Assessing Learning Outcomes and Evaluating Graduate Student Perceptions of a Flipped Classroom

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Motivation and Background

Graduate education in scientific and engineering fields requires students to learn detailed technical information in courses that continue to be taught in a traditional lecture format. A recent op-ed piece in the New York Times\(^1\) brings to light the disparity in learning that occurs when college courses are delivered only in a traditional lecture format. The author notes evidence suggesting the lecture format, when used without other instructional techniques, unfairly disadvantages women, minorities, low-income, and first-generation students. Furthermore, students entering technical graduate programs increasingly express multimodal learning preferences\(^2\) as well as a predilection for web-based communication and collaborative learning tools\(^3\) (such as google docs, blogs, wikis, etc.).

Our department offers Master of Science degree programs in both Engineering Management and Management Science. Each program of study consists of 36 semester hours and includes a culminating capstone experience. The Probability & Statistics for Engineers course, in addition to being a core requirement for each degree program, serves as either a pre- or co-requisite for many other courses in our program. Additionally, the course fulfills a math or technical elective for other majors in the School of Engineering. Currently, The Probability & Statistics for Engineers course is offered three times per year (fall, spring, and summer) in a traditional classroom setting. Fall and spring terms consist of 16-week semesters while the summer term is condensed to 12 weeks. In order to accommodate working professionals, classes are delivered on campus and are also simulcast over the Internet via web conferencing software. The simulcast sessions are recorded and available for asynchronous viewing.

The work presented in this paper details a major course revision for a blended, graduate-level probability and statistics course with an emphasis on improving student engagement, promoting life-long learning by developing self-reliant learners, and embracing the increasing diversity in our student population. This study builds upon a previously successful improvement effort based on mastery techniques\(^4\).

In Fall 2015, 35 students from 10 different majors were enrolled in the Probability & Statistics for Engineers course. Females comprise 20% of the student body, and approximately 50% of the students are international. With such a diverse group of students, we believe that implementing more learner-centered teaching methods will greatly benefit the students. Our research examines the following question: what is the quantifiable advantage of transitioning from a strict lecture based classroom environment to a more active, technology enabled classroom for introductory graduate level engineering coursework? We test that question by altering the teaching methods in the Probability & Statistics for Engineers course and evaluating both student performance and perceptions. We eliminated traditional lectures by revising the course structure to that of a flipped classroom. In the flipped (or inverted classroom), students obtain content knowledge outside of class and spend class time involved in active, group-based learning activities. In this paper, we describe our efforts to implement and assess the effectiveness of a flipped classroom.
We compare students’ performance as measured by equivalent exams from previous offerings of the course, and solicit student feedback through two surveys.

**Review of Recent Literature**

In the Proceedings of the 2013 ASEE Annual Conference, Bishop and Verleger\(^5\) provide a comprehensive survey of the research on the flipped classroom. Their work focuses primarily on the use of the flipped classroom for undergraduate students. The study makes reference to 83 research articles, 39 blog posts and news articles, 5 websites dedicated to the flipped classroom, and 6 websites that serve as resources for flipped classroom teachers. In their investigation, Bishop and Verleger limit their review to only those research studies and references that include a requirement for students to watch pre-recorded video lectures outside of class. They suggest that future research on the flipped classroom include controlled studies that examine student performance throughout the classroom.

While the majority of the flipped classroom literature has focused on undergraduate education, a few recent studies have focused on graduate education. Successful implementations of the flipped classroom have been reported in the medical field including nursing\(^5\), pharmacy\(^7\), physiology\(^8\). In fact, Tune, Sturek, and Basile\(^8\) conducted a controlled experiment with two sections of the same class and found students in the flipped classroom scored significantly higher on exams. Homework and in-class quizzes were used as motivating factors to ensure students completed the out-of-class preparation activities.

This study differs from those presented by Bishop and Verleger in several ways. Most significantly, this study applied the flipped classroom approach to a graduate engineering course as opposed to the previously studied undergraduate courses and graduate courses in the medical field. Second, we did not require students to watch videos as part of their class preparation activities although optional videos were made available. Furthermore, we were unable to conduct a controlled experiment as only one section of this course is offered each term. However, we provide a quantitative analysis of student’s exam performance from previous semesters as well as survey results on student perceptions of the flipped classroom.

