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Comparison of Traditional, Flipped, and Hybrid Teaching Methods in an Electrical Engineering Circuit Analysis Course

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Comparison of Traditional, Flipped, and Hybrid Teaching Methods in an Electrical Engineering Circuit Analysis Course

Abstract

This research builds on recent studies which have assessed advantages and disadvantages of a flipped classroom as compared to a traditional face-to-face classroom in Electrical Engineering Circuit Analysis courses. Flipped classrooms afford more opportunity for problem solving activities with students reading and viewing pre-recorded lectures prior to each in-class session.

A hybrid classroom incorporates components of both traditional face-to-face and online learning allowing for greater flexibility in enhancing the learning and improving the understanding of course material. We applied all three teaching pedagogies in a Circuit Analysis class in a recent semester at a first-tier public research university. Students were surveyed at the end of the semester to assess their perceptions of the course, confidence in performing tasks, and interest in a fully on-line course.

Task competencies surveyed included: Knowing the basics of instruments used in electrical engineering; Measuring voltages and currents using instruments; Building a variety of AC/DC circuits; Analyzing and modeling circuit performance using simulation tools; Understanding the purpose or function of a presented circuit; Building a circuit based upon results of a design calculation.

We elaborate further on the pros and cons of all three teaching methods, summarize students' perceptions and make suggestions based on the survey results and student comments.

Introduction

Curricula for Electrical, Computer, Civil, Mechanical, and Biomedical Engineering degrees at most universities require at least one course in Electrical Engineering Circuit Analysis. There are several different approaches that can be and are employed in teaching this course. These pedagogies include traditional face-to-face lectures and active learning techniques. A flipped classroom is an example of active learning in which students prepare themselves prior to in-class sessions, allowing time during class for active problem solving activities.

Traditionally, most of the Electrical Engineering Circuit Analysis courses use a lecture format where concepts are introduced followed by one or two example problems that are solved during the class session [1]. It was long felt by engineering professors that this method was the most effective in covering the large amount of required material in time periods allotted for the course [2, 3]. Since large amounts of information can be given by the lecturer in relatively short periods of time, the historical belief has been that this is the most effective means of teaching the material. Mejias [3] argues that this belief, however, is predicated on the assumption that students are "empty receptacles waiting to be filled with knowledge." Borrego and Bernhard [4] found that "lectures are an efficient means of delivering material to large numbers of students, however evidence is mounting that this format does not necessarily promote a high level of learning or retention of knowledge." According to Pitterson and Streveler [1], "traditional lecturing has been classified as ineffective in helping students develop critical thinking skills necessary to take up their roles as engineers in more professional settings."

Until recently, most lecture format courses have been passive learning experiences [5]. According to Kim *et al*. [5], students' "active" participation in such cases may take the form of "texting, 'Facebooking,' or sleeping." In contrast, active learning has been defined as "any instructional method that engages students in the learning process." [6] Cavalli *et al*. [7] note that the loss of lecture time which decreases the amount of material covered is typically the most significant drawback to active learning approaches such as problem-based learning and collaborative/cooperative learning.

An active learning approach that minimizes the above concern is the flipped classroom pedagogy. This method has become quite prevalent in several disciplines in recent years. As Elliott [8] indicates, the basic premise is that students "interact with the course material *prior* to coming to the classroom so that face-to-face time can be used for active learning." The usual approach is for students to either read the material or watch recorded lectures before coming to class. The flipped classroom is based on a variety of active learning theories and methods: [9]

- Student-centered learning
- Constructivism
- Problem-based learning
- Peer assisted learning

Elliott [8] summarizes a number of reasons why instructors have used flipped classrooms:

- The amount of material introduced in the class can be increased.
- It can serve as a validation that students read or view required material.
- There is more time for hands-on learning in the classroom.
- Students have more time to participate in collaborative or peer learning during regular class time.

