Lessons Learned in Flipping an Introductory Plastics Engineering Technology Course

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Abstract

In a transformative educational endeavor taking place in a department of mechanical engineering technology at a 4-year degree awarding institution, it was decided that 75% of the courses would be delivered with "active-learning instruction" by fall 2017 in order to better prepare its graduates to succeed in the "new" evolving industrial revolution, industry 4.0. A strategy adopted by the author in contributing towards this goal is demonstrated in flipping a plastics engineering technology course that was taught with the traditional classroom approach, which consisted of in-class lectures and out-of-class homework assignments. This study reports the process of flipping the course and its subsequent comparative results using the traditional classroom approach of teaching the course as a baseline. Also, the author shares some of the lessons learned in this preliminary endeavor.

Introduction

Many studies have examined aspects of the flipped or inverted classroom phenomena. This claim is supported by studies such as those done by Bishop and Verleger[1] and O'Flaherty and Phillips.[2] The former authors' study provides an excellent historical context and a survey of research endeavors being done on flipped classroom while the latter authors, in their scoping review, focused on the use of flipped classrooms in higher education. Both of these studies reviewed the past and ongoing research efforts in this field. So, it seems valid to ask, "Why should someone undertake another study about the application of a flipped classroom?" This paper provides an answer to that question.

For the first institution attended by a first-time, full-time bachelor's degree-seeking students at 4-year postsecondary institutions, the National Center for Education Statistics (NCES)[3] reported that average graduation rate was 39.8% for students that started in 2008. While graduating rate has been increasing from 33.7% for students that started classes in 1996 to 39.8% for students that started classes in 2008, it seems rather low because these rates suggest that about 4 out of 10 students graduate in four years from 4-year institutions. Similarly, NCES[4] reported that the retention rate was 80% (that is, the percentage of students returning the following fall) at 4-year-granting institutions in 2013. Given these results, most academic institutions are exploring transformative educational approaches to improve their graduation and retention rates, and many institutions are adopting the flipped classroom approach to achieve these goals.

Defining a flipped classroom, Bishop and Verleger[1] write that it is "an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom." This definition suggests that in a flipped classroom activities such as lectures that were normally done in a traditional classroom are now being done partially or entirely outside the classroom (perhaps, at home) via videos or reading assignments, and activities such as homework assignments that were usually done outside the classroom can now take a significant portion of the classroom time. Hence, a flipped classroom offers opportunities for the students to interact among themselves and with instructors in an “active learning”[5] classroom environment instead of “passively” listening to lectures.

In a department of engineering technology at a 4-year bachelor’s degree awarding institution, where transformative educational strategies have been employed to prepare its graduates to succeed in the “new” industrial revolution, namely, Industry 4.0, it is the goals of the department that 75% of its courses be delivered with “active learning” instruction by spring 2017, improve its graduation rate, and its retention rate. The primary reason for this paper is to share with the public lessons learned in the process of flipping a freshman plastics technology course in an attempt to contribute to the goals of the department.

Background

The plastics technology course is a 100-level course that is required for mechanical engineering technology majors but is an optional course for engineering technology and manufacturing engineering technology majors. The author taught this course in fall 2015 with a traditional approach, which consisted of in-class lectures, quizzes and lab experiments, and out-of-class homework assignments.

The Flipped Classroom

In fall 2016, the same course was taught using a flipped classroom approach. In this approach, the students were required to watch videos on topics to be covered in class. So, students were first exposed to a topic via a video or videos. After watching a video, the students were required to take an online quiz on the topic being considered, and they had three attempts to complete the quiz. Thus, they had opportunities to re-visit the videos for possible answers if they failed any questions. The quizzes were given online through Blackboard, which kept records of each student’s attempts on a quiz. Desiring to earn 100% on the quizzes, most students used the three attempts. Based on the results of a quiz, the author will spend more time in class on concepts that the students may be having difficulties understanding. The time spent on classroom lectures depends on the prevailing situation at the time. But on the average, the class lectures and discussions, may last about 30 minutes to 1 hour in a 2-hour lecture period. To reinforced materials covered in the videos and the class lectures, the students work in teams consisting of three to four students per team on questions and calculations problems on the topic under consideration.

