Implementing a Hybrid-Flipped Classroom Model in an Introduction to Engineering Course

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Abstract

Much has been written recently about the use of the flipped classroom models in which students absorb most of the content prior to class through reading, exercises, or videos and use the class time for discussion, clarification, or problem solving. This paper discusses how this process was adapted for the Introduction to Engineering courses at the University of Arkansas. As the class consists almost entirely of first-year students from various high school backgrounds, students begin with large discrepancies in preparedness, study skills, and previous exposure to topics. This can make instruction difficult as some students struggle while others are bored. Using a flipped classroom model with instructional videos followed by time to work problems in class allows well prepared students to not feel restricted by slower working classmates. The additional problem of poor study skills or discipline is overcome by our use of an instructional computer lab. This allows students to have access to the instructional videos during the class as a refresher (or a first look). This also aids with struggles students have entering answers in an electronic format.

Keywords

First-year course, flipped-classroom, instructional methods

Introduction

The Freshman Engineering Program (FEP) at the University of Arkansas (UofA) was established in 2007 with the primary objective of increasing the retention of new freshman in the College of Engineering (CoE) to their sophomore year. This objective supports college-wide retention and graduation rate goals. Based on our increased retention rates[1], we believe we are providing our students with a solid foundation for success in engineering study.

A key component of the FEP is the Introduction to Engineering course sequence which serves as the first year experience course for new students in the CoE. The course sequence is offered as two, one-credit hour courses each semester of the first year. The students meet for two 50 minute lectures and one 50 minute drill section each week, as well as a 30 minute peer mentor meeting. This results in a total of 180 minutes of weekly contact. In general, lectures focus on engineering problem solving, drill sections focus on major selection and professional development, and peer mentor meetings focus on personal and academic success. The lecture content is further divided into spending roughly half the time on theme-based team projects and the rest on basic engineering skills used by all engineering students.

Course Content: Technical Material

The topics covered in the Introduction to Engineering I course include the following:

- Engineering Fundamentals
  - Significant Figures
  - Unit Conversions
  - Dimensional Analysis
- Descriptive Statistics
  - Mean, Median, Range, Standard Deviation
  - Excel Functions: AVERAGE(),MEDIAN(), MAX(), MIN(), & STDEV()
- Charts & Graphs (Excel)
  - Constructing Bar Graphs & Scatter Plots
  - Labelling: Titles, Axis Titles, Units
  - Trend lines

Then during Introduction to Engineering II (second semester) students are introduced to these topics:

- Data Management I (Excel)
  - Formatting
  - Functions: Count(), Sum(), Average(), Median(), Max(), Min()
  - Sorting
  - Filtering
- Data Management II (Excel)
  - IF(), COUNTIF(), AND(), OR()
- Engineering Economics
  - Time value of money
  - Cash Flow Diagrams
  - Loan Repayment tables

Technical Content Delivery

Due to the varied abilities and previous experience of students entering the course, we found that many students would become bored with our lectures while others would struggle to understand new concepts. This was especially evident on topics such as fundamentals where some students had been exposed to the concepts in high school as well as in the chemistry and physics courses they were taking alongside the Introduction to Engineering class. Similarly, when it came to learning to use Microsoft Excel, some student s were experts while others had never seen it before. Lecturing on how to use excel had the additional problem of one student halting the entire class of fifty since we were teaching sequential steps. In our flipped classroom model, the devised process for each assignment was students watch video lectures, complete an electronic "Concept Quiz", complete the necessary calculations or questions on a provided worksheet, and finally complete the assignment by submitting the answers electronically on Blackboard. This process is discussed in detail below.

Videos

Over a period of two years, flipped modules were created for each topic. These modules generally use the same PowerPoint slides that we had used in the past with voice-overs. On some topics, the recording was of a problem being worked on paper while being explained. One of the keys to this was breaking up the 50 minute lecture into 5-10 minute segments. This helps solve attention span problems and allows students to review specific areas without weeding through a large video. For excel topics, we created some videos of our own, but also relied on the vast amount of videos available on youtube.com. Using outside video, helps students realize that this is something people use outside of this class and breaks up the monotony of our videos. We also use self-paced guides which contain written step by step instructions. Once the modules were created, we upload them to our course Blackboard page.

Concept Quiz

After watching videos, students were to complete an online concept quiz. The concept quizzes consist of 5-10 quick questions covering information from the videos, previously covered skills, and often questions about assignment submission details such as due date or file name. Students are required to complete the concept quiz in order to open submission for the assignments.

Assignments

The other goal of our flipped classroom was to reduce the amount of hand graded activities so that teaching assistants would have more time for one-on-one help during office hours. This was accomplished by creating assignments which could be automatically graded through Blackboard submission. Students complete assignment by working out the solutions on provided worksheets, scratch paper, or Excel files. Then, they answer (mostly fill in the blank) questions on the blackboard system. The biggest struggle with creating the electronic submission assignments has been adjusting for multiple possible right answers or being very specific when asking for format of the solution. The result of the electronics assignments are that students can get immediate feedback when it previously took a week for a teaching assistant to grade them.

Theory vs. Reality

The idea behind the flipped classroom is that students would watch the videos and complete the concept quiz at home. This leaves class time to clarify mistakes with the concept quiz, complete the assignment while being helped by other students, the instructor, and the teaching assistant. Students can then enter all of the correct answers into the electronic submission and leave with a perfect assignment. The reality of course is that many students do not watch the videos or attempt the concept quiz before class.

Our solution to this problem is that we spend most of these class days in our 52 seat computer lab housed within our freshman engineering program. Providing students access to computers ensures they have the opportunity to view the videos and any other resources they may need. Teaching assistants and instructors often first respond to questions with, “Did you watch the video?” If the answer is yes then they can help the student determine what concept they are struggling with. If the students have not watched the videos, then we provide headphones so they

can listen to the video lecture, or if they prefer, the students may view the slides with instructor's notes.

