Enhancing Learning Outcomes in Mechanical Drawing Practice Courses Using Student Teams Achievement Divisions

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Received 28 December 2024; received in revised form 11 June 2025; accepted 12 June 2025

DOI: https://doi.org/10.46604/emsi.2024.14690

Abstract

This study applies the STAD teaching method in a mechanical drawing course for 14 tenth-grade vocational students in Taiwan. It uses a three-cycle action research design to verify its effectiveness empirically. The results show improved learning outcomes, notable progress among female students, and enhanced self-efficacy. However, STAD slightly reduced students' willingness to engage in peer discussions. In addition, the method supports teacher professional development. Future research is recommended to explore its broader applicability and long-term effects.

Keywords: mechanical drawing practice, Student Teams Achievement Divisions (STAD), learning motivation, learning outcomes, action research

1. Introduction

The goal of technical and vocational education is to help students develop adaptively, quickly adjust to industries, and become professionals after graduation. However, according to an investigation by the Ministry of Education [1], most vocational high school students still choose to pursue further education rather than enter the workforce directly. From 2017 to 2021, the enrolment rate of recent graduates from the specialty group division ranged between 79.4% and 82.4%, while the employment rate was only between 12.2% and 14.5%.

All students related to the mechanical industry, whether designers or makers, need a deep understanding of mechanical drawings to collaborate effectively with teams and ensure production quality. Proficiency in reading and drafting mechanical drawings is crucial for enrollment in higher education and employment in the mechanical sector, making "mechanical drawing practice" a critical course.

However, the existing literature provides limited discussion on the application of STAD in specialized subjects at vocational high schools. Therefore, the uniqueness of this study lies in its exploration of the practical implementation and effectiveness of STAD in a mechanical drafting practice course. The researcher selected STAD as the instructional method for this course primarily because numerous studies have shown that cooperative learning strategies can significantly enhance students' motivation and academic achievement.

Furthermore, STAD is relatively easier to implement than other instructional approaches. Consequently, this study adopts STAD as the teaching strategy for the mechanical drafting practice course, intending to empirically verify its effectiveness.

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2. Literature

2.1. Mechanical Drawing Practice Course

Mechanical drawing practice is an important specialized subject for mechanical groups in technical high schools, covering mechanical division, casting division, sheet metal division, and other related fields. Three credits are allocated for both the first and second semesters of the first year, totaling six credits in total [2]. This course significantly impacts students' future enrollment in higher education and employment. The course content includes engineering drawing interpretation, drawing tools, lines, notations, and orthographic drawing reading and drafting. This research focuses on "orthographic drawing, reading, and drafting" and discusses relevant knowledge, line sequence, and teaching content for drawing interpretation and drafting.

2.2. Student Teams-Achievement Divisions (STAD)

Student Teams Achievement Divisions (STAD) is a common cooperative learning mode that promotes student academic progress through heterogeneous grouping and mutual assistance between team members [3]. Its core emphasis is on team cooperation, individual progress, and collective performance to maximize learning achievement. Heterogeneous grouping allows students to learn from one another and fosters the sharing and discussion of knowledge from diverse backgrounds, thereby improving each student's learning outcomes.

The implementation process of STAD involves heterogeneous grouping, team discussion, and individual assessments. Individual progress is evaluated based on the difference between an individual's test and baseline scores, motivating continuous improvement and relieving competitive pressure. Meanwhile, team scores are calculated by the combined improvement of all members. This approach emphasizes the synergistic effect of group collaboration, encouraging students to assist one another and form an active learning environment.

STAD has been validated across multiple subjects and teaching environments as an effective teaching method, particularly in fields requiring a deep understanding and application of knowledge [4]. It promotes active learner participation and facilitates knowledge construction through collaborative engagement [5]. It enhances students' academic performance and improves their learning motivation and cooperative abilities, which is especially beneficial for students with weaker academic skills. Through team support, these students can gradually build confidence and competence, leading to the collective growth of both individuals and groups.

2.3. Learning Motivation and Learning Achievement

Learning motivation is a key factor in helping students reach their learning targets, and its sources can include both an inner thirst for knowledge and external rewards [6,7]. The reinforcement theory emphasizes influencing behavior through rewards and punishments, the demand theory promotes learning engagement by satisfying students' basic demands, and cognitive theory addresses students' attribution and confidence in learning [8,9]. Learning effectiveness is typically assessed through tests that evaluate students' knowledge acquisition, providing a basis for teachers to improve their instruction. Students' abilities, environment, teaching methods, and other factors are considered comprehensively to promote their holistic development [10].

2.4 The Application of STAD in Vocational Education

An analysis of the seven related studies and journal articles listed above reveals that the majority of research subjects are concentrated among elementary and junior high school students. In contrast, studies involving students from technical high schools are relatively scarce, with only two papers focusing on this demographic. Regarding the subjects in which the STAD

method was implemented, three studies targeted mathematics, followed by English and biology. Within the context of technical high schools, one study each was conducted on mechanical engineering and food and beverage service practices.

