

The effectiveness of the STAD Cooperative Learning Method assisted by Flashcard Media in improving students' learning outcomes

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Abstract: This study explores the effectiveness of the Student Teams Achievement Divisions (STAD) cooperative learning model, supported by flashcard media, in enhancing student learning outcomes in Manufacturing Technical Drawing at SMK Negeri 1 West Sumatra. A quasi-experimental control group design was employed, where the experimental group used the STAD method integrated with flashcards, and the control group received traditional lecture-based instruction. Post-test results showed that the experimental group significantly outperformed the control group, achieving a higher mean score of 79.68 compared to 63.84, with an N-Gain score of 50.81%, indicating moderate improvement. The study found that the STAD model, combined with flashcards, boosted academic achievement and promoted more consistent and equitable learning outcomes. Flashcards played a vital role by simplifying complex concepts and enhancing student engagement. This study fills a gap in vocational education by demonstrating the effectiveness of combining cooperative learning and visual aids in technical education. The research offers valuable insights for educators in similar contexts, proposing a cost-effective and scalable instructional method that can be applied across various technical disciplines. However, the study's limitation lies in its short-term implementation, and further research is needed to explore the long-term effects of this combined learning strategy.

Keywords: STAD cooperative learning; flashcard media; manufacturing technical drawing; vocational education; learning outcomes

1. Introduction

Education plays a pivotal role in shaping high-quality human resources who are competent in their respective fields and capable of competing at the global level ([Abunaser et al., 2024](#); [Makinde et al., 2024](#)). The learning process must be designed effectively to achieve optimal educational outcomes, focusing on content mastery and the appropriate selection of engaging methods and instructional media. As highlighted by ([Zamiri & Esmaeili, 2024](#)), the effectiveness of a learning approach largely depends on the use of suitable media that facilitates deeper knowledge acquisition and skill development.

However, many school learning processes remain rooted in traditional approaches, typically characterized by teacher-centred lectures and chalkboards ([Justus-Smith, 2024](#); [H. Li, 2025](#)). This conventional method often results in low student achievement. According to ([H. Li, 2025](#)), collaborative learning in groups encourages peer support in understanding subject matter, ultimately improving learning outcomes. Consequently, cooperative learning has been widely recommended to enhance instructional quality. Among various cooperative learning models, Student Teams Achievement Divisions (STAD) is an effective method ([Guntoro et al., 2024](#); [Serjali & Halim, 2020](#)). STAD emphasizes heterogeneous group learning, where students support one another and share responsibility for the group's success. According to ([Safiudin, 2024](#)), STAD significantly boosts academic performance by fostering teamwork and motivating

students through collaborative group dynamics.

Additionally, integrating visual aids such as flashcards has proven to improve learning effectiveness. Flashcards are particularly beneficial as they make information more memorable and enjoyable to learn ([Chen & Chan, 2019](#); [J. T. Li & Tong, 2019](#)). Within the STAD model, flashcards can introduce new concepts, facilitate group discussions, and reinforce students' comprehension of the material. As ([Kustyarini et al., 2020](#)) emphasizes, "instructional media should stimulate student interaction and enable a more engaging and enjoyable learning experience." Observations conducted during the Field Teaching Practice at SMK Negeri 1 West Sumatra, particularly in the Manufacturing Technical Drawing class (Grade XI), revealed that teaching was still heavily lecture-based, relying on job sheet illustrations displayed on the board. Many students struggled to understand icons and features within the Inventor application and had difficulty retaining the material over time ([Grover et al., 2019](#); [Sheen & Luximon, 2021](#)). These challenges led to low student engagement, passive learning behaviour, lack of focus, and frequent distractions during lessons. Interviews with the teacher further revealed that more than 50% of students had not reached the Minimum Mastery Criteria of 75, with pre-test results showing that over half scored below this threshold.

