Shaping the Engineering Freshman Experience through active learning in a Flipped Classroom

Dr. Tareq Daher and Michael Loehring
University of Nebraska – Lincoln /University of Nebraska Lincoln

Abstract

The Freshman Orientation eight week course at the University of Nebraska – Lincoln was submitted to an extensive major redesign over a three-year period. The course structure was transferred from the passive lecture mode of instruction to an active and engaged flipped classroom. This paper provides details on the course redesign process including the learning outcomes, online and in-class activities, and assessments. The data analysis indicates that the flipped approach created learning opportunities that increased student engagement. Despite an increase in students' self-regulated learning, students in the flipped approach found the course as useful as their peers from previous offerings.

Keywords

Flipped classroom; Active learning; First Year Students; Freshman experience

Introduction

When high school students transition into college they are faced with several challenges associate with their new environment. Students must learn to navigate these challenges to be successful. Academic institutions have provided the body of literature on student success and student retention of first-year students. This literature makes it clear that both pre-college orientation and on-going freshman support programs lay the groundwork for degree completion [3,4,11,16,17] and the same is true of freshman engineering programs [3]

In this paper we discuss one crucial part of the freshman engineering experience at the University of Nebraska – Lincoln: The Freshman Orientation course (ENGR 10). ENGR 10 has been offered to engineering freshman for over 25 years with over 500 students enrolled each of the last five years. In 2014, members from the deans' office, student services, and instructional design and technology team worked collaboratively to redesign the course to address logistical and instructional challenges as-well-as to increase student engagement in the course.

Pre-Flipped

The freshman orientation course (ENGR 10) was developed to introduce students to engineering disciplines, provide an orientation into all engineering departments and programs within the college, and to prepare students to think critically about their undergraduate experience and academic goals.

ENGR 10 is a zero-credit hour, pass/fail, eight-week course that all first-year engineering students are required to take during their first term as an engineer. In recent years, it was the position of the College of Engineering that since UNL did not have a centralized 'university 101' course that taught students study skills and basic college transition strategies, that an ENGR 10 seminar course could fill that void.

In the previous model, there was no work outside of class and the in-classroom format was primarily lecture-based. The course material focused on lecturing students on success strategies (how to take notes, study strategies, take tests, and other campus resources) and resources to help them persist at the university.

We introduced the engineering disciplines to engineering students by asking department chairs or faculty to lecture on their major. At the end of the eight-week course, all ENGR 10 students would go on an engineering industry trip to a neighboring city to learn about what engineers do.

Course Challenges

The pre-flipped course design presented several instructional and logistical challenges. The three-year course redesign efforts targeted the following challenges: (a) students were less likely to be excited about the freshman orientation course because it is a zero credit hour required course; (b) in the traditional lecture-based classroom, students were not actively engaged with the content, themselves, or their instructor, and spent most of class time passively listening to the lecture; (c) there was no formal assessment conducted on whether this model was effective or not, which made it difficult to assess whether or not the lecture-based format was the best design given the content and goals of the course; (d) it was difficult to schedule department chair presentations for each of the four (or more) sections, even though providing a general disciplinary understanding of engineering program is a primary objective the course; and (e) the course lacked active learning and team approaches to teaching.

The Flipped Approach

To address these challenges, the course redesign committee applied the flipped approach to teaching and learning. For three years, the committee met weekly throughout the summer weeks to work on course improvements, discuss online and in-class activities, and reflect on the previous course's evaluations. The committee redesigned the learning experiences to increase student engagement and enhance the student learning experience.

Lage and Platt [8] provided an early broad definition of the inverted classroom (more commonly known as flipped approach) as "events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa," with the focus being on not using classroom time to deliver lectures. Recent definitions include short descriptions of active in-class and student-centered learning activities, such as interactive groups, team work, and case studies [1,8,13] as well as content delivery modalities such as pre-recorded video lectures watched outside of the classroom. [5,12,13]

Engineering faculty have also shared their findings on the flipped approach. For example, in a recent study, Li and Daher[10] flipped a water resources engineering course and investigated students' performance on a quiz and benchmark problem on the final exam. They compared students' performance to previous years' results when the topic was introduced using traditional lectures. The t-test indicated positive significant differences when students were engaged in a flipped classroom. Similarly, Bland[2] applied the flipped model in an undergraduate electrical engineering classroom and reported enhanced learning. Comparably, the benefits of flipping the classroom are widely documented in STEM [6,13,14,19] and in Engineering [9,12,15,18] fields alike. It is essential to note that several of the aforementioned studies allude to the importance of the thoughtful integration between online and in-class activities.

