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The Impact of collaborative learning strategies on Engineering Students' Ability to Problem Solve and Apply Theories to Practical Applications

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Session XXXX

The Impact of collaborative learning strategies on Engineering Students' Ability to Problem Solve and Apply Theories to Practical Applications

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Abstract

Teaching is a demanding mission and complex task. Several teaching methods have been implemented to enhance students' learning outcomes and deliver materials most effectively. Most of those studies focused on students in the fields of education. There has been a lack in observing those methodologies in the engineering fields. Engineering is one of the challenging fields and requires additional efforts and new creative ways in delivering the materials to ensure optimal outcomes. This requires additional efforts associated with employing various teaching strategies. Additional data is required in the field of engineering to evaluate the optimal teaching pedagogies that can fit various engineering topics and the nature of engineering classrooms. This study focused on the impact of collaborative learning strategies on engineering students' ability to problem solve and apply theories to practical applications. Statics course is considered one of the core courses and the challenging courses for students in the fields of Mechanical, Civil, Environmental Engineering. Think-Pair-Share TPS pedagogy was adopted as a teaching tool in this course to enhance students' ability to understand the course contents. TPS is one of the active learning methodologies that showed promising outcomes in the field of education. However, its influence on the engineering field in general and Statics course in specific is still ambiguous and yet to be explored. The quantitative method approach was used in collecting and analyzing the data. The study showed that this interactive pedagogy reflected an increase in students' performance over traditional lectures.

Introduction

Think Pair Share is a cooperative learning method that gives students time to think and respond and help each other, by which time the thought be a powerful factor in improving students' ability to respond to questions[1]. Many researchers have suggested that think-pair-share, are one of the pedagogical practices that aims to support a more participatory and interactive experience for students in the college classroom and encourage learning and connections across time and place[2,3]. Considerable research suggests that the ability to engage and collaborate with others encourages learning and the creation of knowledge[4,5]; however, most traditional college classrooms and learning management systems are teacher-centered pedagogy in which the instructor provides the content[6].

Direct learning is teacher centered, interaction between students is lacking, and there are no cooperative groups. Lack of activity makes students face difficulties in understanding the learning material. Therefore, it should take a learning model that stimulates students' responses and activeness[7]. Linsenmeyer suggested that traditional class lectures can be enhanced by turning them into "interactive class lectures". Interactive class lectures diffuse active learning opportunities throughout traditional class lecture and across the class time period. Interactive class lectures include opportunities for student interaction with their peers and the instructor. This helps students begin to work towards active learning that promotes development, evaluation, and revision of information networks used to understand the real world and learn how to implement theories into practical applications[8].

Think-pair-share is a teaching strategy that promotes active and collaborative learning; however, the effectiveness and applicability of this strategy in its original or altered form remain to be established in various educational fields[9]. This research objective is to determine the influence of think-pair-share on achievement and understanding of engineering concepts and problem solving in student learning. In addition, this study is aim to determine the impact of the interactive lecture on engineering students' ability to apply theories to practical applications.

Research Methods

During this study, nineteen students from ENGR 2321: Engineering Mechanics: Statics course, at Tarleton State University in the fall of 2021 were involved in this study. The participants were male and female, over age 18, and diverse in race/ethnicity, and age. The targeted students were in the treatment group that utilizes an interactive lectures and traditional lectures. The main topics taught in the course include theory and analysis of bodies in equilibrium, vector algebra, Newtonian mechanics, forces due to friction; forces acting on members of trusses and frame structures, and determinations of centroids and moments of inertia.

As part of designing this study, the decision was made to select two topics that are within the same level of difficulties such that one topic can be used for the traditional method while the other topic can be used for the TPS method. This decision was made in order to limit the variables. Considering the Statics course, it was possible to have three sets with two topics within each set that are at the same level of difficulties.

