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Incorporating Active Learning Strategies into an Engineering Economics Course

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Abstract

This paper describes a methodology aimed at increasing student engagement in an engineering economics course by incorporating proven active learning strategies. This was accomplished by flipping some parts of the course. Partially flipping the course involved delivering some course concepts through reading assignments, online videos and computer-based learning modules thus freeing up more class time to engage students in problem solving, discussions and intensive teamwork. The engineering economics course was selected for active learning implementation because it is a course that students are required to take for their Mechanical Engineering and Industrial Engineering degrees at University X. Engineering economics is a course that is critical to industry-bound students due to its real-world applications. In addition, it is a course that is integral to engineering senior capstone projects at University X. Changes in this course focused on collaborative learning to help promote critical thinking and to encourage more active interaction among groups of students and across different student groups. The results of this study provide insight into innovative teaching methods that can be applied to engineering economics courses and other courses in STEM. In addition, this paper highlights strategies that worked best and lessons learned to inform other instructors implementing active learning strategies in their classrooms.

1. Introduction

Despite advances in instructional technology advancements, traditional lecture-based models remain the most common teaching method across college classrooms in engineering even though there is evidence showing that these methods are not very effective. Lecture-only classes do not adequately address crucial components of engineering education including critical thinking, problem-solving, and teamwork skills. Furthermore, over-reliance on lecture-based educational models do not equip students with the soft skills including communication and collaborative skills required to face the multi-faceted challenges in the 21st century engineering workforce. There is clearly a need to use active learning methods that promote student learning, engagement and the development of critical skills

This study describes changes to an engineering economic course aimed at increasing student engagement by incorporating proven active learning strategies such as project-based and problem-based learning strategies. This was accomplished by flipping some parts of the course and spending more class time on discussions, intensive team work and group projects. The plan was to completely flip the course over time so that fundamental concepts will be primarily delivered through reading assignments, online videos and computer-based learning modules. The engineering economics course was selected because it is a course that students are required to take for their Mechanical Engineering and Industrial Engineering degrees at University X. It is also a course that is integral to senior design projects in the Mechanical and Industrial Engineering department at University X. Furthermore, Engineering Economics is important to industry-bound students due to its real-world applications.

Changes to the course focused on collaborative learning to help promote critical thinking and to encourage more active interaction among groups of students but also across different student groups. These changes also provided opportunities for students to learn how to provide support to each other and how to evaluate each other's ideas. Fundamental concepts in the course were broken into learning modules completed outside of class. The out-of-class components were designed to increase students' active participation in the learning process. Students were also involved in projects that have real life implications and required them to solve a wide variety of engineering economic problems.

2. Active Learning: The Flipped Classroom

There is increasing evidence that traditional forms of teaching, particularly the lecture style of presenting information to students, is not the most effective instruction style. Teaching methods that focus on active learning strategies have been shown to improve student-learning outcomes (Freeman et al. 2014, Norman and Wills, 2015). An analysis of 225 studies comparing students' performance in traditional classrooms versus active learning classrooms found a noticeable improvement in student performance in exams (Freeman et al., 2014). In engineering specifically, a study by Benson et al., (2010) showed that using active learning strategies in the classroom led to enhanced learning. Furthermore, active learning has been found to improve students' attitude towards learning.

Although flipped classroom models have existed for many years, they have only recently begun to grow in popularity in engineering. Various studies have shown flipped classes to be particularly effective in engineering (Ankeny and Krause, 2014; Marks, 2014; Xiaobin et al. 2015). More specifically, studies have been conducted on flipping engineering economics courses (Lavelle, Stimpson and Brill, 2013, Lavelle, Stimpson and Brill, 2015). The flipped class model "flips" the traditional lecture-based classroom. Bishop and Verleger (2013) define a flipped classroom as "an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom." Some advantages of flipped classes are that they promote students' engagement in the learning process and that the professor is focused on helping students apply the course contents (Norman and Wills, 2015).

3. Methods

The class discussed in this study was made up of 37 students including three female students. The class was partially flipped meaning that some lecture still took place in the classroom. However, most of time in the classroom was spent on problem solving and other active learning activities. The class had three 50-minute sessions per week. Two sessions were spent mainly on problem solving while one of the sessions was predominantly lecture based. Prior to coming to class, students were required to watch videos, complete a reading and then take a timed quiz based on the videos and readings. The students had three attempts at the quiz questions. At the beginning of the semester, when students were still getting used to the new teaching format, they could use all three attempts at the quiz and still receive full credit if one of the three attempts were accurate. However, the grading was adjusted during the semester so that students received partial credit after a certain number of attempts. In addition, hints were provided to students for certain questions if they were not successful in their first attempt. This provided additional information to the students as they tried to solve the problem again.