Six studies indicated that the implementation of the STAD method significantly enhanced students' learning motivation [11, 12, 13, 14, 15, 17, 18]. C. F. Shen [16], while reporting no significant improvement in learning motivation, noted that STAD cooperative learning could enhance teaching effectiveness from the instructor's perspective.

Table 1 Items of the Learning Motivation Scale for the Mechanical Drawing Practice Course

Researcher	Subject Area	Research Findings
W. Y. Chang [18]	Elementary School Mathematics	The implementation of STAD increased learning motivation and academic achievement among second-grade students.
Y. C. Tsai [13]	Elementary School English	(1) STAD helped enhance students' English learning performance. (2) Most students responded positively to the instructional approach.
Y. L. Hsueh [17]	Junior High School Mathematics	(1) The experimental group showed a significant difference in learning motivation before and after instruction. (2) Their math achievement was significantly higher than that of the control group.
C. F. Shen [16]	Food and Beverage Service Practice in the Department of Tourism Industry (Vocational High School)	(1) No significant improvement in learning motivation after implementing STAD. (2) STAD helped improve students' learning outcomes.
W. T. Chen [14]	Mechanical Mechanics (Vocational High School)	(1) Improvement in students' academic achievement. (2) Improvement in students' learning attitudes.
P. Y. Tsai [12]	Junior High School Mathematics	(1) Students' post-test scores in math achievement were significantly higher than their pre-test scores after cooperative learning was implemented. (2) Cooperative learning effectively enhanced students' motivation and attitudes.
Z. R. Jia [11]	Junior High School Biology	(1) The experimental group scored higher in self-efficacy and achievement tests than the control group, though the difference was not statistically significant. (2) Students responded positively to the course design.

Moreover, six studies demonstrate that STAD significantly improved students' academic performance [12, 13, 14, 15, 16, 17, 18]. One study indicated that STAD did not result in a significant enhancement in learning achievement; however, it proposed that extending the duration of implementation could produce more noticeable effects [11].

The researcher identifies a deficiency in studies concentrating on professional subjects within technical high schools. To address this research gap, the current study selects the Mechanical Drafting Practice course at a technical high school as the focus for the implementation of STAD, aiming to investigate its practical effectiveness in this educational setting

3. Research Design and Implementation

This research aims to discuss the application of STAD in mechanical drawing practice courses and observe its influence on students' learning motivation and learning achievement.

This research adopted a behavioral study approach to improve students' learning motivation and learning achievement in mechanical drawing practice and address issues encountered in the teaching environment through continuous implementation and reflection. The research was conducted in a hand-drawing classroom at a technical high school. The participants were 14 first-year students from the Further Study Department who were divided into four groups. Heterogeneous grouping was based on students' learning status and gender to implement the STAD teaching method. Research tools included a learning motivation scale, a learning achievement test, and a team learning sheet. Data collection consisted of both quantitative and qualitative

data. Analysis was conducted by organizing and coding the data to evaluate the influence of team cooperation on learning motivation and learning achievement.

3.1 Research Participants

This study selected 14 first-year students (4 females and 10 males) from the Drafting Department of the Continuing Education Division at a technical high school as research participants. The selection of this group was based on the following criteria:

First, students in the Continuing Education Division typically work during the day and can only attend classes at night, which limits their available learning time and may negatively impact their academic performance. This study aims to explore strategies for enhancing learning motivation and achievement; therefore, this group was selected to improve their learning conditions through action research.

Second, based on the results of a pretest on academic performance, students were divided into heterogeneous groups for cooperative learning. Each group included students with high, medium, and low achievement levels, ensuring the presence of at least one female student in each group. This grouping strategy aimed to foster peer support and enhance overall learning outcomes. Consequently, the number of participants was determined to meet the requirements for heterogeneous grouping while also aligning with the actual class size, thereby ensuring the feasibility and effectiveness of the research design.

3.2 Data Collection and Analysis

This study collected and analyzed both qualitative and quantitative data to evaluate the impact of the STAD teaching method in the Mechanical Drafting Practice course, ensuring the completeness, reliability, and validity of the research.

3.3 Research Instruments

The Learning Motivation Scale was administered before and after the implementation of the Student Teams-Achievement Divisions (STAD) method for pre- and post-test analysis.

Learning Achievement Tests were conducted before and after the implementation of STAD and were analyzed using descriptive statistics and paired-sample t-tests.

Weekly Quizzes: These assessments are designed to evaluate student progress, calculate group scores, and adjust baseline scores.

(1) Task Report Sheets: Documented group observations and proposed solutions.
(2) Group Peer and Self-Evaluation Forms: These forms enable learners to evaluate their collaboration within the group.
(3) Teacher Observation Forms: Documentation of classroom discussions and interactions.
(4) Teacher's Teaching Journal: Documented post-class reflections and adjustments to teaching strategies.
(5) Learning Feedback Forms: Collected student opinions and experiences regarding the STAD method.