These findings underscore the urgent need for more effective teaching strategies to improve student comprehension and performance. Therefore, this study examines the effectiveness of the STAD cooperative learning model supported by flashcard media in enhancing student learning outcomes in Manufacturing Technical Drawing. This research introduces a novel instructional strategy by integrating the STAD cooperative learning model with flashcard media, a combination that remains underutilized in the context of vocational education, particularly in technical drawing instruction. The study addresses a significant gap in the literature concerning the synergistic effects of cooperative learning models and visual media on cognitive learning outcomes in technical education.

The study focuses on improving cognitive learning outcomes and addresses the following research question: Can implementing the STAD model assisted by flashcards effectively enhance student achievement in Manufacturing Technical Drawing? The research is expected to offer theoretical insights for developing improved instructional models and to provide practical contributions for educators, students, and researchers in enhancing teaching and learning quality. By integrating the STAD model with flashcard media, the learning process is expected to become more interactive, engaging, and conducive to deeper student involvement and understanding. This combination may also be a viable alternative strategy in modern education, where creativity and instructional effectiveness are increasingly vital.

2. Methods

2.1 Research design

This study employed a Quasi-Experimental Control Group Design to examine the effectiveness of the STAD (Student Teams Achievement Divisions) method assisted by flashcards on student learning outcomes in the subject of Manufacturing Technical Drawing ([Capili & Anastasi, 2024](#)). The experimental class received instruction using the STAD method and flashcards, while the control class was taught using conventional lecture methods. Post-tests were administered after the treatment to assess learning outcomes. This research compared the two groups to observe the causal relationship between different teaching methods ([Prasertcharoensuk et al., 2021](#); [Savolainen et al., 2022](#)). This design was selected because it allows researchers to evaluate the impact of instructional interventions without randomization, while still providing meaningful insights into the method's effectiveness.

2.2 Research subjects

The study was conducted at SMK Negeri 1 West Sumatra, located at Jl. M. Yunus No. 26-10, Anduring, Kuranji District, Padang City, West Sumatra. The research was carried out in Grade

XI Mechanical Engineering (TP) classes, specifically in the Manufacturing Technical Drawing course. According to ([Piotrowski, 2021](#)), research subjects are individuals, groups, or objects to which research variables are attached. The subjects of this study consisted of all students in Grade XI TP1 and TP2 enrolled in the Manufacturing Technical Drawing course at SMKN 1 West Sumatra during the 2024/2025 academic year. These groups were selected due to the relevance of the instructional content to the research objectives and the students' willingness to participate.

Table 1. Number of students in Class XI Mechanical Engineering

Class	Total students
XI TP1	28
XI TP2	26
Total	54

2.3 Research instruments

As stated by ([Kimberlin & Winterstein, 2008](#)), research instruments are tools used to measure phenomena and collect data to answer research questions. In this study, the instrument used was a multiple-choice objective test consisting of 25 questions. Most of the test items were adapted from the midterm and final examinations in the Manufacturing Technical Drawing course. These items were designed to ensure valid and reliable measurement of student learning outcomes. The test was used to compare the learning results between the experimental and control classes.

The research instruments, including the pre-test, post-test, and student perception surveys, underwent a trial phase and were evaluated by three experts specializing in media and learning materials for the Virtual CNC Laboratory. These experts, who possess 30 to 40 years of experience in teaching and research, hold the academic titles of doctor and professor ([Syahril et al., 2021](#)). To analyze the data obtained from the experts, the Aiken V coefficient was used, following the guidelines set by ([Aiken, 1985](#)), with a threshold interpretation of above 0.05, surpassing the r-table value of 0.396. As shown in Table 2, the validity of each question item was evaluated using the Aiken V coefficient.

Table 2. Validity and reliability of indicators from instrument the question of validity

No	Indicator	Number of questions	Validity	Reliability
1.	Technical drawing reading	1, 2, 3, 4, 5	0.546	0.909
2.	Knowledge of icon functions on the 2D sketch toolbar	6, 7, 9, 11, 16, 17, 18	0.577	
3.	Knowledge of icon functions on the 3D Model Toolbar	14, 15, 19, 20, 21, 22, 23	0.563	
4.	Management of working drawings	8, 10, 24	0.535	
5.	Knowledge of assembly or assembly process	12, 13, 25	0.529	

Additionally, Discriminatory Power was calculated to evaluate how well each item in the test distinguishes between students with higher and lower abilities. As noted by ([Ferrando, 2012](#)), the discriminatory power of a test item is its ability to differentiate between high-performing and low-performing students. The calculation of discriminatory power for each test item is performed using the categorization as shown in Table 3.