Bishop and Verleger [9] define a flipped classroom as a combination of interactive group learning activities in the classroom (prescribed by student-centered learning theories), and computer-based instruction outside the class (prescribed by teacher-centered learning theories). Their comprehensive review of flipped classroom literature resulted in the following findings:

- Students in most studies expressed a preference for interactive in-class activities over in-person lectures, which in turn were preferred over recorded lectures.
- Applying student-centered learning theories inside the classroom using an active learning framework is essential to a well-designed flipped classroom.
- There are two main types of overlapping active learning strategies that can be applied: problem-based and peer-assisted (cooperative, collaborative and peer-tutoring) as shown in Figure 1.

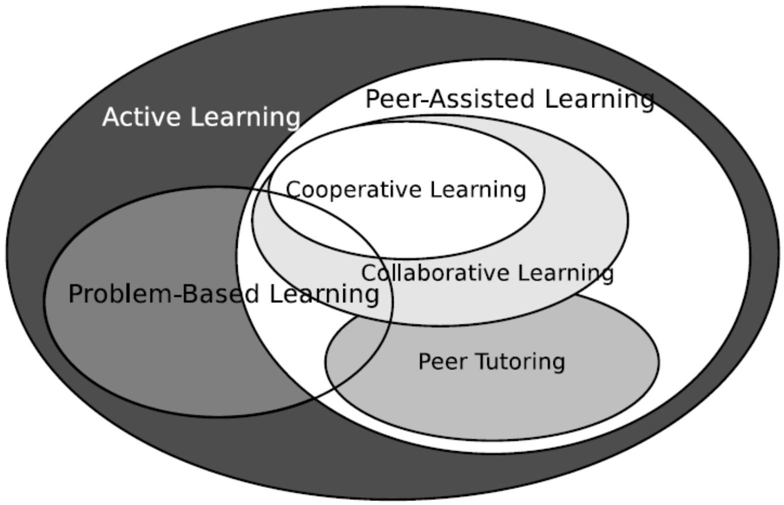

Figure 1. Venn diagram of several student-centered learning theories and methods [9]

Ramirez *et al.* [10] note the following disadvantages of flipped classrooms:

- Technical problems or the need of special software or devices in some cases.
- Not enough examples of problems and their solutions in videos.
- Lack of instant feedback on items not understood while watching the recordings.
- Length of videos.

A hybrid classroom incorporates components of both traditional face-to-face and on-line learning with in-class activities. This approach allows for greater flexibility to enhance learning and may improve student understanding of course material. Prescott [11] cited the following motivations for hybrid classrooms:

- Faculty can take advantage of new classroom facilities and technology.
- Engages students in ways that pure on-line courses cannot.
- Increases learning and retention using new technology and pedagogy.

All three teaching pedagogies were applied in a circuit analysis course at Florida International University, Miami, FL, a first-tier public research university, when the first author was a member of the Electrical Engineering faculty. The goal of the research is threefold:

- Assess students' perceptions of the teaching techniques.
- Assess students' confidence in what they learned.
- Assess students' interest in fully on-line courses.

Methods

During the Spring 2013 Semester, three sections of an Electrical Engineering Circuit Analysis course was taught by three seasoned instructors who had been teaching the Circuit Analysis course for a few years. To minimize the biases in survey results, all course sections were randomly assigned to instructors, a common course book was used throughout the semester, and all students were assessed using a common final exam that was given on the same day and administered by independent proctors. Each section used a different teaching method as follows:

- 32 students were enrolled in a traditional face-to-face course with lecture only.
- 36 students were enrolled in a flipped classroom which featured pre-recorded lectures, class lectures, learning assistants, and team exercises.
- 85 students were enrolled in a hybrid section which included class lecture and an additional weekly 50 minute recitation section.

At the conclusion of the course, all students took a survey. The survey was designed by the first author and refined by a faculty member in the College of Education at Florida International University. Survey questions were focused on labs, overall course experience, lectures, and instructional methods.