The CATME Smarter Teamwork system was used by the instructor to manage student teams. In addition, CATME was used as a tool to teach students how to be effective contributors to teamwork and to be accountable to their team. Using this tool on a weekly basis allowed students to receive timely feedback on their contribution to their teams and to make changes as needed. At the start of the semester students were asked to participate in a "team-maker" activity on CATME, which is a survey aimed at gathering information that will be used to place students in teams. This information collected included the students' gender, ethnicity, GPA, availability, leadership style, familiarity with learning technologies used in the class, schedule and their experience with active learning and flipped classrooms. Based on the information collected students were assigned to groups based on their answers to certain questions. Students worked in groups of 4 or 5 to solve problems during class. Furthermore, they were required to perform a weekly evaluation of team members' performance for their participation grade which represented 10% of the total course grade. Around the midpoint of the semester, the groups were changed to allow students an opportunity to work closely with other members of the class.

During class, students worked in their groups to solve problems and apply concepts from the pre-class assignments (videos and readings). This approach required students to recall and use the information that they learned from watching lecture videos prior to the class. Each group had to solve problems on a white board or chalk board that was visible to the entire class. Due to the location of the boards, groups had adequate space to work with other team members without interruption. The instructor displayed the problem to be solved on the screen and depending on the complexity of the problem spent some time pointing out some of the key components of the problem. Next, students were given some time to discuss the problem with group members before they began to solve the problem on the board. Teams were encouraged to assign roles to individual members and to switch these roles regularly. Some roles included the student writing on the board, the person doing the calculation, time keeper, scribe (taking notes) etc. Once the students began solving the problem, the instructor walked around the classroom to assist groups that had questions. The instructor used multiple strategies including collaborative problem solving and peer-to-peer learning during the class to explain the correct method and solution. For instance, members of a group that understood a problem better taught fellow group members that struggled with parts of the problem. Sometimes other groups were asked to present their results to the rest of the class. This was particularly helpful when whole groups struggled with problems. Since students solved problems on the whiteboards it was easy for them to explain and share their problem-solving approach with team members, with other teams or with the entire class. After class, the students had to complete homework assignments to solidify their understanding of the concepts covered in the class.

The efficacy of the partially flipped class model was assessed using different methods to gauge student understanding and engagement. Surveys were used to assess students understanding, attitudes and perceptions of active learning. Students' feedback during a midterm survey was used to address problems that arose during the first half of the semester and to make improvements to the second half of the class.

4. Results and Discussion

Figure 1 and figure 2 below show the results of the pre-survey gauging students' experience with active learning classrooms and flipped classrooms respectively. Fifty-nine percent of the class

indicated that they had been part of a classroom where active learning methods have been used. Thirty percent indicated they had not been students in a class where active learning strategies were used while 11% were unsure. There had been a recent growth in the popularity of active learning within the College of Science and Engineering at University X with a significant increase in active learning training and learning communities. Many faculty in the college were incorporating various degrees of active learning approaches in their classroom. So, it was not surprising to the author that more than half of the class indicated that they had been part of a class that utilized active learning methods. However, when asked the same question about flipped classes (figure 2), only 35% indicated that they had been in a flipped class with 19% indicating that they were unsure about previously being in a flipped class.