Table 3. Classification of test items based on discriminatory power

Range of Discriminatory Power (DP)	Category
$0.70 < DP \leq 1.00$	Very good
$0.40 < DP \leq 0.70$	Good
$0.20 < DP \leq 0.40$	Fair
$DP \leq 0.20$	Poor

This validation instrument is a questionnaire that will be filled out by expert lecturers and teachers who instruct in the field of Manufacturing Technical Drawing. A maximum of two validators will be involved to gather data on the validity of the created flashcards. The validation conducted by media and subject matter experts can be seen in Tables 4 and 5.

Table 4. Media expert validation instrument grid

No	Aspect	Indicator
1	Didactic aspect	a. Appropriateness of the media with basic competencies
		b. Usefulness of the learning media
		c. Appropriateness of the media with the field of expertise
2	Construction aspect	a. Language appropriateness
		b. Correctness of words and sentences
		c. Simplicity of language
3	Technical aspect	a. Display appropriateness
		b. Ease of use
		c. Coherence of the material
		d. Appropriateness of layout and colors
		e. Visual appeal of the display

Table 5. Subject Matter Expert Validation Instrument Grid

No	Aspect	Indicator
1	Content feasibility aspect	a. Appropriateness of the material with ATP (Teaching and Learning Plan)
		b. Accuracy of the material
		c. Encouragement of curiosity
		d. Currency of the material
2	Contextual assessment aspect	a. Nature of the context
		b. Contextual components

2.4 Data analysis techniques

Various data analysis techniques are employed to assess the effectiveness of the learning methods (Almulla, 2020; Yang & Ge, 2022). Each technique is specifically chosen to evaluate different aspects of the collected data, ensuring a comprehensive analysis of the study's outcomes. The following table summarises these techniques, along with explanations, tests, and the software used.

Table 6. Overview of data analysis techniques

Data analysis technique	Explanation	Test	Software
Descriptive Analysis	Used to provide an overview of the collected data. It includes frequency counts, percentages, and other relevant descriptive statistics.	Presenting data in a systematic and easy-to-understand format	-

Data analysis technique	Explanation	Test	Software
Normality Test (Shapiro-Wilk)	Used to test whether the data is normally distributed or not.	Data is considered normally distributed if the p-value > 0.05. If $p < 0.05$, the data is considered not normally distributed.	SPSS 25.0
Homogeneity Test (One-Way ANOVA)	Used to test the equality of variances between two groups (experimental and control groups).	Data is considered homogeneous if the p-value > 0.05. If $p < 0.05$, the data is considered not homogeneous.	SPSS 25.0
Hypothesis Testing (T-Test 2-tailed)	Used to test the validity of the null hypothesis (H0) and alternative hypothesis (H1). A T-Test is used to compare the mean results between two groups.	A p-value < 0.05 indicates a significant difference between the experimental and control groups. Followed by the N-Gain Score test to measure the effectiveness of learning improvement.	SPSS 25.0

Table 6 provides the data analysis techniques that form the foundation for evaluating the research findings. The Descriptive Analysis provides an initial understanding of the data by organizing it into meaningful statistics (Sundler et al., 2019). The Normality Test (Shapiro-Wilk) checks the assumption of normality in the data, which is crucial for applying parametric tests (Khatun, 2021). The Homogeneity Test (One-Way ANOVA) ensures that the variances between the experimental and control groups are equal, a necessary assumption for comparing group means (Breitsohl, 2019). Finally, Hypothesis Testing (T-Test 2-tailed) is employed to assess the statistical significance of the differences between the two groups, with a subsequent N-Gain Score analysis to evaluate the effectiveness of the learning intervention. All tests are conducted using SPSS 25.0, ensuring the reliability and validity of the results.

