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The Effectiveness of Contextual Teaching and Learning (CTL) in Improving Cognitive Learning Outcomes on Bench Work Practice

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ABSTRACT

This study examines the contextual teaching and learning (CTL) model's effectiveness in improving cognitive learning outcomes of vocational education students. Using a pretest-posttest quasi-experimental design, this study involved 60 tenth-grade mechanical engineering students, divided equally into control and experimental groups. The experimental group received the CTL learning model treatment, while the control group used conventional learning methods. A 20-item multiple-choice test based on Bloom's Taxonomy was used to measure students' cognitive learning outcomes. Instrument validation showed good content validity (Aiken's V=0.714- 1.00) and obtained good reliability results as well (ICC=0.730). The experimental group received a higher average post-test score (89.17) compared to the control group (75.83), with the acquisition of N-Gain values in the experimental group (0.7427) and control group (0.4013), with statistical analysis showing a significant difference ($p<0.05$). These findings indicate that CTL effectively improves basic understanding and critical thinking skills. This study supports the integration of CTL into vocational education systems aligned with international priorities of competency-based learning and workforce readiness. This study provides empirical evidence that CTL can improve learning outcomes and equip students with critical thinking skills.

ARTICLE INFORMATION

Keywords:
contextual teaching learning; learning achievement; vocational education

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INTRODUCTION

Student learning outcomes are the main factor to measure the effectiveness of the education process, including vocational education. Theoretical understanding and practical skills are essential in influencing learning outcomes in vocational education. Several studies have confirmed the effectiveness of contextual learning models in improving learning outcomes. Previous studies show that contextual learning models positively impact theoretical and practical learning outcomes (Ardiansyah & Rochmawati, 2022; Fa'izah et al., 2024; Sinaga & Sinabariba, 2020).

However, despite being supported by various research, the application of contextual teaching and learning (CTL) is still less desirable and utilized in vocational education settings, especially in subjects such as bench work practice, which requires students' technical skills and critical thinking (Dzikri et al., 2023; McGrath & Yamada, 2023). The discrepancy between theoretical learning and practical activities in vocational education often results in outcomes that are difficult to apply in daily practice. The teacher-centered learning model is still dominant, emphasizing theory with limited practical activities (Gupta et al., 2024; Muhamad & Ahyanuardi, 2022). CTL should be widely developed as this pedagogical strategy in vocational education is a basis for students to prepare themselves to face the demands of work or industry. However, previous research and direct

observations in the field show that CTL has not been systematically applied in practical subjects. The difference between the ideal contextualized approach, where learning is student-centered, and the reality in many vocational classrooms results in implementation differences that previous studies have not adequately addressed.

The researcher offers the Contextual Teaching and Learning (CTL) model as an instructional alternative that connects academic learning theory with students' daily experiences in an industrial context. CTL encourages more meaningful learning where learning is student-centered through various collaborative activities and reflection, thus increasing student engagement and relevance (Amaral et al., 2024; Suadiyatno et al., 2020). International studies also state that contextual learning methods are proven more effective because they make learning more relevant and interactive (Mahmuti et al., 2025).

Using Contextual Teaching and Learning (CTL) in digital learning environments has shown promising results. Chintha (2024) states that applying Contextual Teaching and Learning (CTL) through online platforms has significantly improved students' language skills by incorporating daily contexts, interactive activities, and collaborative tasks, even in remote environments. It highlights CTL's flexibility and adaptability across different delivery methods. CTL also significantly benefits from using a variety of appropriate learning media. Integrating materials in contextualized learning improves student performance and learning outcomes, particularly in technical subjects such as technical drawing and mechanical applications (Damanik et al., 2020; Khumaedi et al., 2021). In addition, CTL facilitates meaningful learning through three main stages: activating prior knowledge, building new knowledge, and application in practical activities (Ilham & Siska Dwi Astiati, 2023). This learning model aligns closely with the goals of vocational education, encompassing cognitive, affective, and psychomotor domains (Utami et al., 2023; Yusyac et al., 2021).

