Observations on Using the Flipped Classroom Model in an Introduction to Environmental Engineering Course

Richard O. Mines, Jr.
Mercer University

Abstract

This paper reports on student perceptions of using the Flipped classroom in an undergraduate course on environmental engineering. The responsibility of taking ownership of learning was placed on students by asking them to view recorded lectures, read the text, and complete 6, on-line assignments prior to coming to class. During class time, students worked in teams of 2 or 3 to complete problem-solving activities with assistance from the instructor. A pre- and post-survey were conducted to ascertain student perceptions about using the Flipped classroom approach. Results from the survey indicated that students prefer a combination of a Partially Flipped and Partially Traditional Lecture-based course over the Traditional Lecture-Based course or the Flipped Classroom. These results are most likely attributed to the maturity of the students and their ability to assume the responsibility for life-long learning.

Keywords

Flipped classroom, recorded lectures, cooperative learning, collaborative learning.

Introduction

There is much interest in the implementation of active learning in the classroom. One approach uses the Flipped or inverted classroom. Numerous definitions are found in the literature and the one given by Swartz et al.[1] is provided: "Classroom flipping is a highly flexible classroom time management strategy that creates opportunities to incorporate the methods commonly thought to promote self-directed learning skills, creative thinking and problem solving, and team building exercises".

Some of the reasons espoused to use the Flipped classroom are worth mentioning. Flipping combines a number of teaching methods and builds on theories such as student-centered learning, constructivism, and problem-based learning, and peer-assisted learning[2]. Elliot[3] states that a flipped classroom offers the opportunity to increase the amount of material in a single course while at the same time addressing breadth and depth issues. Inverting the classroom holds students accountable for learning the material[4]. This approach can provide more collaborative and cooperative learning to take place in the classroom session. Using the flipped classroom paradigm allows the in-class session to become a time for responding to questions, solving problems in teams, and explaining more difficult concepts[5].

Background

During summer 2015 the decision was made to offer EVE 290, Introduction to Environmental Engineering, a 3-credit hour required course taken by all students enrolled in the environmental engineering specialization (EVE) at Mercer University as a Flipped classroom for the fall semester. There were several reasons that this pedagogical approach was selected. First and foremost, the author wanted to explore this type of pedagogy in a sophomore level class to see how students would react to it. Secondly, it would allow students to work at their own pace, viewing the recorded lectures at their leisure. Thirdly, classroom time would be used to answer questions and let teams of two or three students work together on their problem-solving skills. This approach should facilitate active, cooperative, and collaborative learning to take place in class.

There were 25 WebEx lectures recorded during the summer and these were made available prior to the first day of class. The average length of lecture was 38 minutes, with a range of 29 to 56 minutes. The class was scheduled to meet on Tuesday/Thursday for 75 minutes.

A variety of assignments (homework/class work, mid-term exam, technical paper, and final exam) were used for assessing student performance and to appeal to different student learning-types. A total of 21 homework/classwork assignments were completed during the semester along with an on-line ethics module. Four of the 21 assignments were completed on-line prior to coming to class and there was one, on-line self-assessment that was completed during the semester. The remaining assignments were completed in teams of two or three during the class and submitted for grade at the end of the period.

Methods

A pre- and post-survey were administered to the students in EVE 290 at the beginning and end of the fall 2015 semester. The surveys were modeled after the one used by Kecskemety and Morin[6]. There was a total of 12 students enrolled in the course. At the beginning of each survey, students were asked to select their preferred classroom approach to teaching and if they had experienced the Flipped classroom before (Table 1).

Table 1. Preferred Classroom Approach and Experience with Flipped Classroom.

Preferred Classroom Approach	**Response** (Select only one response)
Traditional lecture-based classroom	
Partially traditional and partially flipped classroom	
Flipped or inverted classroom	
Experience with Flipped Classroom	**Response: Circle Yes or No**
Have you experienced the flipped or inverted classroom before?	Yes or No

Each survey contained 15 questions (Table 2) that were to be rated on a 1 to 5 Likert scale with: 1—Strongly disagree; 2—Disagree; 3—Neutral; 4—Agree; and 5—Strongly agree.

