A Flipped Classroom Experience: Approach and Lessons Learned

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Abstract

While a number of issues affect student success, an area of great concern is student retention. Studies have shown that students are more likely to stay in college if they have clear goals, are active learners, and are active participants in classroom activities. In other words, students learn more when they are intensely involved in their education and have opportunities to apply what they are learning. Students also benefit when they are engaged in the teaching and learning of their peers, such as group work, peer review, study groups, and peer teaching in and out of class. Flipping the classroom is a relatively new active learning technique that faculty at many institutions have incorporated in their teaching. In a flipped classroom, laboratory and in-class activities replace typical class-lectures. Lectures are normally delivered over some other medium such as video on-demand or podcasts. However, there is no specific model for flipped classrooms, it simply draws on such concepts as student engagement, hybrid course design, and course podcasting. This paper describes how the flipped classroom technique was incorporated into a three-credit electrical engineering course that met twice a week. This paper presents details about the course, discusses student survey results, and describes plans to improve the delivery of this and similar courses.

I. Introduction

Data compiled by the American College Testing (ACT) shows that, currently, the National first- to second-year retention rate in 4-year public institutions averages 65.6%. Meanwhile, the mean for the National 5-year graduation rate of 4-year public institutions is 37.9% [1]. While a number of issues affect student success, the area of greatest concern is student retention. Standardized-test scores, study habits, and living on- or off-campus are not the only factors that affect retention rates. Students are more likely to stay in college if they have clear goals, are active learners, and are active participants in classroom activities.

Students learn more when they are intensely involved in their education and have opportunities to think about and apply what they are learning in different settings. Students also benefit when they are engaged in the teaching and learning of their peers, such as assigned group work, peer review, coordinated study groups, and peer teaching in and out of class [2]. Some students prefer to learn through a hands-on approach. It creates a more dynamic and stimulating learning experience. Also, students sometimes feel that what they learn is useless to their everyday life and, thus, get discouraged. Therefore, having the opportunity to apply their knowledge to real world issues assures students that they are being productive in their learning and that their effort is worthwhile.

It is often said that people learn from their mistakes. When students are asked to explain or define something or approach the board and write their answers, they inevitably miss a few questions. The instructor can then step in and complete the desired flow chart, for example. This approach may take a few minutes but the active involvement of students increases the chances of them retaining the desired material. It also reduces the instructor's workload considerably [3].

A pie chart that appears in *Student Engagement Techniques* [4], illustrates the average retention rates from different teaching methods. According to the chart, active learning is the most effective method with a retention rate of 76%. Active learning techniques are divided among discussion groups (18%), practice by doing (27%), and teaching others (31%). Recently, a number of retention and success efforts have been developed across the country. This paper documents the flipped classroom technique incorporated into a pilot electrical engineering course at Texas A&M International University (TAMIU). The paper also presents feedback results and briefly discusses future plans.

II. Flipping the Classroom

In a traditional lecture, students often try to capture what is being said at the instant the speaker says it. They cannot stop to reflect upon what is being said, and they may miss significant points because they are trying to transcribe the instructor's words [5]. On the other hand, in an inverted classroom, typical class-lecture time is replaced with laboratory and in-class activities. Outside class time, lectures are delivered over some other medium such as video on-demand [6]. The notion of a flipped classroom draws on such concepts as active learning, student engagement, hybrid course design, and course podcasting [5].

"Since helping students learn is our primary goal as teachers, how do we best accomplish that? The simplest answer may be to set up conditions that promote active learning [4]." Therefore, active learning must be an area of focus in view of the fact that students learn best if they are active participants of their own education. Creating an active learning environment that provides appropriate support leads to success and life-long-learning skills. Active learning activities allow students to reflect on their experiences, see connections between different courses, and apply knowledge learned in different settings to solve new problems.