CTL not only improves understanding but also improves students' critical thinking skills. This opinion is supported by Ardiansyah and Rochmawati (2022), Damanik et al. (2020), and Riza et al. (2024), who state that by applying a collaborative and problem-based contextual learning design model, students' ability to think critically also develops. In addition, CTL has also been proven effective in enhancing communication skills, such as speaking fluency and confidence in specific contexts like Maritime English, as shown by Limbong et al., (2024), who confirmed that CTL provided cadets with interactive and meaningful opportunities to apply language skills in actual nautical scenarios, leading to significant improvements in their speaking performance. The effectiveness of contextual teaching and learning (CTL) in fostering higher-order thinking is also evident in language learning contexts. For example, Rahman and Ekkayokkaya (2024) showed that CTL significantly enhanced students' analytical exposition writing skills by promoting critical reasoning, contextual awareness, and effectively organising arguments. Their study affirms that CTL nurtures cognitive engagement and deeper learning even in complex, abstract tasks.

Benchwork practice is a basic subject in mechanical engineering that includes knowledge of hand tools, machines, repair techniques, and work safety procedures in industrial practice activities. This subject positively influences students' understanding of industrial practice by emphasizing hands-on experience and industrial relevance (Sinaga & Sinabariba, 2020). However, tools and infrastructure alone are insufficient; students also need dynamic and context-based learning strategies to understand how to use tools, techniques, machines, and safety procedures to improve production quality (Dzikri et al., 2023; Zaki, 2023). The application of CTL in this field can stimulate students to make learning more active through various workshop project activities, collaborative assignments, and reflective evaluations, thus ensuring students acquire higher-level technical skills and cognitive understanding outcomes.

Cognitive learning outcomes are significant in vocational education because they demonstrate students' ability to understand, process, and apply theoretical knowledge in a real technical context. Bloom's Taxonomy of cognitive learning outcomes consists of six levels: remembering, understanding, applying, analyzing, evaluating, and creating (Razali & Wah, 2011). Mastery of skills at these six levels ensures that students recognize the functions of tools and machines, understand and apply procedures, assess accuracy, and comply with work safety standards. Therefore, this study aims to develop CTL as a pedagogical intervention to enhance cognitive skill development in a vocational education environment.

METHOD

This research employs a quantitative approach, emphasizing systematic investigation of phenomena through numerical data collection and statistical techniques to test hypotheses and explore relationships among variables (Cohen et al., 2017; Creswell, 2012). Derived from the positivist paradigm, quantitative research aims to produce objective, measurable, and generalizable results that inform educational practices and policies.

To evaluate the effectiveness of an intervention, this study used a quasi-experimental design, specifically a control and experimental group pretest-posttest design. This design, recommended by Creswell (2012) when random assignment is impossible, allows us to compare student performance between the two groups, ensuring the internal validity of causal inferences.

The independent variable in this study is the Contextual Teaching and Learning (CTL) learning model. The CTL model is a student-centered approach that highlights the connection between classroom learning and daily applications. In contrast, the dependent variable is students' cognitive learning outcomes measured in bench work practice. This study involved 60 tenth-grade Mechanical Engineering Expertise Program students of SMK Negeri 4 Semarang. The sample was chosen using simple random sampling from two intact classes containing 30 students. This sampling technique ensures that each student has the same or equal chance of being selected, thus increasing the representativeness and internal validity of the research (Fraenkel et al., 2012).

The cognitive learning outcomes were assessed using a 20-item multiple-choice test to evaluate students' knowledge and skills related to hand tools, machine tools, production procedures, and safety measures in the workshop. This assessment was created based on the core competencies outlined in the tenth-grade vocational curriculum, ensuring the content is appropriate and relevant. These questions are by the six levels of the Revised Bloom's Taxonomy, namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6), which are contextualized in the hammer-making practice worksheet, ensuring authentic assessment of student learning outcomes.

The research procedure was conducted in several stages. First, two intact classes were randomly determined as the control and experimental groups. Both groups were given the same pretest questions to measure their initial understanding of benchwork practice materials. Next, the experimental group received learning using the CTL model, characterized by contextual scenarios, collaborative activities, and reflective tasks. In contrast, the control group followed conventional teacher-centered learning. After the learning period, a post-test, similar in format and content to the pretest, was given to both groups. The framework of the research procedure is presented in Figure 1.