Qualitative data were organized by date and source, and triangulation was employed to ensure the reliability and validity of the study, which included:

(1) Multiple Methods: Cross-validation utilizing diverse data sources (e.g., report sheets, feedback forms).
(2) Multiple Data Sources: Involving various subjects and time points to enhance the reliability of the findings

4. Results and discussion

4.1. Teaching Process

The first teaching session was held on December 17, 2023. Issues identified included a lack of active discussion among

students, insufficient concentration, improper allocation of teaching time, and some students simply copying the answers without achieving the expected test scores. To address these issues, the teachers provided active guidance, used random questioning, and eliminated unnecessary activities to enhance students' self-learning and focus.

The second teaching session took place on December 14, 2023. Challenges encountered included unclear explanations of concepts, uneven distribution of learning sheets, and students not achieving the basic test scores. To resolve these problems, the teacher introduced 3D drawing software to assist with teaching, improved the grouping strategy, and redesigned the test in Fig. 1 to enhance students' understanding and ability to apply knowledge.

The third teaching session occurred on December 21, 2023. The main difficulties were excessive time spent on model creation and a lack of team cohesion. The teacher implemented time limits, introduced a point deduction system, and minimized unnecessary group interaction to improve teaching efficiency and foster team cooperation.

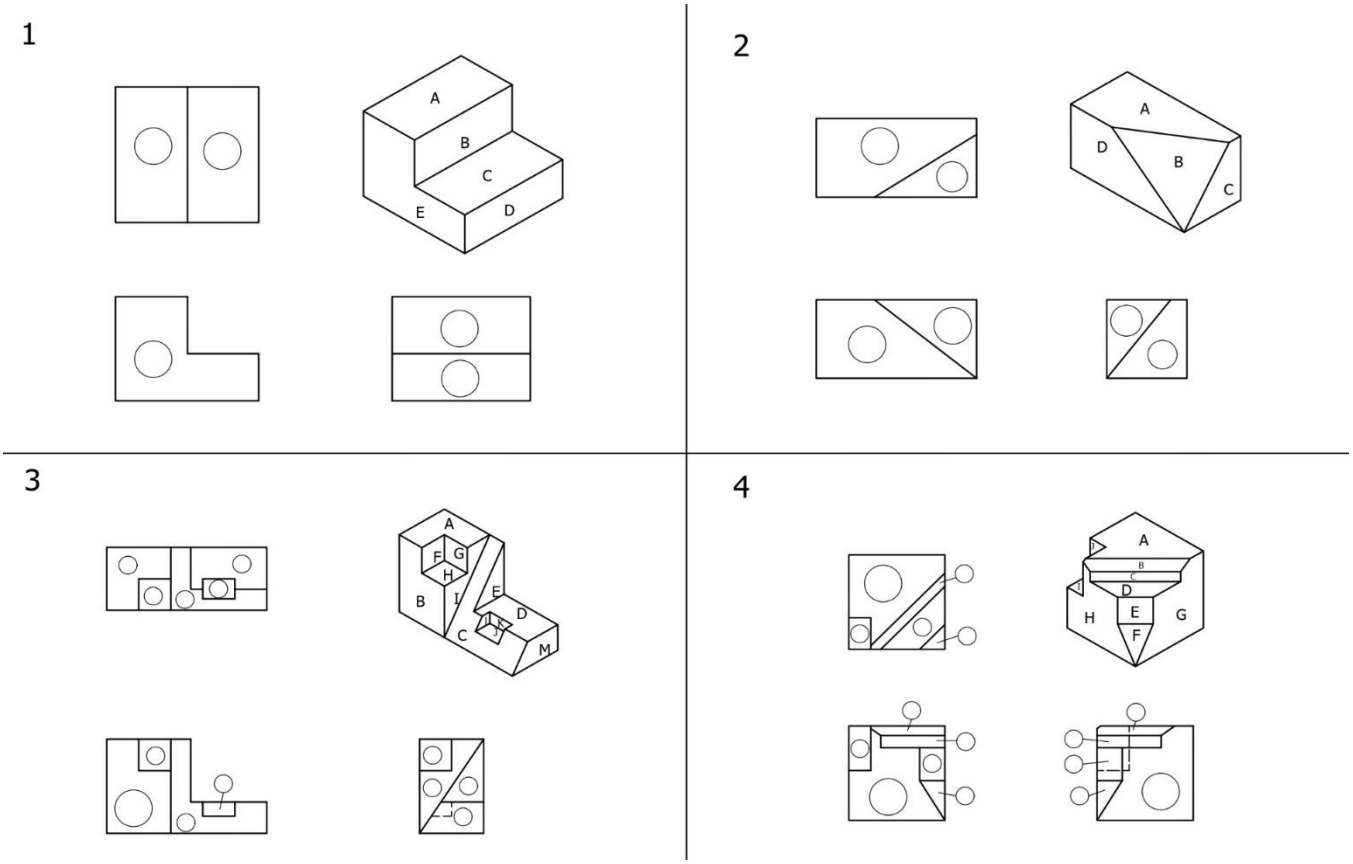


Fig. 1 Drawing recognition practice

4.2. Influence of Implementing STAD in Mechanical Drawing Practice Course on Learning Motivation

To explore the influence of STAD on learning motivation in the mechanical drawing practice course, a systematic analysis was conducted on the learning motivation scale data before and after the implementation of STAD in this research. Changes in the data measured before and after the implementation of this method will be elaborated on in this section. Four aspects of the scale were compared and analyzed; the data are listed in Table 2. The scale items are shown in Table 3.

Table 2 Analysis of Pre-test and Post-test Scale about Learning Motivation in Mechanical Drawing Practice

Aspect	Number of Problems	Average of Pre-test Scale	Sequence of Pre-test Scale	Average of Post-test Scale	Sequence of Post-test Scale
Learning Attitude	11	3.47	3	3.64	2
Learning Situation	9	3.80	1	3.74	1
Self-efficacy	7	3.25	4	3.48	4
Knowledge Application	3	3.53	2	3.56	3

Table 3 Items of the Learning Motivation Scale for the Mechanical Drawing Practice Course