The majority of the questions were either yes/no responses or based on a 1-5 Likert scale with 1 being the lowest and 5 being the highest response. The following questions, which required a 1-5 response were asked of students in all three sections:

- How effective were the Laboratories in learning about circuits?
- How confident do you feel in performing the following tasks on your own after completion of the course?
    - Knowing the basics of instruments used in electrical engineering (e.g. multimeter, oscilloscope, power supply, etc.)?
    - Measure voltages and currents using instruments (such as multimeter, oscilloscope, power supply, etc.)?
    - Build a variety of AC/DC circuits?
    - Analyze and model circuit performance using simulation tools, such as PSpice, Matlab or other software?
    - Understand what is the purpose or function of a circuit if presented to you?
    - Build a circuit by choosing a set of resistors, capacitors and/or inductors based upon the results of your design calculations?
- How effective was the course's textbook content and numerical exercises in helping you learn circuits?
- How do you like the idea of a common comprehensive final exam?

Other questions which were asked of all students included:

- If offered a choice of a Take-Home Hands-on-Lab, would you be interested?
- Do you feel that you learned from the Lab?
- Do you feel that you learned from the course?
- What kind of impact do you think the common comprehensive final exam will have on your final grade?
- Approximately, how many times were you absent from the lecture?
- If a fully online section of the course is offered with a Take-home, Hands-on Self-learning Lab Kit, would you take it?

The remaining survey questions were specific to the individual sections. There were also demographic questions asked, which identified:

- Class year (Freshman/Sophomore/Junior/Senior)
- Gender (Male/Female)
- Engineering Major (Electrical/Computer/Civil/Mechanical/Biomedical/Other)
- Engineering Minor (Electrical/Computer/Civil/Mechanical/Biomedical/Not Applicable)
- Current GPA
- Expected final grade in the course
- Preferred method of instruction (Auditory/Visual/Kinesthetic)

In the initial analysis of the survey results, the demographic information was not taken into account. Future data analysis will take into account several of these variables to determine if differences exist between the identified categories.

A number of hypotheses tests were performed to determine if statistically significant differences existed between sections. Typical p-values were calculated for each test. The following guidelines were used in determining the degree of significance:

- $p\text{-value} < 0.01$: Highly significant result
- $0.01 \leq p\text{-value} \leq 0.05$: Significant result
- $0.05 < p\text{-value} \leq 0.10$: Marginally significant result
- $p\text{-value} > 0.10$: Insufficient evidence to conclude significance (i.e., failure to reject null hypothesis)

For questions where the response was "yes" or "no" and the results were very similar for each section, the proportions were pooled and the following set of hypotheses were tested:

H_0: $p = 0.5$ vs. H_a: $p > 0.5$ when the claim was that there was a majority of "yes" responses

or

H_0: $p = 0.5$ vs. H_a: $p < 0.5$ when the claim was that there was a majority of "no" responses

In this case, p represents the overall proportion of "yes" responses when the results for all three sections were combined.

In other cases where the response was a 1-5 Likert scale rating, the proportion of selected ratings (often 4's and 5's or 1's) were compared for the three sections. In many instances, the distribution of ratings for two sections were very similar (typically for the traditional lecture and hybrid sections) so the proportions were pooled and compared to the other section. For this test, the hypotheses were:

H_0: $p_1 - p_2 = 0$ (i.e., $p_1 = p_2$) vs. H_a: $p_1 - p_2 > 0$ (i.e., $p_1 > p_2$) when the claim is that the proportion for the pooled sections (p_1) is greater than the proportion for the other section (p_2)

or

H_0: $p_1 - p_2 = 0$ (i.e., $p_1 = p_2$) vs. H_a: $p_1 - p_2 < 0$ (i.e., $p_1 < p_2$) when the claim is that the proportion for the pooled sections (p_1) is less than the proportion for the other section (p_2)

Statistical software was used to perform the above tests for proportions and the difference between proportions. Since the usual assumptions for using a normal approximation to the binomial distribution were satisfied, p-values for z test statistics were used.