Faculty members must promote student engagement inside the classroom through a variety of approaches, including being attentive to students' backgrounds and talents, experimenting with engaging pedagogies, providing new students with adequate feedback about their academic performance, requiring them to take advantage of writing centers, math and science tutorials, and technology support centers, as well as encouraging students to learn through peer evaluation, group projects, and study groups [1]. These actions, and many others, can be promoted with the help of curricular initiatives, institutional assistance and academic interventions, student development initiatives, campus climate, and electronic and online tools [7]. Student retention and success are more probable if students are exposed to in-school social connections and group activities throughout their course of study. Such engagement helps to build relationships among students and makes education an important part of their everyday lives.

Hybrid courses offer some of the convenience of all-online courses without the complete loss of face-to-face contact [8]. Hybrid teaching style encompasses recording traditional lectures, providing complementary PowerPoint presentations and text materials, 24/7 online access to lectures, tailoring the teaching method to learning needs, higher level of class discussion, targeting needy areas and topics, maintaining consistency across sections, phased-in recorded lectures, extensive evaluation, and constructive teaching [9].

Many higher education institutions have been including flipped classroom techniques in some of their courses. At the University of Michigan (UM), for example, the math department has flipped its calculus courses since the mid-1990s. UM offers up to 60 small sections of introductory calculus, with a maximum of 32 students in each class, which meet for 80 minutes three days a week. Consistent with the flipping model, students at UM do their reading before class. The instructor gives a brief lecture, asks about the reading, and goes through an example from the textbook. Students take turns going to the board to present their answers or work in groups, which might be followed by another short lecture. Research suggests that UM's teaching methods have led to greater gains in conceptual misunderstanding [10].

At Miami University, the flipped classroom model was presented in the context of software engineering curriculum. The first course to undergo the piloting of the flipped classroom was a special topics course on service-oriented architecture and web services. The podcasted lecture materials for this course consisted of approximately 65 separate podcast episodes ranging in duration of just a few minutes to approximately 50 minutes. The lecture materials consisted of video blogs, PowerPoint presentations with voice overs, and screencasts. The course also consisted of 15 learning activities that were often 1 to 2 contact hours in duration. Data shows that from the viewpoint of students, some level of learning occurred [6].

Researchers at Harvard University have launched the Peer Instruction (PI) Network, a new global social network for users of interactive teaching methods. The PI technique relies on the power of the flipped classroom. Information transfer takes place in advance, typically through online lectures. In short, students study before rather than after class [11].

III. Flipping a Principles of Electrical Engineering Course

a. Background information

The Systems Engineering (SENG) degree program at TAMIU was introduced in Fall 2008. One of the basic courses in the SENG curriculum is ENGR 2305 Principles of Electrical Engineering, a three credit hour course. This course is also available for pre-engineering students who normally transfer to other institutions after completing a number of engineering courses at TAMIU. While enrolling in ENGR 2305, students must also enroll in ENGR 2105 Principles of Electrical Engineering Laboratory. ENGR 2105 is a laboratory-based course that provides students with opportunities to conduct hands-on experiments in a teamwork environment. ENGR 2305 is intended as a terminal course for most engineering disciplines and includes a variety of topics such as fundamentals of electrical circuit analysis, AC power, electronics, and digital systems. Prerequisites for this course are PHYS 2326 University Physics II and ENGR 1202 Foundations of Engineering II. ENGR 2305 was offered in spring semester 2013 as a two-day course (Tuesday and Thursday) with a total enrollment of 32 students. 21 students successfully completed the course with a final letter grade of C or higher.

b. Instructional Method

There is no one model for flipped classrooms. For this particular course, active learning activities took place on both days. At the beginning of the semester, students formed study groups of three or four. Each week, and prior to coming to class on Tuesday, students were expected to review and understand the assigned chapters as indicated in the syllabus. At the beginning of class on Tuesday, the professor briefly reviewed the assigned material and answered a few questions. Afterwards, students took a short open-book quiz that encompasses the major ideas of the assigned material. Quizzes were then graded while students helped each other master the assigned material and solve related exercises. During the last 15 minutes of class, quizzes were returned to students and the solution was explained. The strategy here is to provide immediate feedback to students, so they know whether or not they are applying concepts correctly [12]. Thursdays were mainly used to go over homework solutions, clarify concepts that students were having difficulty with, answer questions, and solve additional problems. The weekly schedule included three tests as shown in Figure 1.