Course Design

The purpose of this class is to help incoming first-year engineering students in their transition into the College of Engineering. The methods used in the present study reflect the online course design process, apparatus, and instructional strategies for both online and in-class activities.

In an effort to address the aforementioned challenges, the deans' office, instructional technology and design team at the college, and student services staff worked collaboratively for three years. In the first year, the first step of the flipped approach was implemented. All guest lectures were recorded and videos were hosted on a YouTube channel and then embedded in the learning management system Blackboard [inc]. Blackboard contained documents for online activities, learning objectives, and in-class activities. In the second year, the collaborative team designed a set of in-class active learning and engaging learning activities to better align with course and ABET outcomes and to better integrate the online and in-class activities. The in-class activities were redesigned in the third year using the National Academy of Engineering Grand Challenges as a theme and to incorporate the development of critical core competencies as defined by the complete engineer initiative.

Course alignment was built following the recommendations of backward of design reported by Wiggins and McTighe [7] where modules were centralized with one module folder for each week of class. The learning management system (LMS), Blackboard [inc] v.9, was used to host content. The navigation of course was divided into three main areas: Orientation, Content, and Tools. Under the Orientation section, students were provided with an in-depth explanation on how to navigate the course, communicate with their instructor, and what it means to partake in a flipped classroom. The Modules section contained a folder for each module, each folder contained information on the online and in-class activities detailing the assignments, discussion boards, learning goals and how they align with ABET outcomes, and, videos and assessments. The Tools section provided access to grades and email. Figure 1 presents the course navigation.

Figure 1

Following the flipped approach, students attended to the online modules before attending class. Each module folder presented the students with a description of the online and in-class activities, learning outcomes they are expected to meet by the end of the module, and any of the Grand Challenges and competencies that it aligns with as presented in figure 2 below.

Figure 2.

Module 1: Welcome to Nebraska Engineering

[Click the Module 1 link above to see videos and reflection questions]

ONLINE:

In this module you will watch one video in advance of the first class and review the general UNL-based resources that are offered to you as a first-year student. The first video is from Dr. Jones, Associate Dean of Undergraduate Studies, who will provide you with a general overview of engineering along with specifics on the UNL College of Engineering. After viewing the videos and browsing the campus resources and academic calendar links, please go to the class blackboard discussion link and fill out your responses to the reflection questions, which are due by Aug. 26 at 5:00 p.m.

IN-CLASS:

In class we review the course syllabus, class expectations, and take a quick survey. Please bring a laptop or mobile device to class. We will introduce Engineering Student Services staff and have a panel discussion reviewing their roles in how they act as a resource to engineering students.

GRAND CHALLENGES:

You will be broadly exposed to all 14 grand challenges in this module.

COMPLETE ENGINEER COMPETENCIES:

This module will help develop your understanding of self-management and understanding engineering ethics.

Learning Outcomes you will meet in this module include:

- Recognize academic and campus resources available to engineering students.
- Develop working knowledge of the complexities of major engineering challenges facing the world today.
- Develop and understand working knowledge of essential non-technical competencies critical to solving engineering challenges.
- Structure time management and study habit skills to better prepare for future classes at UNL.

Given the difficulty of scheduling live presentations from each of the department chairs for all five sections of the course, the instructional design team met with each chair to develop fifteen minute to twenty minute videos. Each chair provided an overview of the programs in their department. The videos were distributed among the modules and an accompanying set of reflection questions were provided. Students were asked to watch the videos for that week and then answer on the online discussion board questions related to the videos. The reflection questions were based on the content provided in each video. The questions served as one measure to prompt and encourage the students to complete the work needed before meeting in the face-to-face class.

An additional measure that is built into the flipped approach is the thoughtful integration between online and in-class activities. The majority of in-class activities required students to have completed the required online assignments. For example, to prepare for class in the second week, students were asked to watch a video introducing the grand challenges and reflect on them by answering online questions. During the in-class meeting of the same week, students were divided into groups and asked to discuss the grand challenge they believed aligned the most with their academic major and which competences or soft skills would be needed to advance solutions to the NAE Grand Challenges. Early in the semester students realize the connections between online and in-class activities. If they had neglected to engage in the preparation for the class, it would have become difficult to successfully complete the in-class activities.