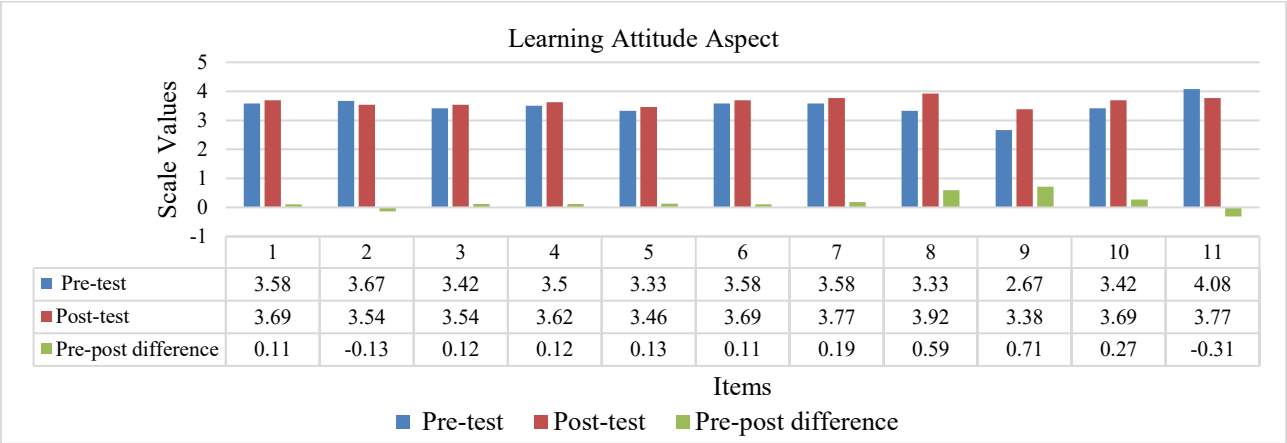
Aspect	Items
Learning Attitude Aspect	1. I look forward to taking the Mechanical Drawing Practice Course.
	2. The mechanical drawing practice course can arouse my curiosity
	3. I am eager to explore topics related to the Mechanical Drawing Practice Course.
	4. I enjoy subjects related to the Mechanical Drawing Practice Course.
	5. The Mechanical Drawing Practice Course is one of the subjects I am most interested in.
	6. I enjoy the course content of the Mechanical Drawing Practice Course.
	7. I like the teaching approach of the Mechanical Drawing Practice Course.
	8. I hope to have more time for the Mechanical Drawing Practice Course.
	9. The thought of learning the Mechanical Drawing Practice Course makes me feel very nervous.
	10. Learning the Mechanical Drawing Practice Course makes me feel physically and mentally exhausted.
	11. I worry about the scores of the mechanical drawing practice course
Learning Situation Aspect	12. I am willing to spend more time learning the knowledge related to the Mechanical Drawing Practice Course.
	13. I am willing to take the initiative to spend time learning mechanical drawing.
	14. I often discuss issues related to the Mechanical Drawing Practice Course with my classmates.
	15. During the Mechanical Drawing Practice Course, I often lose track of time until class is over.
	16. I can focus and immerse myself when taking the Mechanical Drawing Practice Course.
	17. When I encounter problems related to mechanical drawing, I am willing to seek help from others.
	18. If there are parts I don't understand in the Mechanical Drawing Practice Course, I will find ways to understand them.
	19. I am willing to put in effort to complete the assignments for the Mechanical Drawing Practice Course.
	20. Regardless of my exam scores, I am willing to participate in activities during the Mechanical Drawing Practice Course.
Self-efficacy Aspect	21. I can understand the learning content of the Mechanical Drawing Practice Course.
	22. I express my thoughts during the Mechanical Drawing Practice Course.
	23. I can help other students learn during the Mechanical Drawing Practice Course.
	24. I am capable of completing the assignments for the Mechanical Drawing Practice Course well.
	25. I will gain a sense of achievement from the Mechanical Drawing Practice Course.
	26. I am very satisfied with my performance in the Mechanical Drawing Practice Course.
	27. I am confident that I can do well in the Mechanical Drawing Practice Course.
Knowledge Application Aspect	28. Learning mechanical drawing practice is very important for my future life.
	29. I believe that after graduation, I will have basic job skills in mechanical drawing.
	30. The knowledge I acquire in mechanical drawing will be helpful for my future work.