Week #	Topics	Tests/Quizzes
1	Course requirements/Objectives/Overview	Quiz 1
2	Basic electrical engineering concepts	Quiz 2
3	Voltage division, current division, nodal analysis	Quiz 3
4	Mesh analysis, Thevenin, Norton, and superposition theorems	Quiz 4
5	Inductance and capacitance	Quiz 5/Test 1
6	Steady state sinusoidal analysis	Quiz 6
7	Digital systems	Quiz 7
8	Digital systems	Quiz 8
9	Computer-based instrumentation systems	Quiz 9
10	Diodes	Quiz 10/Test 2
11	Field-effect transistors	Quiz 11
12	Bipolar junction transistors	Quiz 12
13	Bipolar junction transistors	Quiz 13
14	Operational amplifiers	Quiz 14
15	Magnetic circuits and transformers	Quiz 15/Test 3

Figure 1: Tentative Weekly Schedule

IV. Student Feedback

A brief survey was administered to ENGR 2305 students in the middle of the semester. Figure 2 shows that there was a large difference in the percentage of students who wanted to continue with the flipped class format (67%) compared to the percentage of students who wanted to go back to the traditional format (33%).

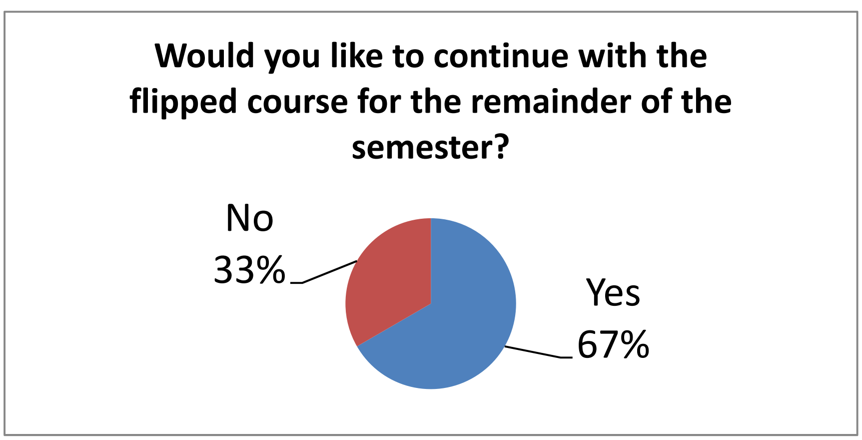

Figure 2: Student responses regarding teaching method for the remainder of the semester

Most students felt that the flipped course format of this class had helped them during the first part of the semester by encouraging them to read and being prepared before coming to class. Some students felt more comfortable asking questions in groups rather than in front of the class. However, other students believed that, as the material became harder, it was more difficult for them to understand it on their own. A few even felt pressured by preparing for the quizzes. At the end of the semester, another survey was conducted. Figure 3 demonstrates that some students changed their minds regarding the flipped course format. Even though the majority (57%) is still in favor of the flipped format, 43% would prefer the traditional format.