In general, the instructor of record started the class by defining the main topic of today lecture and its applications. The instructor then explained the equations of that topic with several examples with their calculations that related to that topic. This study is focused on introducing two instructional strategies simultaneously in an engineering class, which are the traditional teaching method that involves individual self-regulated thinking (without peer-classwork before the quiz) and the think–pair–share TPS method that involves collaborative teamwork thinking (with peer-classwork before the quiz). The students' exam scores were used as the measure of their academic performance through studying the relative effectiveness of these two instructional strategies on engineering students' achievement goals.

Traditional Teaching Method

In this method, the students were asked to solve the quiz problem on their own. It was noticed that some students took some time to start with the quiz. Some students didn't work on the quiz but rather waited for the instructor to solve the quiz on the board at the end of the lecture. The class was quiet and seemed unenthusiastic. After the solution was presented on the board, no questions were asked to the instructor.

Think–Pair–Share Method

During the TPS method, the students were asked to solve the quiz after the TPS approach, it was noticed that there was some confusion at the beginning. Some students asked who they should work with. After about a minute, the students started to engage in discussion. It was noticed that some were listeners where others took the role of discussing and presenting classwork problems to the group members. Once the time for the activity was over the instructor started the quiz that related to the same topic of the classwork.

Results and Analysis

In this data collection set, students voluntarily participated in this study with 6 quizzes. There were 3 quizzes without classwork and another 3 quizzes with peer-classwork before the quizzes. A total number of 114 exam score were collected and analyzed. In both methods, the instructor introduced the lecture topic including one example problem and prepared two additional problems (one for the TPS/traditional method and the other one for the quiz to test the effectiveness of this method). For the traditional method, the instructor explained the first problem then assigned the second problem as a quiz to test the influence of this method. While during implementing the TPS method, the instructor had the students solve the first problem using the TPS method then assigned the second problem as a quiz to reflect the effectiveness of this approach. Designing the research study this way would ensure controlling multiple factors and limiting the variables that could influence the results of this study.

When comparing students' performance after applying the Think–Pair–Share method (collaborative teamwork) before the quiz with the traditional teaching method (without the classwork), the percentage of failures (F and D) dropped from 53% to 5% (Figure 1). The percentage of students who achieved grades A-C (passing grades) increased from 47% to 94% with a specific increase for grade A from 32% to 63%.

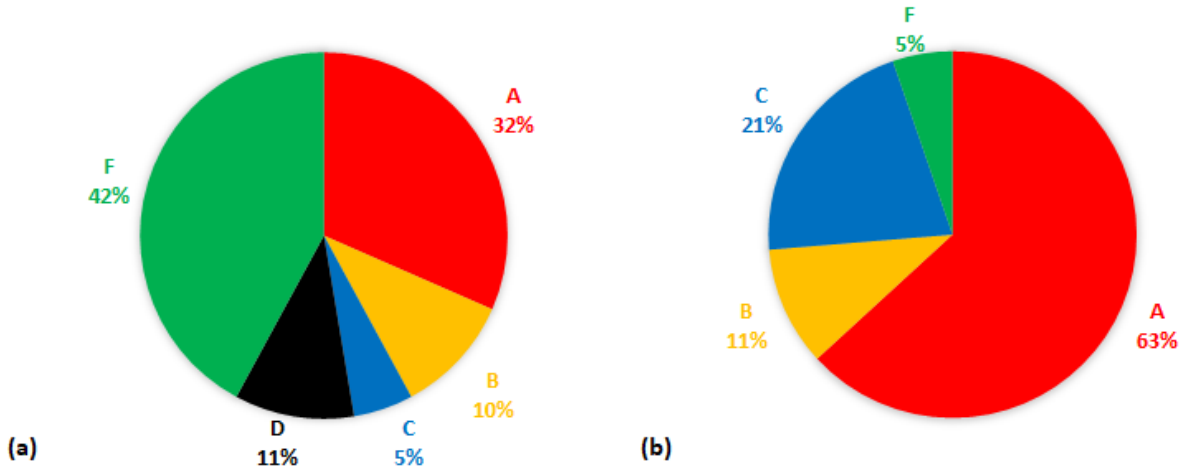

Figure 1. First group of quizzes performance of students (a) without classwork-Traditional teaching method and (b) with classwork-TPS method

Another example of quizzes performance indicates that the failure percentages dropped from 16% to 5% after applying TPS method in class (Figure 2). The total number of students achieving A-C symbols increased from 84% to 95% with the number of students achieving high marks A increasing from 26% to 68%.