3. Results

This study involved two groups of Grade XI students majoring in Mechanical Engineering at SMK Negeri 1 Sumatera Barat. Class XI TP1 served as an experimental group and was taught using the STAD (Student Teams Achievement Division) cooperative learning model supported by flashcard media, while class XI TP2 acted as the control group and received instruction through conventional lectures using whiteboards. The intervention was conducted across four sessions, each consisting of three instructional hours. The pre-test scores were based on midterm assessments, while post-tests were administered after the intervention to evaluate improvements in students' learning outcomes. During the study, two students in the experimental group only participated in two of the four intervention sessions, and one student in the control group was absent during the post-test. The sample size was adjusted to 25 students per group to maintain data validity and ensure balanced comparison.

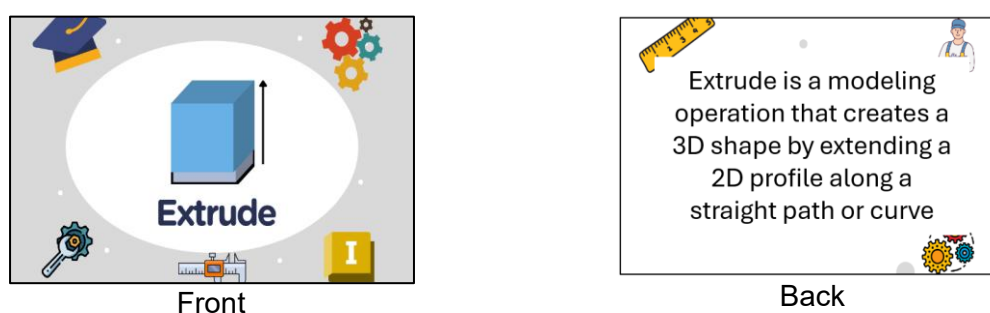


Figure 1. Flashcard: Extrude concept in engineering

3.1 Descriptive data analysis

After administering the post-test, descriptive statistical analyses were performed to obtain the maximum score, minimum score, average score, and frequency distribution for both the experiment and control groups, as depicted in Table 7.

Table 7. Post-test scores of experimental and control class

Group	Mean	SD	Min.	Max.
Experimental	79.68	7.296	68	92
Control	63.84	8.365	52	84

Based on the descriptive data presented in Table 7 and Figure 2, there is a notable difference in the average post-test scores between the experimental and control groups. The experimental group, which was taught using the STAD cooperative learning method assisted by flashcards, achieved a higher mean score of 79.68 compared to 63.84 in the control group, which was trained using conventional lecture methods. This substantial gap of 15.84 points indicates that the experimental approach significantly enhanced students' learning outcomes.