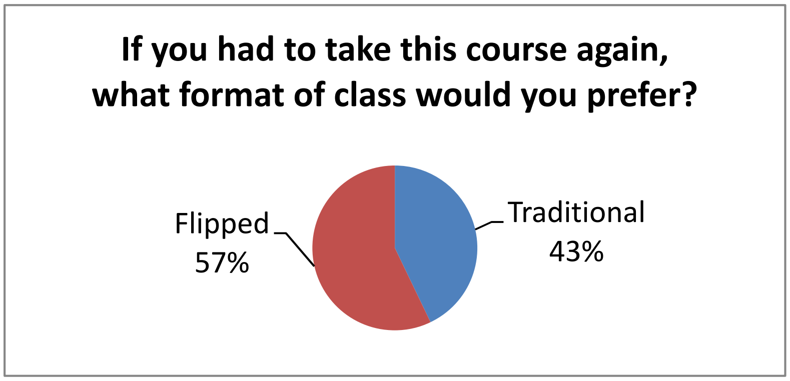

Figure 3: Student responses regarding teaching method if they were to retake the course

Figures 4 and 5 illustrate that a great majority of students agreed that the quick reviews by the instructor before the quiz, the quizzes themselves, and going over homework assignments in class, were all helpful for learning the course material. On the other hand, the in-class group discussions were perceived as the least effective for learning the course material. Most students liked the feeling of independence when studying and the fact that they were encouraged to read before coming to class. However, others felt that they needed more lecture time to understand the material and that some of the groups were not properly focusing on course material.