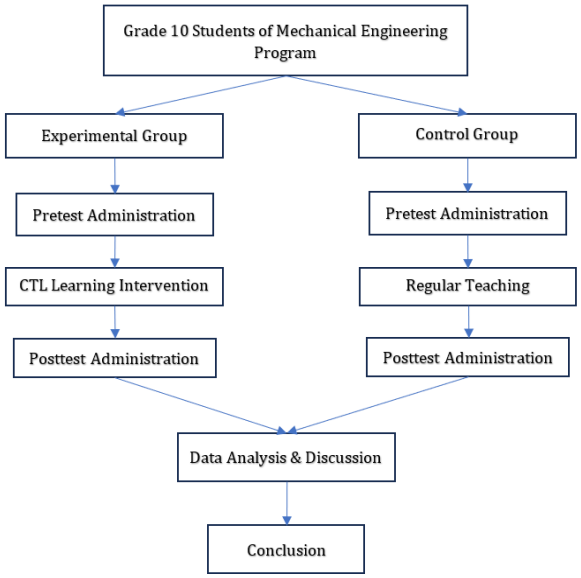

Figure 1. Research Procedures

To maintain the quality of the assessment tool, content validity was tested using Aiken's V, involving seven experts who assessed the relevance of the items using a 5-point Likert scale. The resulting Aiken V values ranged from 0.714 to 1.000, indicating that the content validity tends to be good to excellent (Nurjanah et al., 2023). Inter-rater reliability was assessed using the Intraclass Correlation Coefficient (ICC) with a two-way mixed effects model and absolute agreement. The obtained ICC value of 0.730 reflects a good agreement between raters (Koo & Li, 2016), thus informing the instrument's reliability.

Data analysis was conducted using SPSS software. Descriptive statistics were employed to compute the standard deviation and mastery level average. The normality of the data was evaluated using the Shapiro-Wilk test., while the Levene test was used to test the homogeneity of variance. The pretest and post-test scores of the two groups were analyzed using a paired t-test before and after the intervention, while differences between the groups were assessed through an independent t-test. In addition, Normalized Gain (N-Gain) was calculated with the aim of evaluating the magnitude of learning improvement, with interpretation based on Hake's (1999) classification: high (>0.70), medium (0.30-0.70), and low (<0.30). This systematic methodological approach ensures the research process's validity, reliability, and rigor, facilitating a thorough evaluation of contextual learning models' effectiveness in enhancing cognitive learning outcomes within vocational education settings.

RESULTS AND DISCUSSION

This research was conducted at SMK Negeri 4 Semarang using a pseudo-experimental design with 60 students split evenly into a control and experimental group. Both groups were given pretest and post-test questions to measure the effectiveness of the contextual teaching and learning (CTL) model. The result of the paired t-test on the pretest score showed a significance value of 0.340 ($p > 0.05$) (Table 1), indicating that there was no significant difference in initial cognitive ability between control and experimental groups.

Table 1. Two-tailed t-test of Pretest Scores

	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	.340	2.000	2.080
Equal variances not assumed	.340	2.000	2.080

After the learning intervention, a post-test was conducted to measure students' level of understanding, and there was a substantial improvement in the experimental group. The average post-test score of the experimental group was 89.14 with a standard deviation of 6.576, while the control group had an average of 75.83 with a standard deviation of 6.598. These results are presented in Table 2.

Table 2. Descriptive Statistics of Post-test Scores

Group	N	Mean	Std. Deviation
Experimental	30	89.17	6.576
Control	30	75.83	6.958

The Shapiro-Wilk test, conducted after descriptive statistical tests of post-test scores, showed a significance value of 0.234 (control group) and 0.096 (experimental group), both of which had a value greater than 0.05, indicating that the data distribution in the groups was normal (Table 3).

Table 3. Tests of Normality for Posttest Data

	Shapiro-Wilk		
Class	Statistic	df	Sig.
Control	.955	30	.234
Experimental	.941	30	.096

Using the Shapiro-Wilk test, the Levene test was conducted after the normality test. The Levene test was conducted to determine the homogeneity of data variance. In this test, a significance value of 0.781 (p>0.05) was obtained (Table 4), so the "variance is assumed to be the same" line was used in the t-test.

Table 4. Homogeneity Test of Post-test Data

	Levene's Test for Equality of Variances	
	F	Sig
Equal variances assumed	.078	.781

The independent t-test was conducted to show the significant difference in post-test scores between the control and experimental groups. After testing, it was found that with $p < 0.0001$, informing the experimental group was significantly superior regarding the increase in scores compared to the control group (Table 5).