Table 2. Questions Asked on the Pre- and Post-Survey and Rated on 1 to 5 Likert Scale

#	Question
1	The flipped classroom approach lets me get immediate feedback while working on homework and activities.
2	The flipped classroom approach does not use class time efficiently.
3	The flipped classroom approach lets my instructor focus primarily on topics that are more difficult to understand.
4	The flipped classroom approach does not make good use of technology.
5	The flipped classroom approach makes class time more engaging.
6	The flipped classroom approach creates an active learning environment.
7	The flipped classroom approach helps me to learn topics to a deeper level than a traditional classroom.
8	The flipped classroom approach accommodates my learning style.
9	The flipped classroom approach personalizes learning to me.
10	The flipped classroom approach does not allow me learn at my own pace.
11	The flipped classroom approach helps me because I can revisit the preparation material whenever I need.
12	The flipped classroom approach makes me feel more responsible for my own learning.
13	The flipped classroom approach helps me become a better self-learner.
14	The flipped classroom approach does not encourage me to learn from my peers.
15	The flipped classroom approach grows my life-long learning skills.

Statistical analysis of the data using the Mann-Whitney U test was accomplished in Excel. A two-tailed analysis at a 0.05 level of significance was performed. The results will be presented in a subsequent section.

Four, additional questions (Table 3) were placed at the end of each survey.

Table 3. Additional Questions.

#	Question
1	Did you take other courses this semester using the Flipped classroom pedagogy? List the course number.
2	Do you believe that a Flipped classroom enhanced your learning experience? Why or why not?
3	Have you used WebEx in any of your previous courses? If so, did you like or dislike using it? If you have not used it, do you have anxiety or other concerns about using it?
4	Any other comments that you wish to share about the semester?

Results and Discussion

Nine students completed the pre-survey and ten students responded to the post-survey.

Preferred Classroom Approach and Previous Experience with Flipped Classroom

Table 4 shows the results of the preferred teaching approach to learning and previous experience with the Flipped classroom. None of the students selected the Flipped classroom as their preferred classroom approach to learning; however, the majority of students selected the partially traditional and partially flipped classroom approach. This was somewhat encouraging since the traditional lecture-based approach decreased from 44.4% on the pre-survey to 37.5% on the post-survey, thus indicating that the class had warmed up to using the Flipped classroom approach. Only one of the nine students had been in a Flipped classroom prior to this course offering. It was odd that only 4 students selected having experienced the Flipped classroom at the end of the semester with 2 students not responding at all.

Table 4. Preferred Classroom Approach and Experience with Flipped Classroom Results.

Preferred Classroom Approach	**Pre-Survey**	**Post-Survey***
Traditional lecture-based classroom	44.4%	37.5%
Partially traditional and partially flipped classroom	55.5%	62.5%
Flipped or inverted classroom	0%	0%
Experience with Flipped Classroom	**Circle Yes or No**	**Circle Yes or No**
Have you experienced the flipped classroom before?	8-No 1-Yes	4-No 4-Yes

*Two students did not respond to the preferred classroom approach on the Post-Survey.

15 Survey Questions

Table 5 presents the results of the nonparametric statistical analysis on the survey data using the Mann-Whitney U test. The null hypothesis (H_0) assumes that the two populations are equal. For the two-tailed, test at a 0.05 level of significance, there was no significant difference between the responses on the pre- and post-surveys for each of the questions. A larger sample size may have resulted in a statistical, significant difference.

Table 5. Mann-Whitney U Test Statistical Analysis of Survey Questions.

Question	U	$U_{critical}$	Accept or Reject H_0
1	27.5	20	Accept
2	34.5	20	Accept
3	37.5	20	Accept
4	39.5	20	Accept
5	40.0	20	Accept
6	43.0	20	Accept
7	45.0	20	Accept
8	38.5	20	Accept
9	40.0	20	Accept
10	30.0	20	Accept
11	34.0	20	Accept
12	36.0	20	Accept
13	34.0	20	Accept
14	24.5	20	Accept
15	38.5	20	Accept

Additional Questions

A sampling of the responses for the four, additional questions is presented in this section.

Question #1
For the pre-survey, 8 of 9 students indicated that they had not utilized the Flipped classroom pedagogy; whereas, for the post-survey, 10 of 10 students indicated they had not experienced the Flipped classroom in other courses they were taking during the current semester.

Question #2
Four of the nine students answered that the Flipped classroom would enhance their learning experience on the pre-survey while only three of the ten students believed it enhanced their learning on the post-survey. One student indicated that it was a different experience and would be useful in future courses.