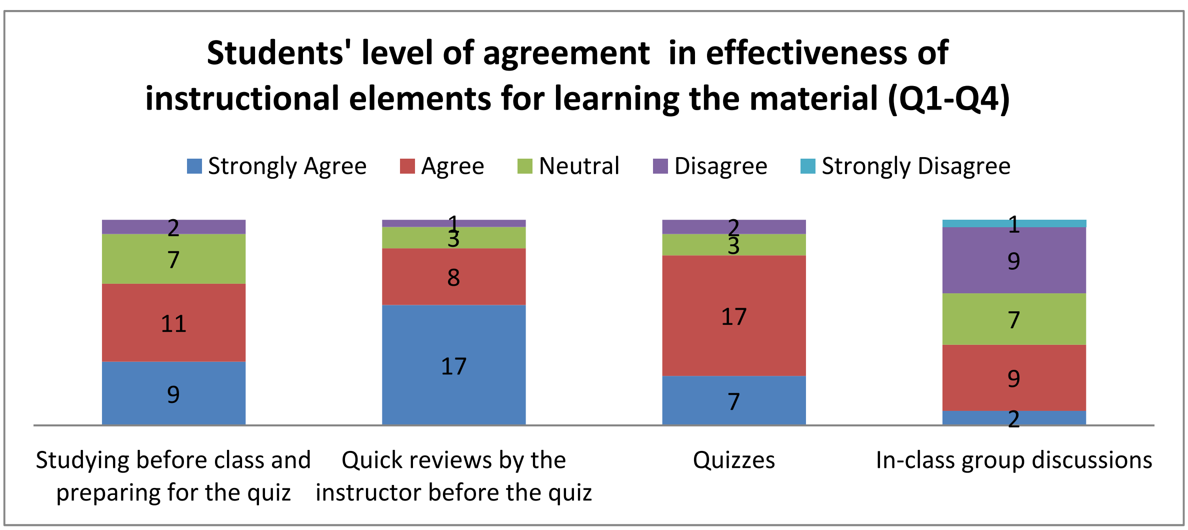

Figure 4: Feedback on questions 1 through 4

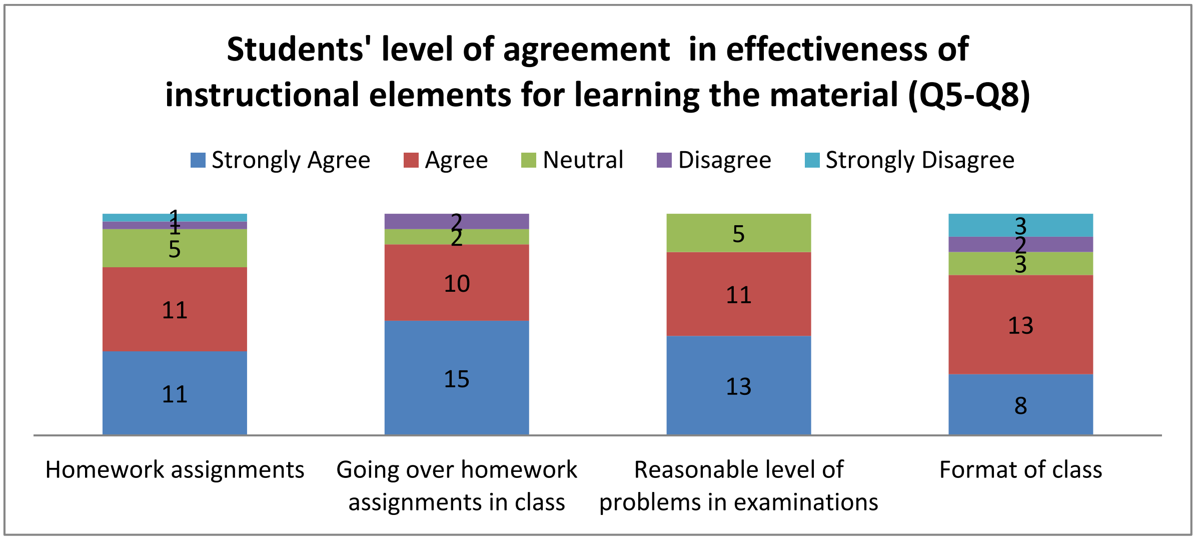

Figure 5: Feedback on questions 5 through 8

Survey results in Figure 6 also show that students did not spend a lot of time preparing for the quizzes every week (about 0-2 hours), which is surprising in this case.

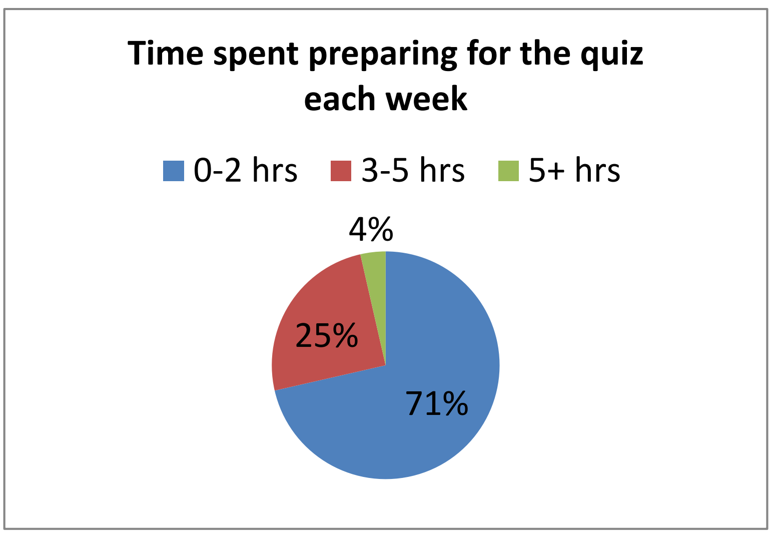

Figure 6: Student responses regarding time spent preparing for the quiz each week

Professors want students to enjoy the class, but that is not the goal of education [10]. For this reason, survey questions focused on how effective the class elements were in helping students learn the class material. At the end of semester, a Student Learning Outcomes survey, shown in Appendix A, was administered to help in the evaluation of student success. Figure 7 shows the results of this survey by course outcome on a 4 point rating scale.