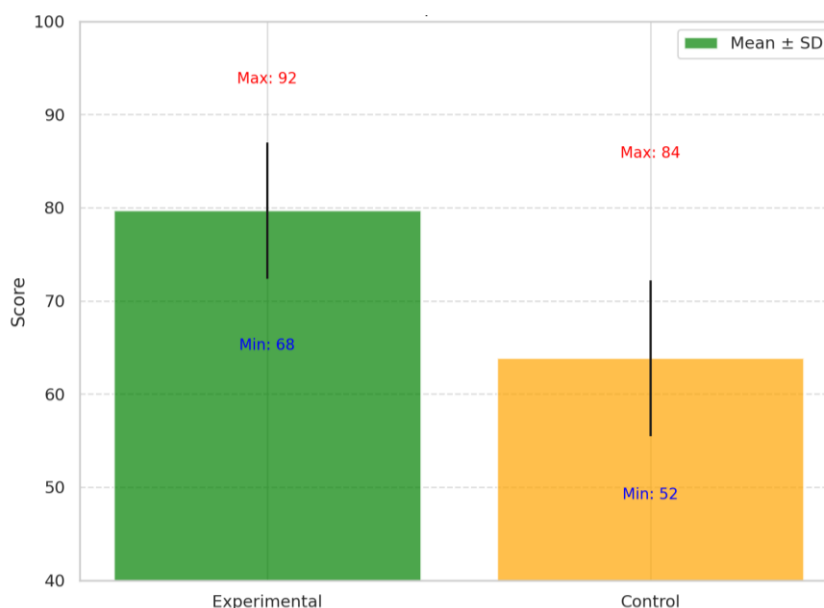


Figure 2. Post-test scores: experimental vs control class

Furthermore, the standard deviation in the experimental group ($SD = 7.296$) is lower than that of the control group ($SD = 8.365$), suggesting that student performance in the experimental group was more consistent and less dispersed around the mean. In contrast, the control group exhibited a wider score variation, reflecting less uniform learning achievements among students.

The minimum and maximum scores also support this interpretation. The experimental group scored 68 and 92, while the control group ranged from 52 to 84. This implies that students in the experimental group not only performed better on average but also maintained a higher baseline performance, with no extremely low scores recorded. In summary, the descriptive analysis demonstrates that using the STAD method with flashcards improved average student performance and promoted more equitable learning outcomes, reducing disparities and enhancing overall effectiveness in the classroom.

The histogram in Figure 3 presents the frequency distribution of post-test scores in the experimental class. It shows that most students, specifically 9 out of 25 (36%), scored within the 76–80 interval, making it the most common score range. The highest score interval, 91–

95, was achieved by three students (12%). This distribution indicates that most students scored above the class average, with a relatively balanced spread across higher intervals. The curve suggests a near-normal distribution with a slight skew toward higher scores, supporting the conclusion that the instructional intervention implemented in the experimental class effectively improved student learning outcomes.

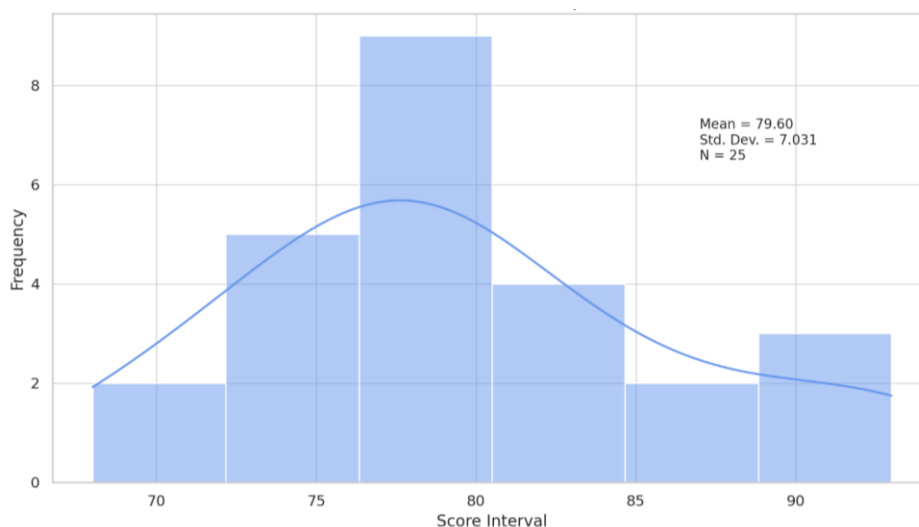


Figure 3. Histogram of Post-test scores in experimental class

The histogram in Figure 3 presents the frequency distribution of post-test scores in the experimental class. It shows that most students, specifically 9 out of 25 (36%), scored within the 76–80 interval, making it the most common score range. The highest score interval, 91–95, was achieved by three students (12%). This distribution indicates that most students scored above the class average, with a relatively balanced spread across higher intervals. The curve suggests a near-normal distribution with a slight skew toward higher scores, supporting the conclusion that the instructional intervention implemented in the experimental class effectively improved student learning outcomes.