Although the instructors reported an increase in student engagement based on their observations, several instruments were used to gather data explained in the following section.

Data Gathering

To gather data, three instruments were used: (a) Student Course Perception (SCP) survey which was delivered during the last week of class (b) Instructor Perception survey (IP), and (c) Student pass/fail data for the course (SPF).

In the SCP survey, student responded to a six question survey that gathered demographic information and allowed the students to rate their confidence in their selection of major. Students also provided their opinions on the flipped course design and any other general comments they had about the course. The IP survey provided the four instructors of the course the opportunity to reflect on and share their perceptions based on their observations. Students pass and fail data were compared to previous years of the course.

Data Analysis and Results

Student Course Perception survey (SCP) – Quantitative

In terms of the year of study, 96% were freshman, 3% were sophomores, 2% were juniors. Only the data from freshman students were analyzed. A total of 180 freshman students responded to the survey. Of the respondents, 27% (n=49) identified as female, 73% (n = 131) identified as male.

In terms of students' perceptions of the course, 69% ($M = 6.93$, $SD = 2.8$) reported confidence in their selection of an engineering major. An average of 53% ($M = 5.26$, $SD = 2.8$) reported that the course allowed them to better connect with other engineering students and 50% ($M = 5.01$, $SD = 2.8$) reported their views of engineering as a discipline had changed. An average of 67% ($M = 6.71$, $SD = 2.7$) believe the course improved their understanding of other engineering majors and 62% ($M = 6.2$, $SD = 3.1$) reported that by the end of the course they were more confident about the engineering program they wanted to major in.

In terms of students' perception on the flipped approach, only 17% of students had participated in a flipped course prior to this course. An average of 58% ($M = 5.78$, $SD = 2.9$) felt that the flipped classroom made them feel more responsible for their learning and 52% ($M = 5.2$, $SD = 2.9$) reported that the flipped approach created an active learning environment. An average of 48% of students preferred the flipped classroom to the traditional approach.

Student Course Perception survey (SCP) – Qualitative

Qualitative analysis was conducted through analysis of the students' general comments on the course. NVivo qualitative analysis software was used to determine any emerging themes. Only 33% provided additional comments on the optional question. The major theme that emerged was that the videos were too long or needed to be condensed.

Instructor Perception survey (IP) – Qualitative

Four instructors were asked to respond to the survey and reflect on their teaching experience. Results of qualitative analysis using the NVivo qualitative analysis software determined three major themes. First, instructors agreed with the students, that the online video presentations needed to be redesigned. Second, although none of the instructors were engineers, the flipped approach allowed them to facilitate learning on engineering disciplines. Third, the time needed for preparation for flipped classroom is similar to that of a traditional classroom.

Student pass/fail data for the course (SPF)

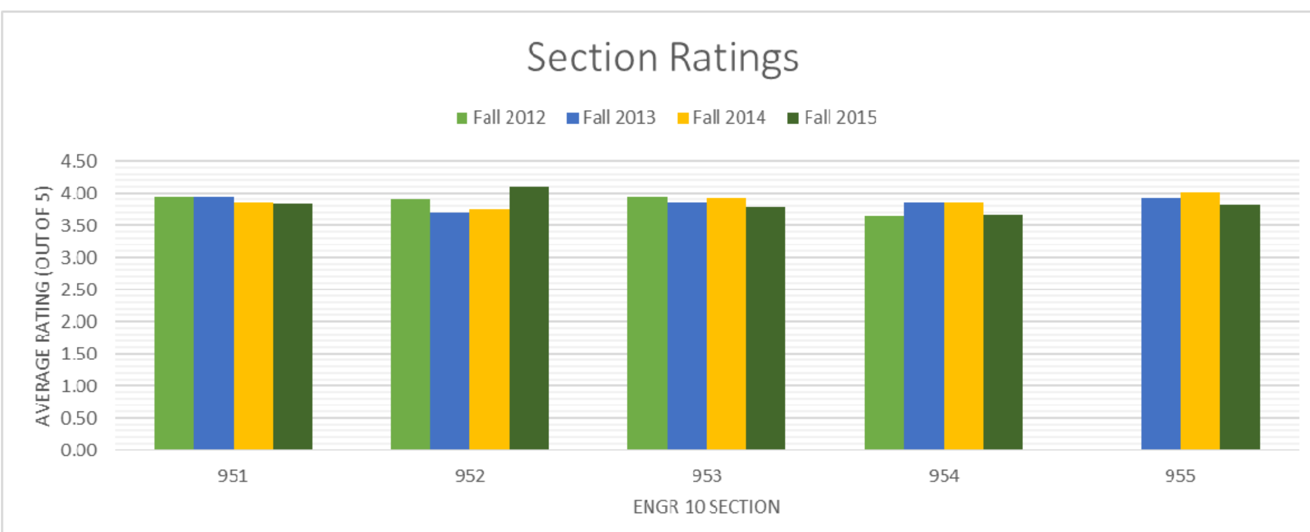
The pass/fail data for previous years shows that more students passed the course in the flipped approach than any of the previous 5 years the course was offered. The data are highlighted in table 1.