The analysis results indicate that the average score of students in the aspect of "learning attitude" increased from 3.47 to 3.64, with an increase of 0.17. This suggests that STAD had a positive influence on learning attitudes. In the aspect of "learning situation," the average slightly decreased from 3.80 to 3.74, a decrease of 0.06. This shows that the influence of STAD is slightly negative. In the aspect of "self-efficacy," the average score increased from 3.25 to 3.48, an improvement of 0.23, demonstrating a clear positive impact of STAD. In terms of "knowledge application," the average score rose from 3.53 to 3.56, an increase of 0.03, indicating a modest positive effect of STAD on knowledge application. Overall, the improvement in "self-

efficacy" was the most significant following the implementation of STAD, which is consistent with the findings of Jia [11]. Although "learning attitude" and "knowledge application" improved, "learning situation" showed a slight decline.

4.2.1. Learning Attitude Aspect

Taken together, Fig. 2 and the data from the pre-test and post-test scales for the aspect of learning attitude indicate that the averages of other items showed a positive increase, except for the items "The mechanical drawing practice course can arouse my curiosity" and "I worry about the scores of mechanical drawing practice course," which decreased by 0.13 and 0.31, respectively. Notably, the increases in "thinking of learning mechanical drawing practice makes me very nervous" and "hope to have more time to take mechanical drawing practice class" are the most significant, rising by 0.71 and 0.59, respectively. This suggests that the students' "learning attitudes" improved after teaching.

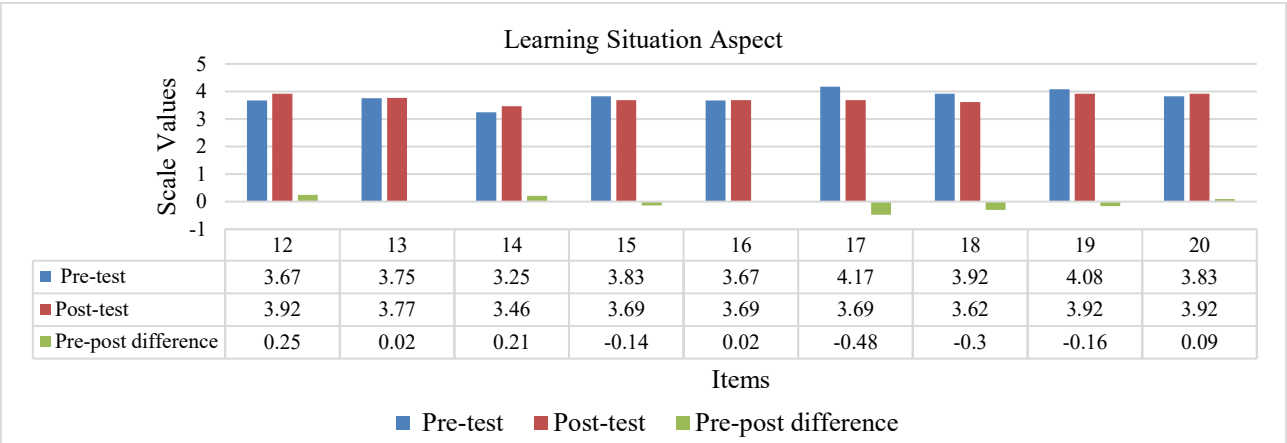


	1	2	3	4	5	6	7	8	9	10	11
Pre-test	3.58	3.67	3.42	3.5	3.33	3.58	3.58	3.33	2.67	3.42	4.08
Post-test	3.69	3.54	3.54	3.62	3.46	3.69	3.77	3.92	3.38	3.69	3.77
Pre-post difference	0.11	-0.13	0.12	0.12	0.13	0.11	0.19	0.59	0.71	0.27	-0.31