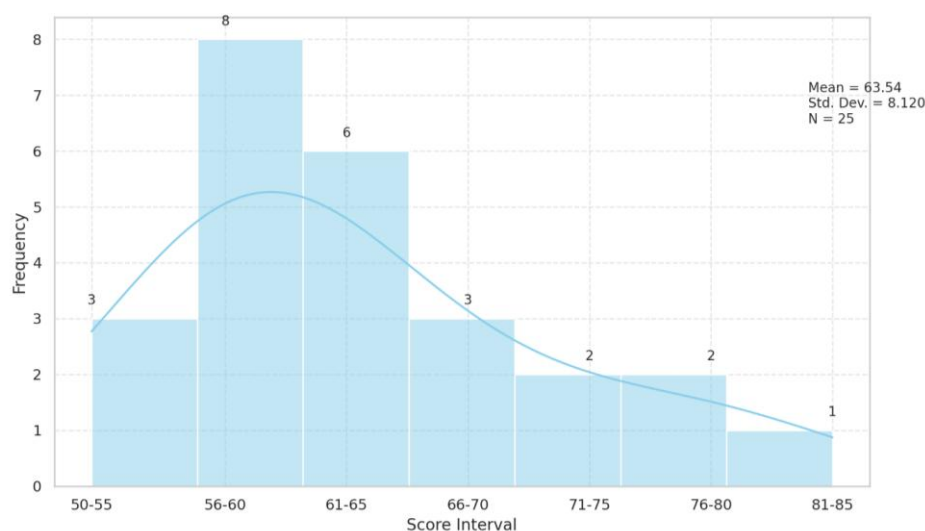


Figure 4. Histogram of post-test scores in control class

The histogram in Figure 4 illustrates the distribution of post-test scores in the control class. The most frequent score range is 56–60, achieved by eight students (32%), followed by the 61–65 interval with six students (24%). In contrast, only one student (4%) reached the highest score interval of 81–85. The curve indicates a slightly skewed distribution to the right, showing that most students scored below the mean of 63.54. This pattern suggests that, without the

intervention applied in the experimental class, the overall performance in the control class remained relatively moderate, with fewer students achieving higher scores.

3.2 Normality test

Before conducting further statistical analyses to determine the effectiveness of the intervention, it is essential to assess whether the data meet the assumptions of normality. Normality testing is a prerequisite for parametric tests such as the independent t-test, ensuring the reliability of the statistical results. In this study, the Shapiro–Wilk test was applied to evaluate the pre-test and post-test scores distribution in the experimental and control groups. The results of this test are summarized in Table 8.

Table 8. Shapiro–Wilk normality test

Class	Statistic	df	Sig.
Pre-test experimental	0.943	25	0.174
Pre-test control	0.949	25	0.147
Post-test experimental	0.939	25	0.141
Post-test control	0.942	25	0.16

The results of the Shapiro–Wilk normality test presented in Table 4 indicate that the data for all pre-test and post-test groups in the experimental and control classes are normally distributed. Specifically, the significance (Sig.) values for the pre-test in the experimental class ($p = 0.174$) and control class ($p = 0.147$), as well as for the post-test in the experimental class ($p = 0.141$) and control class ($p = 0.160$), are all greater than 0.05. Since these p-values exceed the conventional alpha level of 0.05, we fail to reject the null hypothesis of normality. This suggests that the data in all four groups do not significantly deviate from a normal distribution and are suitable for further parametric statistical analysis.

3.3 Homogeneity test

Before conducting further statistical analysis to compare the post-test results between the experimental and control groups, verifying whether the assumption of homogeneity of variances is met, this assumption ensures that the variability in scores is similar across the groups being compared, which is a critical requirement for parametric tests such as the Independent Samples T-Test. To assess this, Levene's Test for Homogeneity of Variances was performed, and the results are summarized in Table 9.