Table 1. Number of students who passed or did not pass ENGR 10 during each of the previous 5 years.

Semester	Pass	No Pass
Fall 2012	453	13
Fall 2013	523	35
Fall 2014	483	25
Fall 2015	470	10

In terms of students rating of the class, despite the increased work on the students' part, on average students rated the course similar to the past 4 years as shown in table 2.

Table 2



Discussion

The flipped approach successfully addressed several of the course challenges. Recording and uploading department and program chairs' presentations online removed the need for scheduled live lectures that had previously used valuable in-class time. Students were no longer passively listening to lectures from the instructor or guest speakers. They were actively engaged in course content several days before attending the weekly class session. Students were activity engaged in-class with discussions and team work. With the addition of a perception survey, course instructors were able to ask specific questions related to the course design and delivery, instruction, and gather an in-depth understanding of the student perception. In addition, students' responses on the discussion board and in the in-class activities made it clear that the vast majority of freshman did in fact meet the course objectives.

In the new design, students were asked to take more responsibility for their own learning. The time required to watch the online videos, complete online reflections, and engage with their peers in the classrooms were notably more than previous pre-flipped offerings of the course in a traditional lecture based format. However, course ratings over the last four years indicate that students did not find the flipped course any more work than previous years. We believe that this due to an obvious increase in engagement. However, only about half of the students preferred the flipped approach to the traditional approach. We believe that this is due in part to the length of online videos and that more attention is needed to better connect some of the in class activities to the online portions.

The instructors' perceptions clearly indicate that although they were not educated as engineers, the flipped approach allowed them to facilitate a learning experience that better introduced the students to engineering. In addition, more students passed the course than in previous offerings of the course. While a decrease in failure rates is a positive outcome, we cannot directly attribute it to the flipped approach as instructors, content, in and out of class activities were altered in the flipped model.

The literature reviewed in this study discussing flipped engineering course are all for credit. In our course, students are not credited for completing the course although it is required. We believe that given the amount of work online and in-class that the students are engaged in, it might have impacted the student perception.

Future Studies and Limitations

We believe this to be the first iteration of our research. Although the course redesign process and data gathering was done over three years, further data gathering and analysis is needed. The major limitation of the study is that the vast majority of the data gathered was qualitative and represented the instructor and student perceptions. Further research on students' performance throughout the semester is needed. Additionally, over the next year a new set of videos that are shorter, more concise, and better aligned with the learning outcomes will be developed. We also believe that we cannot attribute all of the positive impacts to the flipped model based on the data we explored, however we do think that is the drive to an improved learning and student experience.

References

1 Bishop, Jacob Lowell, and Matthew A. Verleger. "The flipped classroom: A survey of the research." In ASEE National Conference Proceedings, Atlanta, GA, vol. 30, no. 9. 2013.

2 Bland, Larry. "Applying flip/inverted classroom model in electrical engineering to establish life-long learning." In ASEE Annual Conference & Exposition. 2006.

3 Budny, D. D., Paul, C. A., & Newborg, B. B. "Educating Freshman Engineering Parents, Improving Freshman Engineering Retention", Proceedings of the 2013 ASEE North-Central Section Conference, 2013

4 Fujikura, T., Nemoto, T., Takayanagi, K., Kashimura, M., Hayasaka, Y., & Shimizu, K. "A Freshman Orientation Program to Provide an Overview of the Medical Learning Roadmap", Journal of Nippon Medical School, 81(6), 2014, 378-383.