Fig. 2 Line Chart for Pre-test and Post-test Scale of Learning Attitude Aspect

4.2.2. Learning Attitude Aspect

Fig. 3 and the data from the pre-test and post-test scales for the aspect of the learning situation indicate that average scores for the five items showed a positive increase. Notably, the average in the post-test for "I'm willing to spend more time learning the content of the mechanical drawing practice course" rose by 0.25, which is the maximum increase; secondly, the average in the post-test for "I often discuss problems about mechanical drawing practice course with classmates" increased by 0.21 compared to the pre-test. However, the average scores for the four items showed a decrease, with the average for "I'm willing to turn to others for help when encountering problems about the mechanical drawing practice course" decreasing the most, with an average in the post-test decreased by 0.48 compared to the pre-test. Overall, the average for the learning situation decreased by 0.06, suggesting a slight downward trend in students' learning situation after the implementation of the teaching strategy.

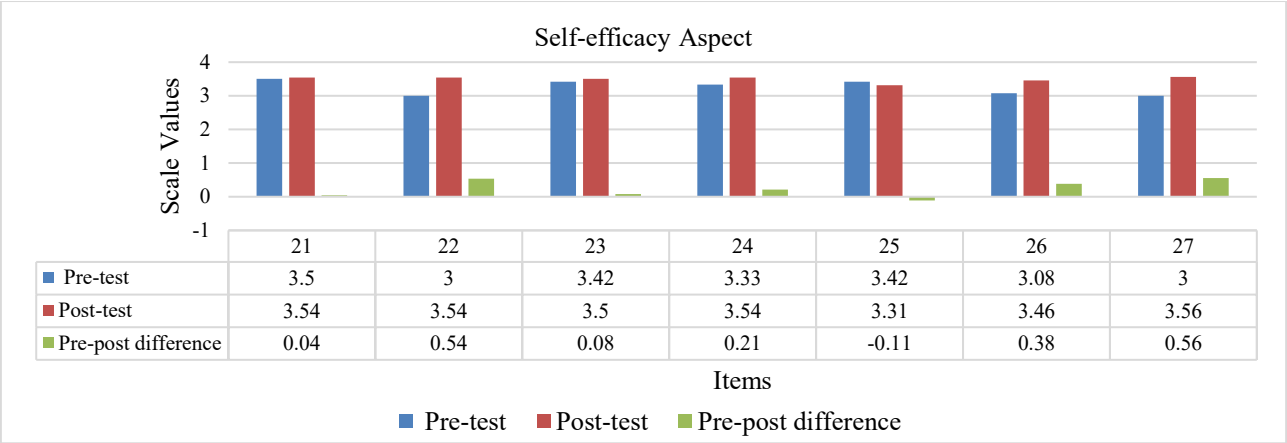


	12	13	14	15	16	17	18	19	20
Pre-test	3.67	3.75	3.25	3.83	3.67	4.17	3.92	4.08	3.83
Post-test	3.92	3.77	3.46	3.69	3.69	3.69	3.62	3.92	3.92
Pre-post difference	0.25	0.02	0.21	-0.14	0.02	-0.48	-0.3	-0.16	0.09

Fig. 3 Line Chart for Pre-test and Post-test Scale of Learning Situation Aspect

4.2.3. Self-efficacy Aspect

Taken together, Fig. 4 and the data from the pre-test and post-test scales for the self-efficacy aspect indicate that the averages of other items showed a positive increase, except for the average of "I get a sense of achievement from the mechanical drawing practice course," which declined by 0.11. Notably, the increase for "I express my thoughts when taking a mechanical drawing practice course" is the largest, with an average rise of 0.54. The average for "I have confidence in learning the mechanical drawing practice course" ranks second, increasing by 0.46. The overall scales from the pre-test and post-test show that the average rose by 0.23, indicating that students' sense of self-efficacy was enhanced through the implementation of the teaching strategy.

