study used the Shapiro-Wilk test with a significance level of $\alpha = 0{,}05$. The normality test uses the help of the R program. Based on the analysis, it is known that the results of the critical thinking ability and self-confidence data on each pretest and posttest data in the experimental class and control class are normally distributed univariately. This is based on the p-value which is greater than $\alpha = 0{,}05$for each class in each variable.

The homogeneity test of the variance-covariance matrix aims to ensure that the variability and covariance between the experimental class and the control class are not statistically significant. To test the assumption of homogeneity of the variance-covariance matrix in this study, the Box M test was used with a significance level of $\alpha = 0{,}05$. This test uses the help of the R program in the biotools library. Based on the analysis, it can be seen that there is no significant difference in each of the pretest and posttest data between the two classes. This is indicated by a p-value of more than $\alpha = 0{,}05$. All classes have similar levels of variability so it can be concluded that the assumption of homogeneity of variance-covariance is met for both classes.

The homogeneity of variance assumption test aims to check the equality of the variance of the two classes for each variable of interest. The statistical test used in this study is the F test with a significance level of $\alpha = 0{,}05$. Based on the analysis, it can be seen that both classes have the same variance for each variable, both before and after treatment. This can be seen from the p-value results which are more than $\alpha = 0{,}05$.

Next, the hypothesis test aims to answer the problem formulation in the research. In this hypothesis test, the statistical tests used to answer the problem formulation that has been explained are discussed in detail.

The comparison test of two mean vectors aims to assess the existence of the influence of the Contextual Teaching and Learning approach. Based on the results of the assumption of univariate normality and homogeneity of the variance-covariance matrix, the test used is the Hotelling's T^2 test. The analysis uses the help of the R program from the ICSNP package. The following are the results of the Hotelling's T^2 test.

Table 3Results of the Average Vector Comparison Test

Data	Two Sample Test Hotelling's T^2 Test	p-value
Pretest	1.13	0.57
Posttest	10.28	0.01

Based on the results of Table 30, it can be concluded that there is no influence of the Contextual Teaching and Learning approach on critical thinking skills and self-confidence before being given treatment ($\mathrm{p-value} > 0{,}05$). So, the abilities in the two selected classes are classified as the same.

In addition, the Contextual Teaching and Learning approach has an influence on students' critical thinking skills and self-confidence after being given treatment ($\mathrm{p-value} < 0{,}05$). In other words, there is a difference in the average of the two classes that are the objects of the study. Multivariate analysis proved significant, so further tests must be conducted to examine the effect of the Contextual Teaching and Learning approach on each variable.

The follow-up test is to examine the existence of the influence of the Contextual Teaching and Learning approach on each variable separately. Based on the assumption of univariate normality and homogeneity of two variances, the test used to analyze the follow-up test is the t-test. This test is calculated using the R program building. The results of the t-test data analysis are presented in Table 4 below.

Table 4Results of Two Independent Sample t-Test

Variables	Two Independent Sample t-Test		95% Confidence Interval for $\mu_1 - \mu_2$
	t-test	p-value	
Critical thinking	2.26	0.03	0.66 – 10.56

Based on Table 4, it can be concluded that Contextual Teaching and Learning has an influence on critical thinking skills, as seen from the value $t = 2,26$(>1.99) and p-value <0.05. Therefore, it can be concluded that the Contextual Teaching and Learning approach is superior to classes with an expository approach in terms of critical thinking skills.

The follow-up test is to examine the existence of the influence of the Contextual Teaching and Learning approach on self-confidence obtained by using the t-test with the help of the R program. Based on the assumption of univariate normality and homogeneity of two variances, the results of the t-test data analysis obtained are in Table 5.

Table 5Results of Two Independent Sample t-Test

Variables	Two Independent Sample t-Test		95% Confidence Interval for $\mu_1 - \mu_2$
	t-test	p-value	
Self Confidence	2.86	0.01	2.09 – 11.69

Based on Table 5, the results of the t-test for self-confidence obtained a value of $t = 2,86$(>1.99) and p-value <0.05. Therefore, it can be concluded that the Contextual Teaching and Learning approach is superior to classes with an expository approach in terms of self-confidence.

Furthermore, at the 95% confidence interval for the average difference of each variable, the value is positive. Based on the results obtained, it can be seen that the Contextual Teaching and Learning class is superior to the expository class in terms of students' critical thinking skills and self-confidence.