**Methods and Analysis**

*Content Delivery and Class Activities*

As noted in the literature review, a key component of the flipped classroom is the use of pre-recorded video lectures that students are required to watch outside of class. However, in this revision of the course, traditional lectures were eliminated completely and class discussions were, instead, motivated entirely by student questions and class activities. The course met three days per week, and prior to coming to class on Monday and Wednesday, students were assigned readings and a set of problems from the textbook. At the beginning of each class, the instructors answered student questions about the class preparation material. During class, students worked in groups to complete an in-class activity. To encourage interaction among a diverse group of students, those students that attended the on-campus class sessions were randomly assigned to a different group each week. To more effectively facilitate on-line communication, the students
that attended class via the web conferencing software worked in the same group for the entire semester.

The class activities were developed to be more authentic by relating to other topics and courses within the Engineering Management program. Below, we provide three representative examples from the class activities. In the first example, students must use concepts learned from the Continuous Random Variables module to solve a reliability-related problem. In the second, the groups are asked to utilize hypothesis testing and provide an executive summary to support a critical management decision, and in the final example students are asked design, conduct, analyze, and use appropriate terminology to describe the results of a simple experiment.

| Let $T$ denote the time to failure (in years) of the drive train for a Regional Transit Authority bus. Suppose the probability density function is given by: $f(t) = 0.2 - 0.02t$ for $0 \leq t \leq 10$ yr |
|------------------|------------------|
| Determine the following: |
| a. Verify that $f(t)$ is a valid pdf |
| b. the cumulative distribution function of $T$ |
| c. the probability the drive train fails within two years |
| d. the probability the drive train fails between the 6th and 8th year |
| e. the expected time to failure of the drive train |
| f. the time to failure exceeded by 95% of drive trains |

Figure 1. Example Class Activity – Probability Calculations
Background Information
For this activity we are going to conduct hypothesis tests and report on the results in a professional format. For each of the cases below, your team will design an appropriate statistical test, conduct the test, and report the results. Each report is limited to one page, and will include a one paragraph executive summary followed by a detailed analysis of the problem.

Problem Statements

1. Your customers have specified that a new part you plan to carry must weigh between 95g and 105g. The supplier you generally use says they can provide that part for you. They measure a sample of 40 parts and create a 95% confidence interval on the mean that spans from 97g to 101g. A normal probability plot of the sample confirms the weight of the parts is approximately normally distributed. What should your company do?

2. Your company maintains a fleet of delivery trucks. Fuel cost is a significant expense for the company and your fleet averages 14.9 miles per gallon of regular gasoline. Clearly, improving the fuel efficiency is desirable. A new Vice President proposes switching to premium gasoline. An experiment is run for eight routes, with these results: 16.1, 16.0, 13.7, 17.6, 14.4, 19.8, 15.4 and 14.8 mpg. What should you tell the VP?

Reaction Time Tests

There are several websites that can be used to test an individuals’ response time. One such test can be found here: [http://www.humanbenchmark.com/tests/reactiontime](http://www.humanbenchmark.com/tests/reactiontime). This website operates as follows: an individual participates in 5 trials of a reaction time test, and the average reaction time is recorded at the completion of the activity.

1. Create a completely randomized experiment in which each team member completes the test three times.
2. Record the average response time for each team member and each replication (in ms). Consider a constant-effects model. That is, consider the difference in response time among the assigned team members.
3. Determine if there is a difference in response time among the members of the group.
4. Build a confidence interval on the mean response time of the 3rd group member.
5. Build a confidence interval on the difference in the difference in the mean response time for each combination of team members?
6. Use Fisher’s LSD Method to analyze the difference in the mean response time for each combination of team members.

In addition to the class preparation problems and in-class activities, students completed mastery level quizzes as preparation for the exams. The mastery-level quizzes, which were part of a previously successful improvement effort, were untimed, and students were allowed an unlimited number of submissions prior to the due date. Furthermore, students received immediate, question-level feedback on their solutions to the quiz problems.
Exams

The transition to a flipped classroom was assessed using the same method as the transition from a traditional classroom approach to the mastery learning approach. Student success on the first of three exams was a key indicator. For this course a minimum grade of 75% on the first exam put the student in position to earn a passing grade in the course, while a score less than 75% indicated a poor start. As an aside, during the four semesters of mastery learning, only 2% of the students who earned a 75% or greater went on to fail the course, while fully 36% of those who earned less than 75% went on to fail the course. The results for this single metric are summarized in Table 1. Note that the transition to mastery learning from the traditional classroom has shown a statistically significant and sustained improvement on this metric. The first semester of the flipped classroom approach has apparently continued that same improvement.