Question #3
There were mixed responses about using WebEx on the pre- and post-surveys. Most students stated that "It was okay or it worked pretty well"; while other students expressed displeasure with it because they "did not like listening to a lecture on-line or they preferred the traditional classroom approach". Overall, the consensus was fairly neutral to using WebEx.

Question #4
Listed below are five verbatim comments from the pre-and post-surveys related to other comments the students could share about the course.

"Even if my professor next semester does not use the Flipped classroom, I will go into the upcoming semester more self-motivated and with a better ability of self-learning"

"I do not like the Flipped classroom. I felt like it had a negative impact on the material that I learned and the grades that I received this semester"

"I enjoy the class and hope to keep the Flipped classroom style"

"Flipped classroom allows more student interaction and preparation outside of class"

"I need concepts reiterated a few times in different ways to comprehend the information"

Approximately half of the comments reported on the surveys were positive and the other half negative. Some of the negative comments describe features inherent to the Flipped classroom. It does force students to take responsibility for self-learning and being self-motivated as is required for life-long learning. Unfortunately, some students have not reached a level of maturity to accept that they are ultimately responsible for learning the material.

Conclusions

The Flipped classroom was implemented in an Introduction to Environmental Engineering class during fall 2015 to determine how sophomore level students would respond to this pedagogical approach. On the final survey, none of the students preferred the Flipped classroom approach while 62.5% selected partially traditional and partially Flipped, and 37.5% selected traditional lecture. Statistical analysis of the 15 questions (rated on a Likert scale) indicated there was not a significant difference in their responses on the pre- and post-surveys for each question. The lack of statistical, significance primarily resulted from a low sample size (12 students). There were mixed responses to the 4 additional questions posed to the students. Overall, the study was helpful to gain student perceptions on using the Flipped classroom; however, the Flipped classroom approach was not well-accepted by this group of students.

References

1 Swartz, Brian, Velegol, Stephanie B., and Jeffrey A. Laman, "Three Approaches to Flipping CE Courses: Faculty Perspectives and Suggestions," 120th ASEE Annual Conference & Exposition, June 23-26, 2013, Atlanta, 2013, Paper ID #7982.

2 Bishop, Jacob L., and Matthew A. Verleger, "The Flipped Classroom: A Survey of the Research," 120th ASEE Annual Conference & Exposition, June 23-26, 2013, Atlanta, 2013, Paper ID# 6219.

3 Elliot, Rob, "Analysis of Student Perceptions and Behaviors in a Flipped Classroom Undergraduate Information Technology Course," 121st ASEE Annual Conference & Exposition, June 15-18, 2014, Indianapolis, 2014, Paper ID# 8863.

4 Marks, Jayne, Ketchman, Kevin J., Riley, David R., Brown, Lisa R., and Melissa M. Bilec, "Understanding the Benefits of the Flipped Classroom in the Context of Sustainable Engineering," 121st ASEE Annual Conference & Exposition, June 15-18, 2014, Indianapolis, 2014, Paper ID# 9053.

5 Maarek, Jean-Michael, "Flipping the Biomedical Engineering Classroom: Implementation and Assessment in Medical Electronics Course," 121st ASEE Annual Conference & Exposition, June 15-18, 2014, Indianapolis, 2014, Paper ID# 8963.

6 Kecskemety, Krista M, and Brooke Morin, "Student Perceptions of Inverted Classroom Benefits in a First-Year Engineering Course," 121st ASEE Annual Conference & Exposition, ASEE, Indianapolis, 2014, Paper ID. #9381.

Richard O. Mines, Jr.

Dr. Mines is Director of MSE/MS Programs & Professor of Environmental Engineering at Mercer University. He is a Fellow of ASEE, ASCE, and EWRI and registered PE in New Mexico. Mines' holds Civil Engineering degrees from VMI (BS), UVA (ME), and VPI (PhD). Dr. Mines was a consultant for 6.5 years with CH_2M Hill and BLACK & VEATCH. He has been in academia for 29 years and authored/co-authored over 100 technical/educational papers. Mines' is the primary author of *Environmental Engineering: Practices and Principles*. His research has focused on water and wastewater treatment, modeling of bionutrient removal systems, and enhancing learning in the classroom.