The final test that was used was a comparison of equal proportions for all three sections:

H_0: $p_1 = p_2 = p_3$ vs. H_a: At least one p_i (i = 1, 2, 3) is different than the other proportions

The Kruskal-Wallis test for comparing three populations was used to determine the p-value in this instance.

Results

The survey was constructed to focus on four general topics:

- Laboratories
- Lectures
- Overall Course
- Instructional Methods

We will summarize the results using the above categories.

Laboratories

There were three questions asked about the labs:

1. On a scale of 1-5 (1 being lowest and 5 being highest), how effective were the Laboratories in learning about circuits?
2. If offered a choice of a Take-Home Hands-on-Lab, would you be interested?
3. Do you feel that you learned from the Lab?

The section with traditional lectures had a higher percentage of 4's and 5's (68.75%) than the other two sections (58.33% for the flipped section and 55.30% for the hybrid section) on the question of effectiveness in learning about circuits. Testing the hypothesis that the proportion of 4's and 5's for the traditional lecture section was higher than for the pooled proportions of 4's and 5's for the flipped and hybrid sections resulted in a p-value of 0.0997 which indicates that there is a marginally significant difference between the traditional section and the other two sections. This suggests that the traditional lecture section had a stronger belief that the labs were effective in learning about circuits than the flipped and hybrid sections.

With respect to a Take-Home Hands-on-Lab, the results were essentially the same for each section with 40% of students overall indicating that they would be interested. The p-value was 0.0061 for a test that the minority of students would be interested in a Take-Home Hands-on-Lab. This highly significant result was based on combining the proportions for all three sections since the results varied little from section-to-section for this question.

In a somewhat surprising result, the highest percentage of students who felt that they learned from the Lab was the flipped classroom section at 86.11%. The lowest percentage was for the traditional section with 71.88% indicating that they learned from the Lab. The hybrid section had 76.47% that responded affirmatively. These results were surprising in comparison to the results for the question on the effectiveness of the Labs in learning about circuits. For a test where the alternative hypothesis was that the proportion for the pooled traditional and hybrid sections was less than the flipped classroom section, the resulting p-value was 0.0845. This is a marginally significant difference.

The lecture only section had a marginally significant overall higher evaluation of the effectiveness of the labs compared to the other two sections but the lowest affirmative response to learning from the labs. In contrast, the flipped section had a lower evaluation of the effectiveness but a marginally significant higher “yes” response relative to learning from the labs.

Lectures

In this portion of the survey, students were asked five questions:

1. On a scale of 1-5, how effective was the course’s textbook content and numerical exercises in helping you learn circuits?
2. On a scale of 1-5, how do you like the idea of a common comprehensive final exam?
3. What kind of impact do you think the common comprehensive final exam will have on your final grade?
4. Approximately, how many times were you absent from the lecture?
5. If a fully online section of the course is offered with a Take-Home, Hands-on Self Learning Lab Kit, would you take it?

The responses for the effectiveness of the textbook were very consistent for all three sections. Only 46.4% of students overall evaluated the textbook a ‘4’ or a ‘5’ in the survey.

With respect to the comprehensive final exam, there was an overall negative response to the idea. Over 70% of all students responded with a ‘3’ or lower to the common comprehensive exam concept. The flipped classroom section had the lowest evaluation of the idea with exactly 50% scoring the question with a ‘1’ response. In a test that the pooled proportion of 1’s was less for the traditional lecture and hybrid sections than for the flipped classroom proportion of 1’s, it was highly significant with a p-value of 0.0056. Likewise, the flipped classroom section had the highest response of a negative impact (30.56%) to the question on the impact that the exam will have on final grade. The highest positive response was only 25% which was for the lecture only section. In a test that there was a significant difference in the proportion of negative responses (out of the total of positive and negative responses) between the three sections, the p-value was 0.1279 which indicates that there was insufficient evidence to detect any differences in the proportion of negative responses (or positive responses) between any of the sections. The vast majority of students, however, in all three sections did not think the impact would be positive or negative or they weren't sure what the impact would be.