<table>
<thead>
<tr>
<th></th>
<th>Flipped Classroom</th>
<th>Mastery Learning</th>
<th>Traditional Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semesters</td>
<td>Fall 2015</td>
<td>Spring 2014 – Summer 2015</td>
<td>Fall 2013</td>
</tr>
<tr>
<td>Number of Students</td>
<td>34</td>
<td>123</td>
<td>35</td>
</tr>
<tr>
<td>Percent Scoring 75 or more on Exam 1</td>
<td>68%</td>
<td>66%</td>
<td>43%</td>
</tr>
</tbody>
</table>

The benefits attributable to the flipped classroom approach for graduate engineering courses have so far been reasonably promising for the entire student body. However, the specific anticipated benefits in course success for minorities and women students have not yet been demonstrated. This is due, in part, to the underrepresentation of women in the graduate engineering field yielding a small sample size. With only one semester of flipped classroom data, we have not demonstrated an improvement over the mastery learning approach. As we continue this research and gather more data, we expect to gain further insights in this aspect of the flipped classroom. We will be particularly interested in the relationship between student perceptions and quantifiable performance in course exams.

Student Survey Results

In addition to the end of semester surveys administered by the university, students were asked to complete two interim surveys regarding their perceptions on the flipped classroom. The first was administered during the 5th week of the semester (prior to the first exam) and the second survey was administered during the 15th week (prior to the final exam). The survey statements presented below were adopted from Johnson9, and students were asked to respond using an even-point Likert scale which is quantified as follows:

- Strongly Agree (5)
- Agree (4)
The first survey had a response rate of 70% (24/35) while the second survey had a response rate of 58% (14/35). For each statement included in the survey, we present the average response (AR), the coefficient of variance (CV), and the percentage of students in agreement (PA), i.e. slightly agree, agree, and strongly agree. Please note a complete account of all student survey responses is presented in the Appendix.

Table 2. Student Survey Response Summary

<table>
<thead>
<tr>
<th>Statement</th>
<th>5th Week Survey</th>
<th>15th Week Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AR</td>
<td>CV</td>
</tr>
<tr>
<td>The flipped classroom is more engaging than traditional classroom instruction</td>
<td>3.38</td>
<td>0.44</td>
</tr>
<tr>
<td>I find value in communicating with other students in the flipped classroom</td>
<td>3.92</td>
<td>0.29</td>
</tr>
<tr>
<td>I regularly complete the class prep tasks (reading the text, viewing the slides, completing the exercises BEFORE the scheduled class meeting)</td>
<td>3.63</td>
<td>0.33</td>
</tr>
<tr>
<td>I am confident about the materials after the class prep tasks but BEFORE coming to class</td>
<td>2.50</td>
<td>0.61</td>
</tr>
<tr>
<td>I am confident about the material AFTER coming to class and completing the in-class activities.</td>
<td>2.75</td>
<td>0.45</td>
</tr>
<tr>
<td>I would NOT recommend the flipped classroom to a friend.</td>
<td>3.08</td>
<td>0.48</td>
</tr>
<tr>
<td>I would rather have a traditional lecture than the flipped classroom.</td>
<td>2.63</td>
<td>0.68</td>
</tr>
<tr>
<td>I am spending less total time mastering the material in the flipped classroom than I would in a traditional class.</td>
<td>2.00</td>
<td>0.77</td>
</tr>
<tr>
<td>The materials on the Isidore course site are presented in a useful manner.</td>
<td>3.63</td>
<td>0.33</td>
</tr>
</tbody>
</table>

In addition to the survey statements above, students were also given an opportunity to answer the following questions:

- What is helping your learning in this class?
- What is hindering your learning in this class?
- Do you have any additional comments, suggestions, or concerns?
Early in the semester, a large portion of the students indicated that (1) the flipped classroom was more engaging than a traditional lecture-based class and (2) they found value in communicating with other students. Unfortunately, this level of agreement was not maintained throughout the term. By the end of the semester, the percentage of students that reported finding value in communicating with other students fell from 92% to 69%. Unfortunately, none of the student responses from the surveys provided insights into this decline.

A large proportion of the students indicated completing class preparation activities (92% and 85%, from the first and second survey, respectively). While they were not very confident about the material before coming to class (42% and 46%, respectively), the majority of students reported being comfortable with the material after completing the in class activities (63% and 69%, respectively). Furthermore, students reported spending more time interacting with and mastering the course material than they would have in a traditional classroom.

While the majority of the students expressed a preference for traditional lectures over the flipped classroom (50% and 62%, respectively). The proportion of students that would NOT recommend the flipped classroom dropped from 79% after the 5th week to 38% after the 15th week. Therefore, while the students expressed a preference for a traditional lecture-based class, we believe they appreciated the value of the flipped classroom. In general, the students responded more favorably towards the flipped classroom early in the semester. We believe this may be related to the decreased response rate for the second survey. That is, we believe the students that were least satisfied with the structure of the course felt most compelled to respond to the second survey.