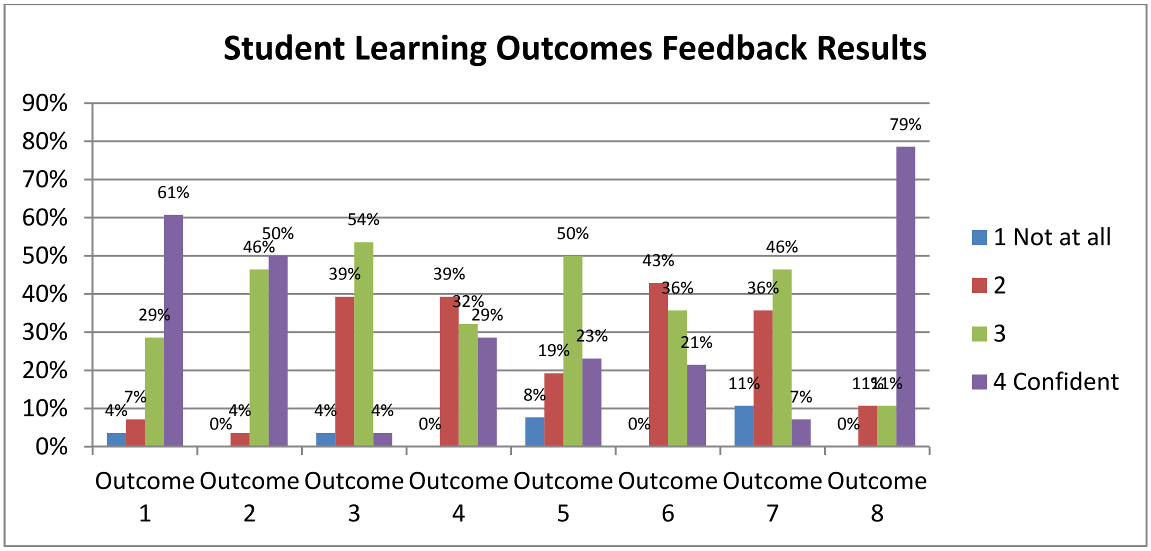

Figure 7: Student Learning Outcomes feedback results

V. Conclusion and Future Work

Overall, flipping the Principles of Electrical Engineering course had a positive effect on student learning. Even though student's perspective towards this teaching method changed towards the end of the semester, the approach was still favored by the majority. In addition, the feedback on the "Student Learning Outcomes" survey was overall positive, with more than half of the students rating their abilities as 3 or 4 (4 being Confident and 1 being Not at all.) In spite of this, there is room for improvement as some issues still need to be addressed in order to enhance the flipped classroom learning experience. For example, it was noted that students found it harder to understand the material as the semester progressed, the group discussion time was not employed properly by everyone, and the time students spent preparing for the weekly quizzes was inadequate. Assigning homework on Thursdays for the chapter that was already covered and then starting a new chapter the following Tuesday while students were still working on the previous week's material was also considered very overwhelming. One possibility is to assign homework on Thursday for the material that will be covered the following Tuesday. This way, students start working on the homework before the chapter is reviewed in class. This allows students to ask appropriate questions during the short lecture and/or during the group discussions. This also helps students indirectly prepares for the quizzes. In addition, supplemental materials such as videos, illustrative problem solving, and application examples should be made available to students.

VI. References

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APPENDIX A

Student Learning Outcomes—Spring 2013
Continuous Improvement Form (Completed by each student)

ENGR 2305 Principles of Electrical Engineering

Instructor: _________________ Course: ___________ Date: ___Spring 2013

As part of our effort to continuously improve our courses and methods of delivery we need your feedback. Please answer the questions below and return the form to a staff member.

Has this course met its objectives in teaching you the following techniques, skills and knowledge of the subject matter? How would you assess your own abilities in the following areas? Please mark the table using a 5 point rating scale with 4 being Confident and 1 being not at all.

Outcome	Description	1	2	3	4
1	Use Kirchhoff's Laws for circuit analysis				
2	Use loop and node analysis techniques to analyze series-parallel networks				
3	Apply network theorems such as superposition, Thevenin's and Norton's to electrical circuits				
4	Perform transient analysis in RC and RL circuits				
5	Design simple transformer circuits				
6	Use common semiconductor components/devices such as transistors, diodes, voltage regulators, waveform generators, op-amps, etc. to design electronic circuits				
7	Analyze and design signal conditioning circuits using op-amps				
8	Design digital logic using AND, OR, NOT, NAND, NOR gates				