The flipped section had the highest percentage of students who attended all lectures at almost 60% with only about 10% of students who missed three or more lectures. This is in contrast to the other two sections where close to 40% of the hybrid section and slightly more than 20% of the lecture only section students missed three or more lectures. A test for comparing proportions was conducted with an alternative hypothesis that the pooled proportion for the traditional lecture and hybrid sections had a smaller proportion of students who missed three or fewer lectures than the proportion for the flipped classroom sections. The p-value for the test was 0.0059 which indicates that the proportion of missing three or fewer lectures is greater for the flipped section. Equivalently the proportion that missed more than three classes is significantly higher for the traditional lecture and hybrid sections than for the flipped section.

In response to one of the most anticipated questions in the survey, an overall majority of students indicated that they were not interested in a fully online section of the course. Over 65% of students responded that they would not take such a course while 35% indicated that they would. The highest percentage of "no" replies were in the lecture only section at 69% with the lowest percentage for the flipped classroom section at 63%. In testing that the minority of overall responses were "yes," the p-value was a highly significant 0.0003. Thus there is very little interest among most students in a fully online section for the Electrical Engineering Circuit Analysis course.

Overall Course

There was a general question which asked "Did you feel that you learned from the course?" along with six specific task competencies which were listed earlier in the Methods section that were used to evaluate the course.

Almost 89% of the students overall indicated that they learned from the course. The results were fairly consistent across all three sections.

On specific task competencies, there was an indication that students in the lecture only and hybrid sections had a more positive view of their confidence in performing identified tasks. With few exceptions, the percentages of '4' and '5' responses was higher for the lecture only and hybrid sections than it is for the flipped classroom section. The following table summarizes the total percentage of 4's and 5's for each of the six tasks:

Task	Lecture Only	Flipped	Hybrid
Knowing the basics of instruments	68.75%	66.67%	74.12%
Measure voltages and currents using instruments	71.88%	68.45%	81.18%
Build a variety of AC/DC circuits	71.88%	58.34%	67.06%

Task	Lecture Only	Flipped	Hybrid
Analyze and model circuit performance	40.63%	44.44%	48.34%
Understand the purpose or function of a circuit	62.51%	47.22%	61.18%
Build a circuit based upon design calculations	62.50%	44.44%	63.53%

In general, students in the hybrid section (lecture plus recitation session) overall had the highest confidence in performing the above tasks. The lecture only section was only slightly behind in their level of confidence while the flipped classroom section lagged in most cases with this section being statistically less confident for the following two skills:

- Understand what is the purpose or function of a circuit if presented to you.
- Build a circuit by choosing a set of resistors, capacitors and/or inductors based upon the results of your design calculations.

When the proportion of 4's and 5's were pooled for the hybrid and lecture only sections for the task of "Understand the purpose or function of a circuit", a test that this proportion was greater than the proportion of 4's and 5's for the flipped section yielded a marginally significant p-value of 0.0639. In a similar test for the second skill listed above, the p-value was 0.0225 indicating a significant difference between the pooled traditional lecture and hybrid sections compared to the flipped section.

Instructional Methods

There were individual questions asked of each of the three instructional pedagogy sections. The following question was asked of each section: On a scale of 1-5 (1 being the lowest and 5 being highest), how do you rate the overall class quality in providing knowledge of circuits? The results for each section were as follows (as measured by percentage of '4' or '5' evaluation scores):

- Lecture only – 90.63%
- Flipped – 52.77%
- Hybrid – 95.29%

Combining the lecture only and hybrid proportions above, a test was conducted to determine if this pooled proportion was statistically greater than the proportion for the flipped section. The p-value <0.0001 was highly significant.