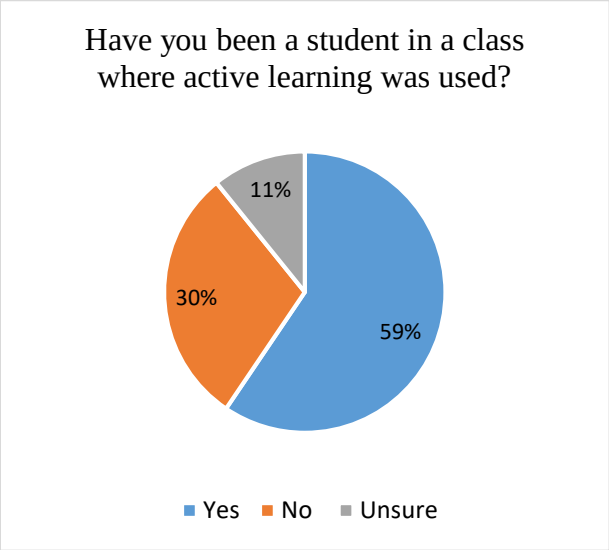

Figure 1. Prior Experience with Active Learning

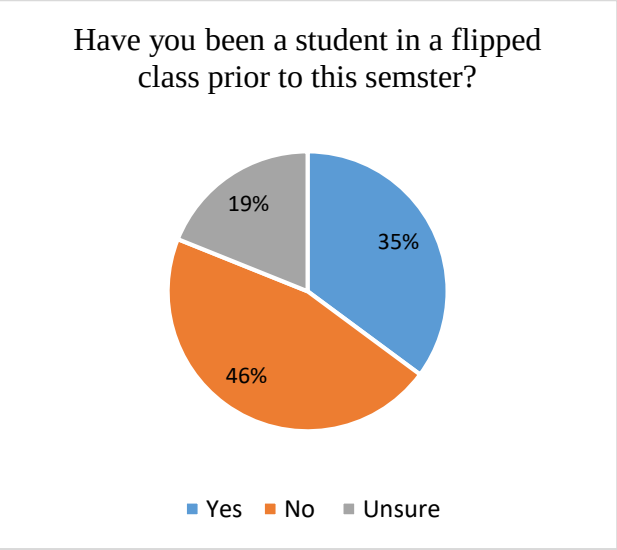

Figure 2. Prior Experience in Flipped Class

Results of the survey at the end of the semester showing responses from 35 students is presented below. It is clear from the results in table 1 that students found group activities including group problem solving activities and the group project to be very useful. When presented with various activities in the class and asked, “which of the following activities did you prefer?”, the majority of students (54%) indicated that they preferred group problem solving over other class activities. The second most popular activity was the group project which was prefered by 23% of the class.

Table 1. Preference for Class Activities

Rank	Class Activity	% (n=35)
1	Group problem solving	54.29%
2	Group Project	22.86%
3	Homework	8.57%
4	Pre-Class Assignments	5.71%
4	Lecture	5.71%
5	Pre-Class Quiz	2.86%

Homework assignment was third place with roughly 9% of students indicating preference for this activity. Lecture and pre-class assignments (videos and readings) were tied at roughly 5.7% each while the pre-class quiz was the least preferred at 2.9%. Furthermore, 60% of respondents selected group problem solving as the most helpful in learning material.

The survey further explored students' experiences and perceptions about group problem solving. Overall, the responses shown in figure 3 were positive with about 75% of respondents agreeing or strongly agreeing that group problem solving during class helped them understand course concepts better. Ninety-two percent agreed or strongly agreed that their group members were very helpful in explaining topics they did not understand. Ninety-seven percent agreed or strongly agreed that they felt comfortable asking group members questions. Lastly 77% agreed or strongly agreed that they enjoyed solving problems with their group members.