Table 9. Levene's test for homogeneity of variances

Results	Statistic	df1	df2	Sig.
Mean	0.894	3	96	0.457
Median	0.895	3	96	0.448
Median (adjusted df)	0.895	3	85.2	0.449
Trimmed mean	0.963	3	96	0.426

The results of Levene's Test for Homogeneity of Variances, as presented in Table 5, demonstrate that the data meet the assumption of equal variances across groups. The significance values for all test methods based on the mean ($p = 0.457$), median ($p = 0.448$), median with adjusted degrees of freedom ($p = 0.449$), and trimmed mean ($p = 0.426$) are all greater than the conventional threshold of 0.05. These findings indicate no statistically significant differences in variance between the experimental and control groups. Consequently, the assumption of homogeneity of variances is satisfied, allowing for the use of parametric tests such as the Independent Samples T-Test in the subsequent analysis.

3.4 Hypothesis testing

After confirming that the data are normally distributed and exhibit homogeneity of variances, the next step is to determine whether there is a statistically significant difference in post-test scores between the experimental and control groups. To test this, an Independent Samples T-Test was conducted. The results of this analysis are presented in Table 10.

Table 10. Independent Sample T-Test Results

Test	t	df	Sig. (2-tailed)
Equal variances assumed	7.135	48	0
Equal variances not assumed	7.135	47.13	0

The results of the Independent Samples T-Test, as shown in Table 10, reveal a statistically significant difference between the post-test scores of the experimental and control groups. The test yielded a t-value of 7.135 with a corresponding p-value of 0.000 ($p < 0.05$), which exceeds the critical t-table value of 2.010. This indicates that the alternative hypothesis (H_1) is accepted, confirming that implementing the STAD (Student Teams Achievement Divisions) cooperative learning method supported by flashcard media significantly improved student learning outcomes. Following this result, an N-Gain analysis was performed further to evaluate the applied method's effectiveness.

Table 11. N-Gain scores of learning outcomes

N	Min	Max	Mean	Average
25	0.2	0.8	0.5081	50.81% (Moderate Category)

Based on Table 11, the N-Gain scores of students' learning outcomes in the experimental and control classes show a minimum score of 0.20 and a maximum score of 0.80, with a mean value of 0.5081 or 50.81%. This average gain falls within the "moderate" effectiveness category. The results indicate that applying the STAD (Student Teams Achievement Divisions) cooperative learning model, supported by flashcard media, moderately positively influenced students' academic performance. Although the improvement was not in the high category, the learning model effectively facilitated measurable gains in students' understanding and mastery of the subject matter, demonstrating its potential as a beneficial instructional strategy in vocational education settings.

4. Discussion

This study explored the effectiveness of the Student Teams Achievement Divisions (STAD) cooperative learning model, integrated with flashcard media, in enhancing cognitive learning outcomes in Manufacturing Technical Drawing for vocational high school students. The results showed a statistically significant improvement in the experimental group's performance, as evidenced by higher post-test scores and more consistent results than the control group. The experimental group achieved a mean score of 79.68, outperforming the control group's 63.84, with a t-value of 7.135 ($p < 0.05$). The N-Gain score of 50.81% placed the improvement in the moderate category, underscoring the intervention's substantial impact.

These findings align with and extend existing literature. Prior studies ([Guntoro et al., 2024](#); [Safiudin, 2024](#); [Serjali & Halim, 2020](#)) have established that STAD enhances student collaboration, engagement, and academic achievement. Furthermore, ([H. Li, 2025](#)) emphasized the role of peer support in improving comprehension through collaborative learning. The improved outcomes observed in this study confirm these insights and reinforce the value of cooperative strategies in technical education.

Methodologically, data triangulation was applied through descriptive statistics, normality testing (Shapiro-Wilk), homogeneity testing (Levene's Test), and hypothesis testing

(Independent Samples T-Test). Descriptive statistics revealed a lower standard deviation in the experimental group, indicating more uniform learning achievements. The normality and homogeneity tests confirmed that the dataset met the assumptions required for parametric analysis. The T-Test established the statistical significance of the results, and the N-Gain analysis provided a nuanced understanding of the intervention's effectiveness.