Results

To determine the students' attitudes toward the flipped classroom delivery they were asked a series of questions within a longer end of semester survey. The responses were kept anonymous through the blackboard submission, and student completion was tracked. Of the 513 students enrolled in the Introduction to Engineering II class in Spring 2015, 337 students responded.

Q1. With regard to the fundamental topics (Unit conversions, Excel, etc.), which method of content delivery would you prefer?

Topic Delivery- Preferred	Count	%
A text book	12	3.6
In-class lecture	122	36.3
Video lecture (by FEP)	140	41.7
Outside video resources (ex Youtube, Kahn Academy)	62	18.5

According to these results, students prefer video lectures only slightly above in-class lecture. Very few would prefer a text book; students have expressed this in the past which is why we do not adopt a textbook for this course. Interestingly, a considerable percentage of students prefer to do more on their own with the help of outside video resources.

Q2. With regard to the fundamental topics (Unit conversions, Econ, Excel, etc.), which method(s) of content delivery do you commonly use? (Select any that apply)

Topic Delivery- used	**Count**	**%**
Videos provided by FEP	184	54.8%
Slides/notes to videos provided by FEP	211	62.8%
Supplemental outside video resources (ex Youtube, Kahn Academy)	75	22.3%
None	38	11.3%
All	33	9.8%

Instructor's slides with notes is the most common method used. This is not surprising since many students know many of the concepts we are covering, they just need a small content clarification. The slides or notes can be searched much more easily than finding the correct spot even in the short videos. However, we are encouraged to see that a majority of students are using the videos we recorded and nearly one in four is taking advantage of outside resources. We were especially excited to see nearly 10% use a combination of all these resources, but equally disappointed to see that 11% do not use any of the provided materials. Hopefully, those students that are not using the resources have already mastered the class material. Since the survey is anonymous, we cannot link these responses to performance.

Q3. With regard to the fundamental topics (Unit conversions, Econ, Excel, etc.), when do you typically watch the FEP videos?

When do you watch FEP videos	Count	%
Before class	19	5.7%
At the beginning of class	41	12.2%
In-class if/when I don't understand something	193	57.4%
Outside of class if/when I don't understand something	34	10.1%
Never or rarely	48	14.3%
<Unanswered>	1	0.3%

Even though we encourage our students to watch the videos before they come to class, most do not (only 6% do), and only a few more (12%) watch them at the beginning of class. Based off our experience of teaching freshman engineering students, we know that students typically do not watch the videos until they have difficulty with a problem. The students' ability to watch the videos in the classroom seems to be of vital importance since this is when 70% of students access them.

Q4. With regard to the fundamental topics (Unit conversions, Econ, Excel, etc.), when do you typically read the video script or lecture notes provided?

Topic Delivery- Scripts	Count	%
Before class	16	4.8%
At the beginning of class	53	15.8%
In-class if/when I don't understand something	178	53.0%
Outside of class if/when I don't understand something	28	8.3%
Never or rarely	59	17.6%
<Unanswered>	2	0.6%

Similar to the videos we created, students tend to access these in-class (69%) and only when they do not understand something (61%).

Q5.With regard to the fundamental topics (Unit conversions, Econ, Excel, etc.), when do you typically watch the supplemental videos?

Topic Delivery- Supplemental Videos	Count	%
before class	15	4.5%
At the beginning of class	33	9.8%
In-class if/when I don't understand something	178	53.0%
Outside of class if/when I don't understand something	35	10.4%
Never or rarely	74	22.0%
<Unanswered>	1	0.3%

We do not necessarily expect students to watch the supplemental videos since all topics are covered in our provided video lectures. We provide these videos as to accompany our lectures and to further clarify topics that students frequently fail to easily recall. Therefore, it is not surprising to us that there are an increased number of students (22%) that say they do not use the supplemental videos. Very few students (14%) watch the supplemental videos before class or at the beginning of class before they begin the assignment. However, students do seem to access these videos during class (63%) when they do not understand something (63%) similar to the other materials we provide.

Q6. Give any feedback you believe would help improve the content delivery for this course.

As one could guess from the survey responses, comments were variable regarding FEP videos, notes, and desire for conventional lecture. The majority of the complaints have to do with the electronic submission of homework assignments. Due to limitations of the software we use to create the assignments, students must be very careful about how they answer a question. This is especially difficult when asking them to enter Excel formulas. While there are often different syntaxes that can arrive at the same numerical answer, the blanks are set for only the method we discuss in the videos or notes. In some cases, there is an underlying reason of our syntax, but other times the alternate syntax would be just as valid. We are careful to make clear instructions on the provided worksheets or electronic files, but those with previous experience tend to ignore those instructions until they get counted off on the homework. That is why we allow two attempts on each assignment, and allow students to have their work checked by the instructor or teaching assistant before submitting their answers.

Conclusions

As with any flipped classroom model there are advantages and drawbacks. Many students prefer not being held back to the speed of the slowest person in the class. If they can complete the assignment early, they are free to go. As noted by question one, many students would still prefer a lecture. In general, we feel students prefer a conventional lecture, because they do not want to work during class. When they attend lecture, they feel that have fulfilled their obligations toward class, whether they absorbed the information or not. However, we believe having the ability for students to complete the assignment in class with guidance and use of the computer, as well as the instructor and teaching assistant, has helped them gain a better understanding of engineering fundamental topics.

References

1 Schneider, K., H.A. Schluterman, C.A Rainwater, “Student Perceptions of a Theme-Based Introduction to Engineering Course,” *Proceedings of the 2013 ASEE Midwest Section Conference*, Salina, KS, 2013.

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