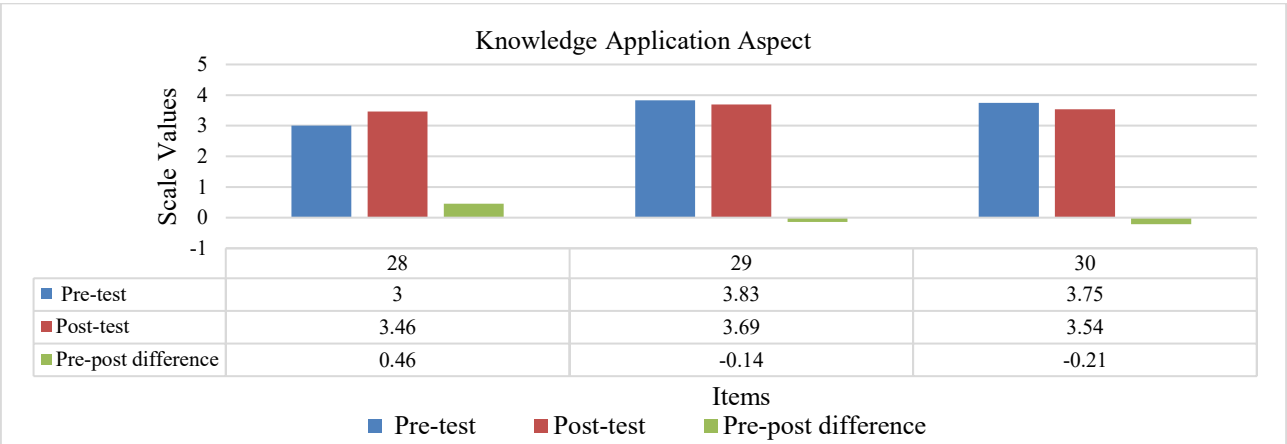


	21	22	23	24	25	26	27
Pre-test	3.5	3	3.42	3.33	3.42	3.08	3
Post-test	3.54	3.54	3.5	3.54	3.31	3.46	3.56
Pre-post difference	0.04	0.54	0.08	0.21	-0.11	0.38	0.56

Fig. 4 Line Chart for Pre-test and Post-test Scale of Self-efficacy Aspect

4.2.4. Knowledge Application Aspect

Fig. 5 and the data in pre-test and post-test scales for the aspect of knowledge application indicate that the averages of the other two items decreased, except for the average of "learning mechanical drawing practice is very important to my life," which increased by 0.46. The overall average also declined by 0.03. This indicates that the perceived importance of mechanical drawing practice to students' lives was not significantly enhanced through the teaching intervention.



	28	29	30
Pre-test	3	3.83	3.75
Post-test	3.46	3.69	3.54
Pre-post difference	0.46	-0.14	-0.21

Fig. 5 Line Chart for Pre-test and Post-test Scale of Knowledge Application Aspect

In summary, following the implementation of STAD over three sessions, the most significant improvement among participants was observed in the area of self-efficacy. This finding aligns with the results of Jia [5], indicating that the use of STAD can effectively enhance students' sense of self-efficacy. Additionally, modest gains were noted in the areas of learning attitude and knowledge application. However, a slight decline was observed in the domain of learning engagement.

The researcher speculates that this decline in learning engagement may be attributed to a shift in instructional focus. Before the action research, classes primarily centered on individual drafting tasks with limited theoretical instruction. In contrast, the three STAD-based sessions placed greater emphasis on theoretical content, which may have led students to perceive class time as longer and less engaging.

Additionally, many group worksheets were based on textbook content or key points provided by the teacher, enabling students to refer to answers already completed by their peers. Consequently, there was a reduced need for peer discussion or deeper understanding of key concepts, as simply copying answers was often sufficient to earn points..

4.3. Influence of Implementing STAD in Mechanical Drawing Practice Course on Learning Achievement of Students

This research aimed to analyze the influence of the STAD teaching method on students. The research subjects comprised 14 participants, including four women and ten men. All subjects completed a learning achievement test on mechanical drawing practice. This test comprised a total of 32 questions, including 18 multiple-choice questions, six drawing questions, and two essay questions. Statistical analysis results indicate that the average score of the pre-test is 11.57, while that of the post-test is 32.29 in Table 4. The increase in the post-test score exceeds 20 points and is statistically significant at the level of p <.001.

Table 4 Test of Paired-sample t of Learning Achievement Test Paper on Mechanical Drawing Practice

Pre-test		Post-test		*t*	95% Confidence Interval of Difference	
Average	Standard Deviation	Average	Standard Deviation		Lower Limit	Upper Limit
11.57	10.12	32.29	12.07	-6.39***	-27.72	-13.71

Note: ***p<.001

Table 5 Students' Scores in Pre-test and Post-test on Learning Achievement Test Paper of Mechanical Drawing Practice

Student No.	Pre-test Score	Post-test Score	Increased Score	Sequence of Increased Score
S01	6	38	32	3
S02	15	54	39	2
S03	3	51	48	1
S04	12	37	25	4
S05	21	33	12	11
S06	0	20	20	6
S07	0	18	18	7
S08	15	26	11	13
S09	18	31	13	10
S10	36	52	16	8
S11	0	25	25	5
S12	12	15	3	14
S13	6	18	12	12
S14	18	34	16	9
Minimum	0	15	3	
Maximum	36	54	48	
Average	11.57	32.29	20.70	

Detailed data regarding student scores in the pre-test and post-test for learning achievement in mechanical drawing practice are presented in Table 5. The range of the pre-test is from 0 to 36 points, while the post-test ranges from 15 to 54 points. The increased scores for the entire class range from 3 points to 48 points, indicating that all students showed measurable progress.. Notably, the five students with the greatest improvements were S03, S02, S01, S04, and S11—four of whom (S01 to S04) were female. This suggests that female students exhibited particularly significant gains in learning achievement..