Flashcards were pivotal in the STAD framework, serving as concrete visual aids to simplify abstract content in technical drawing. This aligns with ([Gayathri & Vijayalakshmi, 2025](#); [Xodabande et al., 2024](#)), who highlighted the power of visual media to enhance memory and concept acquisition. Furthermore, ([Hamer & Rohimajaya, 2018](#); [Inuk et al., 2021](#)), also stressed the importance of cognitive engagement, a function effectively fulfilled by flashcards in this study. These tools helped bridge the gap between complex content and student understanding, making instruction more accessible and engaging.

The novelty of this research lies in its integration of STAD and flashcards within a vocational education context, a domain underrepresented in prior cooperative learning studies. Particularly in Indonesian vocational schools, technical drawing instruction has seldom been paired with cooperative and visual strategies. This study therefore addresses a clear research gap, introducing a hybrid instructional model that is both innovative and contextually relevant. Theoretical contributions of this study include reinforcing the value of multimodal learning strategies and cooperative frameworks in vocational settings. Practically, the study offers a scalable, cost-effective teaching method adaptable across similar educational contexts. The success of this model suggests broader applicability in other technical subjects, especially where visual-spatial skills are critical.

For future research, longitudinal studies could evaluate the long-term effects of the STAD-flashcard model on student retention and performance across multiple semesters. Additionally, qualitative approaches such as classroom observations and student interviews may uncover deeper insights into learner motivation, engagement, and perceptions. Future adaptations might incorporate digital flashcards or gamified learning platforms to increase interactivity and student interest further. In summary, the STAD cooperative learning model supported by flashcard media has demonstrated its effectiveness in enhancing student achievement in Manufacturing Technical Drawing. By combining collaborative structures with engaging visual tools, this approach improves academic outcomes and cultivates critical soft skills essential for 21st-century learners. The model presents a compelling pedagogical alternative for vocational educators seeking practical, innovative strategies to transform their classrooms.

5. Conclusion

The study confirms that integrating the STAD cooperative learning model with flashcard media significantly enhances student achievement in Manufacturing Technical Drawing. The experimental group demonstrated higher performance, with more consistent results and greater engagement than the control group. Cooperative learning and visual aids proved an effective instructional strategy, facilitating better comprehension and retention of technical concepts. This model shows promise as a practical and scalable teaching approach for vocational education, offering a novel and engaging method that can be adapted across various technical subjects. Future studies should consider exploring the long-term effects of this intervention and include qualitative research to gain deeper insights into student experiences and engagement. The study was limited to one semester and focused on a specific vocational class. The short-term nature of the intervention restricts the ability to assess long-term impacts on student retention and mastery of the material. Additionally, the sample size was relatively small, limiting the generalizability of the findings. Further research with larger sample sizes and longitudinal studies would provide more robust insights into the effectiveness and sustainability of the STAD-flashcard model in vocational education.

Author's Declaration

Author contribution

Yoan Alfarezy Indra: Conceptualization, methodology, software, investigation, writing - original draft, formal analysis, visualization. **Febri Prasetya:** Methodology, data validation, writing - review & editing, software, visualization. **Primawati:** Conceptualization, supervision, project administration, resources, writing - review & editing. **Zainal Abadi:** Methodology, data analysis, writing - review & editing, visualization.

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Competing interest

The authors declare that there are no competing interests related to the research or publication of this article.

Ethical clearance

This research involved human participants (students). All participants were informed about the study's purpose, procedures, and their rights, and their participation was voluntary. Informed consent was obtained from all participants prior to the study. All data collected from the participants were handled confidentially and anonymized to ensure privacy. The research procedure was in accordance with the Declaration of Helsinki regarding the involvement of humans as research subjects. Ethical approval for this study was obtained from the West Sumatra Provincial Education Office, as documented in letter number 000.9/3068/SEK/DISDIK-2025.

Data availability

Due to the involvement of human participants, the raw research data are not publicly available to protect confidentiality.

AI statement

Grammarly was used to improve the grammatical structure of this article. The authors reviewed and verified the accuracy of the content, and an English language expert validated the data and language used.

Publisher's and Journal's Note

Researcher and Lecturer Society as the publisher, and the editor of Journal of Engineering Researcher and Lecturer state that there is no conflict of interest towards this article publication.

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