5 Herreid, Clyde Freeman, and Nancy A. Schiller. "Case studies and the flipped classroom." Journal of College Science Teaching 42, no. 5, 2013), 62-66.

6 Johnson, Lisa W. "Effect of the flipped classroom model on a secondary computer applications course: Student and teacher perceptions, questions and student achievement." PhD diss., University of Louisville, 2012.

7 Kleinsmann, Maaike Susanne. Understanding collaborative design. TU Delft, Delft University of Technology, 2006.

8 Lage, M. J., and Platt, G., "The Internet and the inverted classroom.", Journal of Economic Education, 31(1), 2000, 11-11.

9 Lemley, E. C., B. Jassemnejad, E. Judd, B. P. Ring, A. W. Henderson, and G. Armstrong. "Implementing a Flipped Classroom in Thermodynamics." In Proc. ASEE Annu. Conf. Expo., 2013.

10 Li, Yusong, and Tareq Daher. "Integrating Innovative Classroom Activities with Flipped Teaching in a Water Resources Engineering Class." Journal of Professional Issues in Engineering Education and Practice (2016): 05016008.

11 Mackensen, E., Lurz, C., Reichert, A., & Köbler, J. Enhancing the motivation and success of freshman students in interdisciplinary engineering degree programs, IEEE Global Engineering Education Conference,2015, pp. 659-667.

12 Mason, Gregory S., Teodora Rutar Shuman, and Kathleen E. Cook. "Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course." IEEE Transactions on Education 56, no. 4, 2013, 430-435.

13 McLaughlin, Jacqueline E., Mary T. Roth, Dylan M. Glatt, Nastaran Gharkholonarehe, Christopher A. Davidson, LaToya M. Griffin, Denise A. Esserman, and Russell J. Mumper. "The flipped classroom: a course redesign to foster learning and engagement in a health professions school." Academic Medicine 89, no. 2, 2014 236-243.

14 Moravec, Marin, Adrienne Williams, Nancy Aguilar-Roca, and Diane K. O'Dowd. "Learn before lecture: a strategy that improves learning outcomes in a large introductory biology class." CBE-Life Sciences Education 9, no. 4 (2010): 473-481.

15 Nelson, Nancy. "FLIPPING THE ENGINEERING CLASSROOM." Proceedings of the Canadian Engineering Education Association (2015).

16 Permzadian, Vahe, and Marcus Credé. "Do first-year seminars improve college grades and retention? A quantitative review of their overall effectiveness and an examination of moderators of effectiveness." Review of Educational Research 86, no. 1, 2016, 277-316.

17 Posey, Posey, Timothy, Eddie Hill, Edwin Gomez, Mike McFall, Shea Humenik, and Dakota Clifford, "Student Adjustment to College: Examining the Impact of an Outdoor Orientation Program", Illuminare: A Student Journal in Recreation, Parks, and Tourism Studies 13, 2015.

18 Toto, Roxanne, and Hien Nguyen. "Flipping the work design in an industrial engineering course." In 2009 39th IEEE Frontiers in Education Conference, pp. 1-4. IEEE, 2009.

19 Wilson, Stephanie Gray. "The Flipped Class A Method to Address the Challenges of an Undergraduate Statistics Course." Teaching of Psychology, 2013, 0098628313487461.

Biographical Information

Tareq Daher

Tareq Daher earned his Bachelors in Computer Science from Mutah University in Jordan. He pursued a Master's of Instructional Technology at the University of Nebraska –Lincoln (UNL) while working as the coordinator for the Student Technology Program on the UNL campus. Currently, Dr. Daher works as an Instructional Design Technology Coordinator for the Office of Online and Distance Education at the University of Nebraska – Lincoln leading the instructional design team at the College of Engineering. Dr. Daher collaborates with engineering faculty to document and research the integration of innovative instructional strategies and technologies in his classroom. His latest collaborative submitted publication discusses using the Flipped approach in a water resources course and the blended approach in a construction management course.

Michael Loehring

Michael currently serves as the Senior Director of Student Services for the College of Engineering at the University of Nebraska-Lincoln. In this role, Michael is responsible for the first-year seminar course development, academic advising, student/career development, admissions, and recruitment initiatives for all engineering programs in Lincoln and Omaha. He has more than 10 years of professional experience in student affairs and enrollment management at several public institutions. Michael graduated from the University of Central Missouri with a B.S. in Public Relations and a M.S. in College Student Personnel Administration.