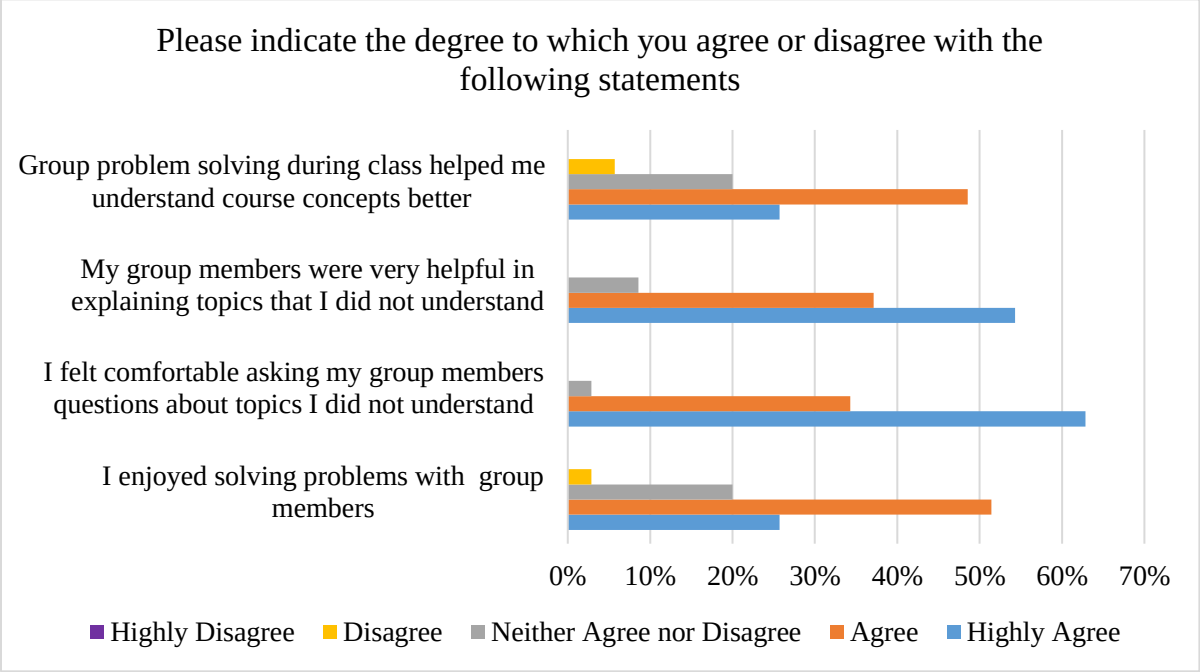

Figure 3. Experience with Group Problem Solving

As part of the survey, students were asked what format they prefer for the course. Despite the positive experiences with the team problem solving, roughly forty-six percent of students indicated that would prefer more lecture and reduced group work and problem solving. Only about six percent indicated that they prefer a flipped format where students watch lecture videos before class and then spend the class time on activities such as problem solving, group work and discussions. Overall, more students indicated that they did not enjoy the flipped format compared to the number of students that indicated they enjoyed the flipped format. Furthermore, students did not like having to evaluate group members every week. During this class it appears that overall, student enjoyed the group activities. However, based on open-ended answers as well as feedback gathered from students during the semester, the added responsibility required for flipped classes including having to prepare for class by watching videos, completing assigned

readings and then taking a quiz was not welcome by some students. In some cases, students really liked to work with each other during class but disliked the added responsibility of the flipped class even more thus leading to a less than positive overall experience.

Some challenges faced during the class include resistance from some students and technical issues with the online learning environment. The instructor experienced push back from some students that indicated that they did not like flipped classes or that they preferred the traditional lecture-based method. For example, the following comment was received from the survey at the very start of the semester (before the active learning activities began). “Flipped and active learning classes are a waste of time and not effective”. Another student comment from an assessment at the end of the semester was “I did not like the flipped class style however, solving problems during class help me understand the material better”. One recommendation to reduce resistance would be better preparation and perhaps an earlier introduction of students to active learning methods including flipped class methods. Educating students on the benefits of these teaching methods or introducing them to the methods earlier could help reduce resistance and shock later. Secondly, there was a technical issue with the online learning environment which caused problems with student submission of assignments. This issue with the learning environment owned by the publisher of the course textbook, continued throughout the semester. However, the instructor made some changes to the quiz requirement and discontinued submission of the homework through the site to minimize the impacts

5. Conclusions

This study describes the implementation of a partial flipped teaching method in an engineering economics course. The course was redesigned to increase engagement of students in the class and to improve performance. Results show that students enjoyed the group problem solving activities and the increased interaction with fellow classmates. However, the plurality of students indicated that they would prefer if the class included more lecture. Only a small percentage indicated that they would like the class to be taught as a flipped class. The results of this study provide insight into innovative teaching methods that can be applied to engineering economics courses and other courses in STEM as well as associated challenges.

References.

Ankeny, C. J., & Krause, S. J. (2014). Flipped Biomedical Engineering Classroom using Pencasts and Muddiest Point Web-enabled Tools. *Proceedings of The ASEE Annual Conference & Exposition*, June 15 - 18, 2014. Indianapolis IN.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410-8415.

Benson, L. C., Orr, M. K., Biggers, S. B., Moss, W. F., Ohland, M. W., & Schiff, S. D. (2010). Student-centered active, cooperative learning in engineering. *International Journal of Engineering Education*, 26, 1097-1110.

Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. *Proceedings of the ASEE Annual Conference & Exposition.* June 23-26, 2013. Atlanta GA.

Norman, S. and Wills D., (2015). Flipped Classrooms in Economic Instruction –It's not all or nothing, *National Conference on Teaching and Research on Economic Education*, May 27 - May 29, 2015. Minneapolis MN.

Lavelle, J. P., Stimpson, M. T., & Brill, E. D. (2013). Flipped out engineering economy: Converting a traditional class to an inverted model. *Proceedings of the 2013 Industrial and Systems Engineering Research Conference*. May 18-22, 2013. San Juan, Puerto Rico.

Lavelle, J. P., Stimpson, M. T., & Brill, E. D. (2015). Evolution of a flipped engineering economy course. *Proceedings of the ASEE Annual Conference & Exposition*. June 14-17, 2015. Seattle WA.

Marks, J., Ketchman, K. J., Riley II, D. R., Brown, L. R., & Bilec, M. M. (2014). Understanding the Benefits of the Flipped Classroom in the Context of Sustainable Engineering. *Proceedings of The ASEE Annual Conference & Exposition*. June 15 - 18, 2014. Indianapolis IN.

Xiaobin, L., Ma, G. G., & Duva, A. W. (2015). Testing the flipped classroom approach in engineering dynamics class. *Proceedings of The ASEE Annual Conference & Exposition*, June 14-17, 2015. Seattle WA.