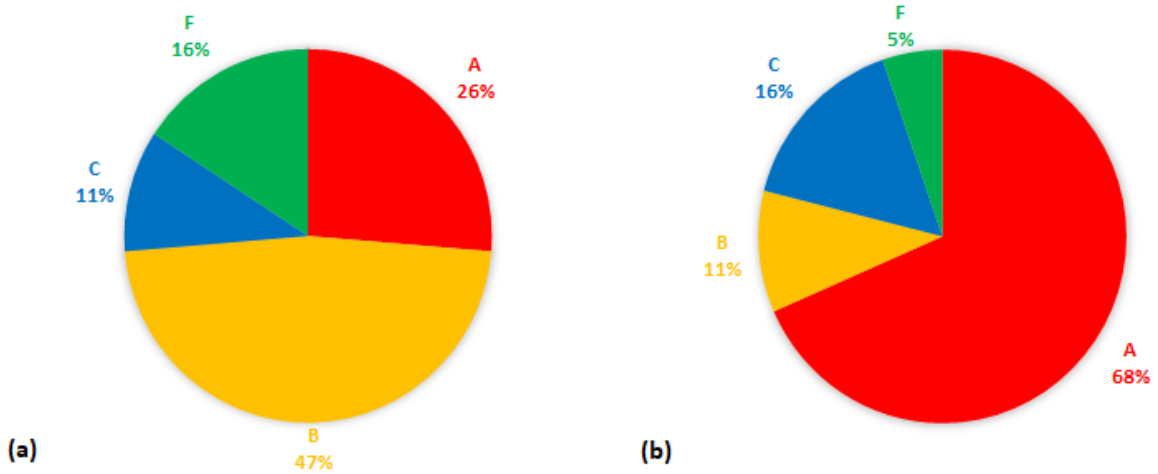

Figure 2. Second group of quizzes performance of students (a) without classwork-Traditional teaching method and (b) with classwork-TPS method

Generally, the results of the three quizzes with and without classwork in bar chart diagram (Figure 3) depicted that however the students' performance of the 2nd quizzes group was less than 1st & 3rd quizzes group; it was noticed that always quizzes with TPS method are better than quizzes with traditional teaching method.

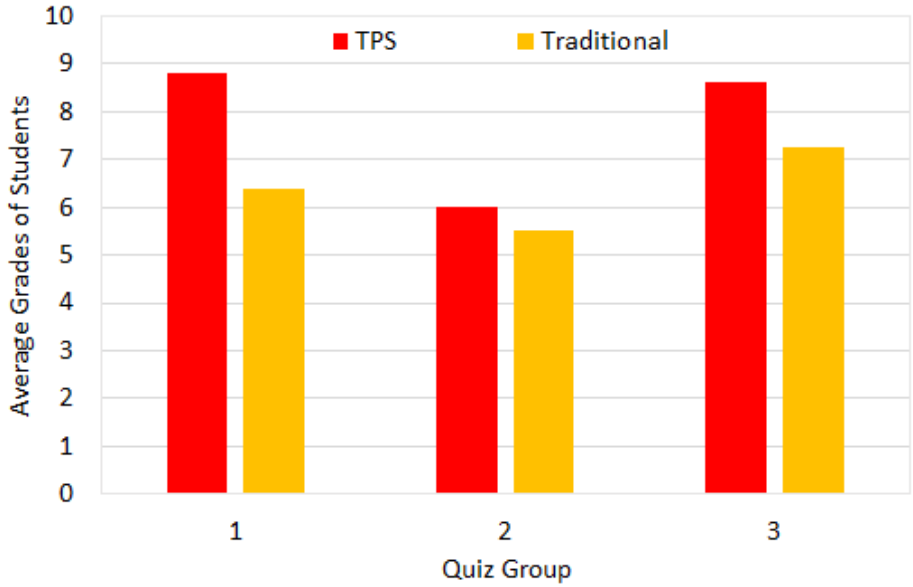

Figure 3. All quizzes performance of students without classwork-Traditional teaching method and with classwork-TPS method