Table 5. Right-tailed t-test Post-test Scores

	Sig. (2-tailed)	Mean Difference	Std. Error Difference	t	df
Equal variances assumed	<0.0001	13.333	1.748	7.628	58
Equal variances not assumed	<0.0001	13.333	1.748	7.628	67.816

The N-Gain analysis was conducted after the independent t-test to measure the learning effectiveness and compare the control and experimental groups' effectiveness. The N-Gain analysis showed that the experimental group had an average N-Gain of 0.7427 (high category), while the control group had an average N-Gain of 0.4013 (medium category) (Table 6).

Table 6. Descriptive Statistics of N-Gain Scores

Group		N	Minimum	Maximum	Mean	Std. Deviation
Control	Ngain	30	.13	.78	.4013	.18559
	Pretest Score	30	40	75	58.33	8.543
	Posttest Score	30	60	90	75.83	6.958
Experimental	Ngain	30	.38	100	.7427	.16631
	Pretest Score	30	40	70	56.33	7.535
	Posttest Score	30	75	100	89.17	6.576

The results of this study showed that the contextual teaching and learning (CTL) model effectively improves students' cognitive learning outcomes, especially in vocational education. The lack of significant differences in pretest scores indicates that both groups possess equal initial abilities, reinforcing the research design's internal validity. After the treatment or intervention, the experimental group showed a higher understanding of the material than the control group. This is consistent with Sari et al. (2024), who found an increase in student achievement and learning motivation through the CTL learning model. The average increase of 13.33 points and N-Gain of 0.7427 strengthen the effectiveness of the CTL learning model in building mastery of more effective and meaningful learning concepts. This finding is reinforced by Ilham and Siska Dwi Astiati (2023), who assert that CTL enhances meaningful learning by connecting learning content with actual contexts. In this study, contextual learning activities such as product manufacturing enabled students to apply their knowledge of tools, machines, production sequences, and work safety procedures by national vocational competencies (C2-C3 level in Bloom's Taxonomy). In addition, CTL proved effective in improving students' cognitive skills, including analysis and evaluation (C4-C5). Students in the experimental group showed the ability to identify production errors and assess the quality of tasks more critically than the control group, according to Ardiansyah and Rochmawati (2022), Cahyanto and Munadi (2021), and Ulinnuha (2021).

The difference between this and previous studies is the new application of the contextual teaching and learning (CTL) model in the technical-practical domain. At the same time, most of the other studies focused only on general education or social sciences. This study provides empirical evidence that CTL can be adapted and impactful in a vocational education setting. It connects classroom learning with industry expectations, addressing the need for technical and vocational education reform. This study contributes to the scientific literature by showing that CTL, when linked with competency-based assessment, can improve scores on academic performance and students' understanding and work readiness in vocational education. As suggested by Amaral et al. (2024) and McGrath and Yamada (2023), integrating contextualized learning strategies is essential for equipping students with transferable skills that align with the demands of the 21st-century job market.

CTL allows students to be more actively involved with learning materials and learning methods that are more relevant and meaningful. Applying CTL through collaborative task activities, scenario-based activities, and reflection-based learning helps students understand theoretical concepts and higher-level cognitive abilities such as analysis and evaluation. This finding supports previous studies that suggest incorporating CTL learning models in general and vocational education, particularly in enhancing students' critical thinking skills and their preparedness for the workforce. Nonetheless, this study has some limitations that the researcher must acknowledge. This study was conducted in one vocational school with a relatively small sample. In addition, the treatment duration was limited to a short learning period, without measuring the long-term retention of students' knowledge directly in the real work environment. This study only focused on the cognitive domain without further examining the affective and psychomotor aspects.

CONCLUSION

This study concludes that the contextual teaching and learning (CTL) model is a theoretical and practical approach to improving students' cognitive learning outcomes in vocational education. Students taught using a contextual learning approach significantly improve their learning outcomes compared to those taught with conventional lecture methods. Future research is recommended to apply CTL to various other vocational subjects, involve a larger sample, and use a long-term approach to evaluate longer impacts, and can also explore the influence of CTL on other aspects such as motivation, practical skills, and a more comprehensive understanding of the role of CTL in vocational education. Despite its limitations, this study offers empirical evidence that CTL is a relevant learning model with a positive impact on improving the quality of learning and aligning education with workforce needs.

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