The above results were consistent with the responses to the level of confidence for the task competencies. In addition, as seen in the skills portion of the survey, there was a slightly higher positive result, but statistically insignificant, for the hybrid section (lecture plus recitation) than the lecture only section. They were both, however, considerably higher than the flipped classroom section.

There were also specific questions asked of students in each section. Those results are summarized next.

Lecture Only

Students were asked the following two questions:

1. On a scale of 1-5, how strongly do you believe that there should be an additional recitation/help section to better comprehend the course material?
2. What would you like to see in the future sections for the course? (More Theory/More in-class problem solving/Help section)

There was not a strong feeling that an additional recitation/help section should be added as 53.13% scored the question a '4' or '5' while the remaining 46.87% indicated a score of '1', '2', or '3' with the results being fairly uniformly distributed.

The above results were reinforced with the second question as 37.5% would like to see a help section added. Overwhelmingly, 71.88% would like to see more in-class problem solving included in the course while 28.13% would like more theory. Multiple responses were possible for this question.

When asked to "please write any other observations/comments regarding this course," the responses were consistent with the results on in-class problem solving:

- "More explanations of problems"
- "Explanation of more problems"
- "Go over more problems"
- "More practice problems"
- "I'd like to add more problem solving"
- "I'd teach a concept and then do practice problems"
- "More problem solving"
- "More practice questions"

Flipped Classroom

Students were asked three survey questions where they were to respond on a 1-5 Likert scale:

1. How do you rate the overall quality of the pre-recorded video lectures and lecture notes in providing knowledge of circuits?
2. How do you rate the overall quality of the learning assistants in providing help during each class session?
3. How do you rate the effectiveness of team exercises during each class session?

Students were considerably more positive about the learning assistants than either the pre-recorded video lectures and lecture notes or the team exercises. The following is a summary of the percentage of '4' and '5' scores for each question:

- Pre-recorded video lectures and lecture notes – 61.11%
- Learning assistants – 77.78%

- Team exercises – 52.78%

Students in this section were also asked the following two questions:

1. What is the approximate percentage of time that you have watched pre-recorded lectures and read the lecture notes before coming to the class section?
2. If you did not watch/read the lecture, what would be a specific reason?

About half (47.22%) of students indicated that 51% to 75% of the time they watched the pre-recorded lectures and read the lecture notes before coming to class. Less than 20% responded that they did so 76% to 100% of the time while over 30% indicated that they did no more than 50% of the time.

With multiple responses possible, the reasons that students did not watch/read the lectures were:

- Too much extra work – 33.33%
- There was no connection between the pre-recorded video and in-class lectures – 16.67%
- Other – 16.67%
- I understand circuits without any additional help – 2.78%

Most of the class comments dealt with the videos and time required:

- "Videos were much too long."
- "Pre-recorded are good, but it's like having another class."
- "Remove pre-recorded lectures." (Multiple similar responses)
- "Too long, should be shorter."

Hybrid (Lecture plus recitation)

Most of the questions in the survey dealt with the weekly 50 minute recitation session. Students were first asked: "Approximately how many times did you attend the additional 50 minute recitation section offered on Fridays?" Almost a third of students did not attend any of the sessions, and over 90% indicated that they attended half or less of the sessions.

Students were asked two questions where they were to respond 1-5 on a Likert scale:

1. How do you feel that the additional 50 minutes recitation section has enhanced the learning and improved understanding of course material?
2. How likely will you take other courses offered in a similar fashion (class lecture plus recitation)?

Even though a small proportion of students attended more than 50% of the recitation sessions, respondents were positive to the above two questions. More than 63% answered either a '4' or '5' to the question on enhanced learning and improved understanding. Similarly, almost 78% indicated with a '4' or '5' that they would take other courses offered in a similar manner.

In a question which asked “Do you believe an extra 50 minute recitation section was needed?” almost 2/3 of the respondents replied ‘yes’.” Students were also asked reasons that they were not able to attend a recitation session if they wanted to. More than 75% responded that it was due to schedule or timing.