A unique feature of the flipped classroom is the videos used in this process. They were off-the-shelf videos obtained from different sources. This is important because Schmidt and Ralph[6] observed that

> “the most successful flipped classrooms report that they utilize videos of the content that they have gotten from a variety of places. By obtaining videos from other sources the students indicate they are more engaged and found the information refreshing. Videos from the same person can become mundane and boring. Taking boring lectures and recording them and making students watch them on their own time is not the purpose of the flipped classroom.”

Another reason for using videos from different sources is that students tend to take the technical information conveyed from different sources more seriously than from just one source.

While the author has described the concept of a flipped classroom, in other quarters the same description may be regarded as a blended[7] or as a hybrid flipped classroom.[8] For convenience, the author has chosen to adopt the flipped classroom definition explained the preceding paragraphs.

Results

Table I shows a slight increase in students' overall performance when a flipped classroom approach was implemented in a traditionally taught plastics engineering technology course. Notable among the metrics examined was the students' retention rate. Even though the flipped classroom had more students than the traditional classroom, the retention rate was 100% for the flipped classroom while it was 80% for the traditional classroom. The students' evaluation of the course increased by 2% over the traditional approach method. Similarly, students' performance in the mid-term and final exams increased by 5.7%, and their favorability ratings of the instructor increased by 8%, perhaps because of the increased interactions between the students and the instructor that emanated from the flipped classroom approach.

In addition to metrics in Table I showing improved students' performance, the author had taught the plastics engineering technology course for several years in another 4-year degree awarding institution before teaching a similar course at the present institution. Because of this experience, the author believes that the flipped classroom approach was helpful in improving students' performance in the present course. Furthermore, to support the author's claim, some students at the present institution who were not receptive to the flipped classroom approach and chose not to watch many of the videos, nor to take the quizzes, performed poorly in both exams and the in-class activities. Some of these students worked about 30 hours a week and complained about not having enough time to do the preparatory assignments before the in-class activities. However, overall the flipped classroom approach had a positive impact on the students' performance.

Table I: Effect of Flipped Classroom Approach on Students' Performance

	Traditional Classroom (Fall 2015)	**Flipped Classroom (Fall 2016)**	**Comments**
Number of Students	5	13	
Withdrawn/Failed	1	none	
Retention Rate	80%	100%	20% increase from 2015
Average Exam Scores	71.0% ± 8.5%	76.7% ± 9.5%	5.7% increase from 2015
Students Evaluation of Course	4.3/5.0	4.4/5.0	2% increase from 2015

Students Evaluation of Instructor	4.3/5.0	4.7/5.0	8% increase from 2015

Digging a little deeper, the students were asked through a survey instrument to rank the components of the flipped classroom method that had a positive impact on their learning outcomes for the course. The survey instrument used a Likert Scale where "1" = strongly disagree, "2" = disagree, "3" = neutral, "4" = agree, and "5" = strongly agree. Table II shows the results of the survey. Lab experiments were ranked the highest followed by in-class activities, which included team-based problem solving and class discussions. These results suggest a preference for team-based activities as a strategy for improving students learning outcomes, at least, in a plastics engineering technology course. The reason for the preference for team-based activities may be explained by comments from the students suggesting that they were able to learn and retain the course contents better when they had immediate opportunities to apply or examine the concepts covered in class in team-based activities instead of doing with homework assignments and exams.

Table II: Students' Ranking of the Effectiveness of the Components of the Flipped Classroom Approach on Students' Performance

Activity	**Score (maximum score = 5)**
Lab Experiments	4.77 ± 0.44
In Class Team-work	4.62 ± 0.51
Watching Videos	4.38 ± 0.77
Quizzes	4.23 ± 0.60

Conclusion

In this study, the author examined the use of a flipped classroom approach to improve students' performance, retention rate, and learning outcomes in a plastics engineering technology course. Results shown in Table I suggested a slight improvement in students' performance using a flipped classroom approach over a traditional classroom approach consisting of in-class lectures and out-of-class homework assignments. Comments from the students in the flipped classroom indicated that team-based in-class activities helped them to learn and retain the course contents better than with the traditional classroom approach. While these results were specific to a plastics engineering technology course, similar results have been reported elsewhere in materials science courses.[9,10] However, the author plans to continue this study by adopting the flipped classroom approach in other engineering technology courses such as thermodynamics, applied strength of materials, and engineering materials. The results of the future studies will further elucidate the findings of this preliminary work.

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