In summary, the findings of this study indicate that the implementation of the Student Teams-Achievement Divisions (STAD) approach in a mechanical drawing practice course had a statistically and educationally significant positive impact on students' academic performance. These results are consistent with prior research conducted by P. Y. Tsai [12], Y. C. Tsai [13], W. T. Chen [14], C. F. Shen [16], Y. L. Hsueh [17], and W. Y. Chang [18]. Moreover, this study identified a notable improvement among female students—a result that has not been widely reported in existing literature and may warrant further exploration in future research.

4.4. Analysis and Discussion on the Feedback Sheet of the Mechanical Drawing Practice Course

After concluding the three mechanical drawing practice course sessions, the researchers analyzed the students' feedback sheets. The analysis can be divided into seven parts:

(1) Team learning sheet: Student widely believed that the learning sheet is conducive to deepening their understanding and providing opportunities for review. For instance, S03 mentioned that answers can be conveniently found, while S14 expressed that combining the learning sheet with engaging teaching methods allows for a clearer understanding of their learning progress.
(2) Individual test: Students hoped to have more time for review to enhance their understanding and scores. Both S03 and S04 indicated that additional time for digestion is needed to connect the learning sheet with the examination.
(3) Teaching of teachers: Students suggested that teachers should use diagrams to assist with teaching (S03) and demonstrate patience (S04, S09).
(4) Cooperative team members: Students responded positively to the supportive atmosphere (S05, S06); however, some students (S03, S09) expressed dissatisfaction with team members who did not offer assistance.
(5) Self-acting in the group: Most students believed they participated actively (e.g., S05 took a leading role, and S03 provided answers), while some students (e.g., S10) felt they mainly received help.
(6) Self-expression: Students' assessment of their performance varies. Satisfied students (S02, S04) believed their performance was good, while dissatisfied students (S01, S11) mentioned insufficient concentration.
(7) Suggestions on the course: Students suggested increasing review and practical courses (e.g., S04) and supporting continuing team learning (e.g., S12). However, some students (e.g., S03, S09) were dissatisfied with the grouping and believed it may lead to unfair scoring.

Overall, student feedback indicates that the team learning sheet, teaching methods, and cooperation positively influence learning achievement. However, there is still room for improvement, such as increasing review opportunities and adjusting grouping strategies.

Based on student feedback, the following suggestions have been proposed to enhance the implementation of the STAD learning strategy:

(1) Enhance Review Opportunities and Practical Sessions

Students have expressed a desire for more opportunities to review course content, especially before examinations, as they believe this would enhance their comprehension and retention. Additionally, they suggested incorporating more hands-on practical activities, as these experiences deepen their understanding and improve overall learning effectiveness.

(2) Continue Group-Based Learning

The student specifically recommended the continued use and expansion of group-based learning in future lessons. They observed that collaborative learning not only improved learning efficiency but also positively impacted their overall educational experience.

In summary, students felt that additional review time and practical opportunities would deepen their understanding of the course material, while collaborative group work could further enhance their cooperative learning skills.

5. Conclusion

The purpose of this study was to investigate the impact of implementing the STAD cooperative learning strategy in a mechanical drafting practice course on students' learning motivation and outcomes, as well as to analyze its contribution to teachers' professional development. The participants included 14 first-year students (four females) from the evening division of the Department of Drafting at a technical high school in Taiwan. An action research approach was adopted, involving three instructional cycles over a total of 15 sessions, during which both quantitative and qualitative data were collected and analyzed.

(1) Students' average test scores improved from 11.57 to 32.29 points, with female students demonstrating the most significant progress. This finding suggests that the STAD method can effectively enhance students' academic performance.
(2) STAD significantly increased students' engagement and confidence in the course. The most notable improvement was observed in the area of self-efficacy, indicating that STAD fosters the development of autonomous learning attitudes.
(3) Student engagement was relatively low during theoretical lessons. Certain worksheets resulted in increased copying behavior, which negatively impacted the depth of learning and the quality of classroom interaction.
(4) Through the three action research cycles, the teacher engaged in continuous reflection and made adjustments to the course, thereby enhancing their understanding of cooperative learning strategies and instructional design skills.
(5) This study focused on a single class in the evening division of a technical high school, which had a small sample size. Most students were employed during the day, creating a learning context that differed from that of full-time students. Consequently, the findings may not be generalizable to other populations. Future research should aim to expand the sample size and investigate the effectiveness of the Student Teams-Achievement Divisions (STAD) method in various professional fields or educational settings to enhance the breadth and depth of the research.

Although the results indicate that STAD can enhance students' learning outcomes and self-efficacy, overall classroom participation still needs improvement. It is recommended that teachers tailor group roles according to students' characteristics and course content, and create worksheets that are both challenging and interactive to discourage mere copying. Furthermore, increasing the time allocated for practical activities and group discussions may further promote active student participation and foster deeper learning engagement.

Conflicts of Interest

The authors declare no conflict of interest.

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