The class comments primarily dealt with the recitation sessions:

- “I like the option of attending recitation if the material is not mastered.”
- “I really like the non-mandatory class sessions on Friday.”
- “More flexible schedule for recitations.”
- “More variety in recitation times.”
- “More availability of time for recitation.”
- “Nothing on Friday.”

Conclusions, Suggestions and Limitations

Three teaching pedagogies for an introductory Circuits Analysis course were compared at a first-tier public research university. Using survey results at the end of the semester, students were asked questions on the following four elements: Laboratories, lectures, overall course, and teaching methodologies.

The primary conclusions from this empirical study are:

- A highly significant majority of students would not be interested in a Take-Home Hands-on Lab if they were offered the choice.
- Almost 2/3 of the respondents would not take an online section of the course if it were offered with a Take-Home, Hands-on Self Learning Kit.
- There was overall a greater level of confidence in performing various tasks by those in the hybrid and traditional sections than in the flipped classroom section. In particular, there was statistically significantly greater confidence for the following tasks:
    - Understanding what is the purpose or function of a presented circuit.
    - Building a circuit by choosing a set of resistors, capacitors and/or inductors based upon the results of design calculations.
- Students in the hybrid and traditional sections also had a much greater positive perception of the overall class quality in providing knowledge of circuits than the flipped classroom section.
- The negative feelings in the flipped classroom section were primarily due to two factors:
    - Pre-recorded lectures were too long.
    - It required too much extra work to watch the pre-recorded lectures.

Based upon the survey results and student comments, our suggestions are:

1. Maintain the lab sections as currently structured. They were perceived extremely positively by students in all three sections. There was not much interest in a Take-Home Hands-on Lab.

2. Adjust the schedule for the lecture only section to include a recitation session. The results between the lecture only and hybrid sections were consistently similar. For the questions where the results were different, the student comments seemed to indicate that the differences were due to the benefits of the recitation session.
3. To improve the flipped classroom experience, we suggest:
    - Shortening the pre-recorded lectures into a set of modules that can be watched throughout the week.
    - Including low-impact self-check quizzes to incentivize pre-class participation.
    - Adding online problems for each module.
    - Adjusting the in-class schedule (which was once a week) to two or more times per week (shorter sessions) to allow for more interaction with learning assistants and other students.
4. Gain a greater understanding of why there was little interest in a potential online section for the course.

We acknowledge that there were limitations in this study including the following:

1. Randomization was not used to assign students to sections. Instructors were randomly assigned to sections to alleviate bias. However, students self-selected the section that they were going to be in.
2. Survey results are available for just a single semester.
3. The results are available from a single public urban university. The study has not been replicated beyond this university to other institutions to determine what differences may exist.
4. While self-perception and preference were comprehensively captured, actual performance with respect to the surveyed competencies was not measured and compared to survey responses.

Future Work

Based upon this initial analysis of the survey results, there are a number of additional studies that we want to pursue:

1. Use the demographic information that was detailed in the Methods section to determine if there are significant differences in the results when the following variables are taken into account:
    - Class year (Freshman/Sophomore/Junior/Senior)
    - Gender
    - Major
    - Minor
    - GPA
    - Expected final grade
    - Preferred method of instruction (Auditory/Visual/Kinesthetic)
2. Replicate the study using randomization of students to each of the instructional pedagogies. The sections were self-selected in the initial study.

3. Perform the study at another institution. The authors are currently at a public urban university whose mission is education of traditionally underserved students and working adults. There is a desire to compare the results at this university to those that were obtained at the first-tier public research university.
4. Expand the study to include an appropriate mixed method approach[12] that includes objective performance measurements of learning outcomes to compare and contrast with survey responses, as recommended by Bishop and Verleger.[9]
5. Conduct the study in other disciplines to determine differences that may exist between engineering students and students in other fields.

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