Figure 3 shows that the average grades of quizzes with embedding classwork is better than quizzes without classwork. Thus, the overall performance of students would be better if the classwork assignments are embedded in the course.

Moreover, most treated students showed good improvement on their grades with respect to the applied methodology of think-pair-share, as shown in Figure 4. Few students showed no influence of having classwork on their average of quizzes. However, it was noticed that for some of them (specially student #4 and #9) the average grades of quizzes with classwork were lower than the average grades of quizzes without classwork. This trend indicated that those two students did not work with others to improve their knowledge on the topics. It could be that they might not have the ability to work with other students, thus the think-pair-share was not effective for them. From this result, it can be observed that the TPS method is effective at a percentage of 89.5%.

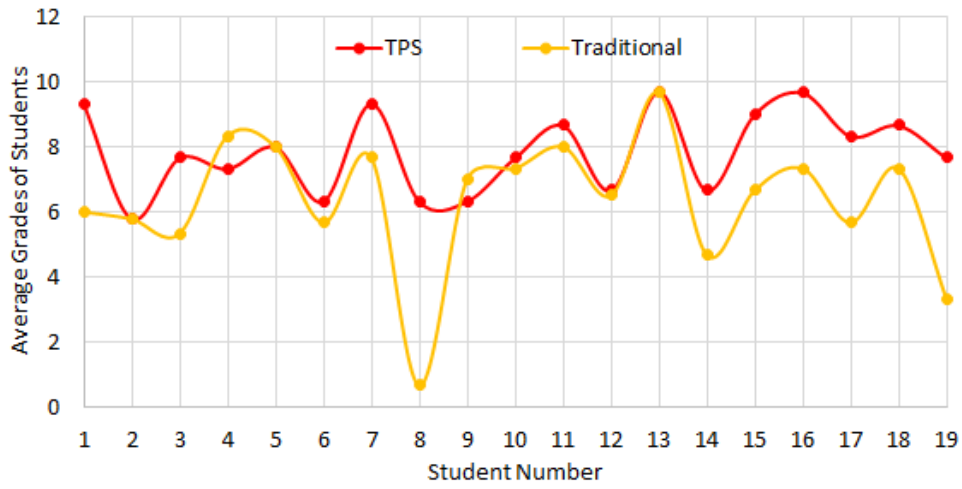

Figure 4. Average grades of each student for all quizzes based on Traditional teaching method and TPS teaching method

Summary and Conclusions

This work has indicated the importance of class activities for engineering students' success. The paper presented taking quizzes with two different pedagogy methods: the traditional method and the 'think– pair–share' TPS method. The second method allowed students to discuss their topics and approach among each other before the quizzes. It also prompted students to understand the topics better and helped the professor clarify certain misunderstandings before the quizzes. A total of six quizzes, three were performed using TPS and the other three were done without using TPS method. The quantitative approach was obtained to collect and analyze the outcomes. Using the TPS approach, the average percentage of failures dropped from 49.3% to 21%, while the percentage of students who achieved grades A-C increased from 50.67% to 79%, in general. Thus, this interactive pedagogy indicated a positive change in students' performance over traditional lectures. Moreover, this study concluded that collaboration amongst students was seen to play a significant role in students' success as some students were more comfortable learning from each other. The methodology demonstrated in this work can be employed by other lecturers and academic managers to increase the success in other engineering modules which in turn will be beneficial.

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