This study provides strong empirical evidence regarding the differential impact of learning approaches on the development of students' cognitive and affective abilities simultaneously. The first finding, based on the Hotelling T2 test (T2=10.28, p=0.01), indicates that both the CTL-DL and Expository approaches together do indeed have a significant influence on students' critical thinking skills and self-confidence. This suggests that structured learning interventions, whatever their form, tend to have an impact on student development compared to no intervention at all. However, this multivariate significance is the basis for further exploration of which approach has a more dominant and positive influence.

Further univariate analysis revealed the significant superiority of the CTL approach. Regarding critical thinking skills, CTL-DL was proven to have a positive effect and was significantly superior (t=2.25, p=0.03) compared to the Expository approach. The higher average posttest score of the CTL-DL group (48.31) compared to the Expository group (42.69) strengthens this finding. The superiority of CTL-DL can be explained through its core characteristics which emphasize constructivism, inquiry, and connections between subject matter and students' real-life contexts (relating, experiencing, applying). As stated by Abdullah et al. (2023), learning that links concepts to concrete and relevant experiences encourages students to not only memorize, but also analyze, evaluate, and create solutions, which is the core of critical thinking. In contrast, the Expository approach, which tends to be a one-way transmission of information from teacher to student, provides less space for students to actively construct knowledge and practice these high-level thinking skills.

In parallel, this study also found a significant effect of CTL-DL on increasing students' self-confidence, with a significant advantage (t=2.69, p=0.01) compared to the Expository approach. Again, the average posttest self-confidence score of the CTL-DL group (91.25) exceeded the Expository group (84.36). This increase in self-confidence is most likely the result of the more empowering CTL-DL learning environment. When students successfully solve problems that are relevant to their world (contextualization), they feel an authentic sense of accomplishment that builds self-confidence. Active involvement in the learning process (active learning), as opposed to passive acceptance in the Expository model, gives students a sense of control and competence (Fitriani, 2024). In addition, the collaborative aspect that often accompanies CTL-DL can reduce anxiety and provide social support, which further contributes to self-confidence (Susanto & Wijaya, 2022). The Expository approach, with its focus on individual performance in absorbing information, may be less effective in building this affective aspect.

Overall, these findings underscore that the CTL-DL approach is not only superior in honing critical thinking skills but also simultaneously effective in building students' self-confidence. The interconnection between these two variables is important; more confident students may be more willing to take the intellectual risks required for critical thinking, and success in critical thinking can strengthen self-confidence. This is in line with the holistic view of education that emphasizes the simultaneous development of cognitive and affective domains (Nurhayati & Setiawan, 2020). The implication is clear: to develop students who are not only academically intelligent but also have positive self-confidence, the implementation of active and contextual learning strategies such as CTL-DL is highly recommended compared to traditional expository teaching methods.

CONCLUSION

Based on the results of the study and discussion, overall, this study makes a significant contribution to the Contextual Teaching and Learning (CTL) and Discovery Learning (DL) literature by presenting strong empirical evidence of the superiority of the CTL-DL approach in simultaneously improving students' critical thinking skills and self-confidence, compared to the expository approach. These findings add to our understanding of how structured and contextualized learning interventions impact not only students' cognitive but also affective aspects.

For future implementation, it is recommended that educators further integrate CTL-DL principles into everyday learning designs, by creating learning scenarios that are relevant to students' real-world contexts and encouraging them to actively discover and construct knowledge. Furthermore, these findings underscore the importance of comprehensive teacher training. Professional development programs for teachers should focus on providing skills to design and facilitate CTL-DL-based learning, including strategies to connect content to context, encourage inquiry, and build learning environments that support students' self-confidence. Thus, the benefits of this approach can be realized more widely and effectively in educational practice.

This study recommends that mathematics teachers implement the contextual teaching and learning-deep learning approach, supported by schools, because it has proven to be superior in improving students' critical thinking skills and self-confidence. The implication is that CTL-DL is an effective strategy theoretically and practically to develop students' cognitive and affective skills, becoming an important input for educational policy. However, it is still an open problem for the specific elements of CTL-DL that are most influential, the generalization of its effectiveness across contexts, and how to overcome the challenges of implementation in real classes for future research.

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