Conclusions and Future Work

From the instructor’s perspective, this format greatly improved student engagement in the classroom. The majority of students regularly attended the class meetings (either on campus or through the web conferencing software) and appeared to be actively engaged in the class activities. However, in the spirit of continuous improvement, a number of changes will be incorporated into future offerings of the course.

First, we will incorporate short overview lectures back into the course. The lack of traditional lectures was definitely a hindrance for some of the students in the class; therefore, at the end of each week, we will give a short overview of the material to be covered in the following week. This lecture will focus on important terms and concepts as well as the learning outcomes which will help guide and focus the students’ individual preparation activities.

Next, we will make use of the textbook publisher’s on-line teaching and learning environment to incorporate accountability for the preparation activities. In the surveys, most students indicated they had completed the class preparation activities (i.e. reading the textbook, viewing a set of supplementary PowerPoint slides, and working some textbook problems). However, students frequently complained that they did not understand many of the course concepts. Unfortunately, very few students asked questions in class or sought additional assistance or clarification outside of class.
Finally, we will incorporate additional accountability with respect to class participation. While most students regularly attended class and actively participated in the group activities, there were inevitably students that did not regularly attend or fully participate. To increase student accountability, group assignments will be made for extended periods of time throughout the semester, and students will be given the opportunity to evaluate the contributions of each group member. We expect these change to address the decline in reported satisfaction in the flipped classroom approach.

Bibliography

## Appendix

### Table 2. 5\textsuperscript{th} Week Survey Student Response

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The flipped classroom is more engaging than traditional classroom instruction</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>I find value in communicating with other students in the flipped classroom</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>I regularly complete the class prep tasks (reading the text, viewing the slides, completing the exercises BEFORE the scheduled class meeting)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>10</td>
<td>5</td>
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<tr>
<td>I am confident about the materials after the class prep tasks but BEFORE coming to class</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I am confident about the material AFTER coming to class and completing the in-class activities.</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>I would NOT recommend the flipped classroom to a friend.</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>I would rather have a traditional lecture than the flipped classroom.</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>I am spending less total time mastering the material in the flipped classroom than I would in a traditional class.</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>The materials on the Isidore course site are presented in a useful manner.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>13</td>
<td>4</td>
</tr>
</tbody>
</table>

What is helping your learning in this course?

- Youtube is helping me so much.
- The pre class preparation help me to understand and learn stuff by myself. It helps me to explore more on what I learn, which I believe to be more advantageous than traditional class. Moreover class activities, helps in understanding the concepts still better. Only doing problems on my own or with a friend.
- The in-class activities. However, I have been finding that most students are just as confused as I am.
- Seeing the in-class examples and getting live feedback from instructors on the class activities, the livescribe pdf examples with lecture-style step by step explanation
- Reading the text, slides and working the problems helps; and getting questions answered in class too
- Practice, Practice, Practice. What I find most helpful is working problems, both homework and in class activities.
- I like working on the problems in a flipped classroom because it is giving me a chance to see what I had been doing wrong in the homework.
- The class activities give us a chance of solving the problems with our peers discussing the concepts that helps.
- Class activities are helping me. But, basis can be discussed in a more clear way before starting with the class activity.
- I do like having a work day on fridays where we are simply working on the classroom assignments.
- All the prep tasks and in class activities, I think.
- Working through the problems both before and as part of the class activity is helping me learn the material. It is somewhat backwards because typically I would attempt homework after the material was explained in class, so I have a theoretical explanation of the concepts that I then attempt in the homework,
whereas in this case I am attempting the problems without slides and only the material in the book, which isn't as thorough in its explanations as I'd like.

- Working problems and having questions answered.
- Group activities
- The exercises which are needed to be done before class.
- What is specially helping is the interaction in class and the freedom that we have to engage with professors whether its during lecture or during class activities.
- The class activity and slides
- Class prep tasks
- The class activity (sic)
- The class activities and materials provided in isidore are helping me to learn the course.
- The approach of flipped classroom and working on problems on our own.
- Group Class Activity helps me in working out with many Students. These Activity also helps me in interacting with many international students and also sharing and grasping the knowledge with others.

What is hindering your learning in this course?

- The reference book makes me confused most of the time.
- Nothing (4)
- The speed that the material is covered. It is gone over very fast and I am not a statistics master like the instructors. It takes me longer to understand even some of the basic principles and by the time I do understand them a new topic is already being presented.
- Not having a traditional lecture and understanding where/how the equations are to be used. Rather than if I am doing a problem from chapter X, then I know I will use an equation from that chapter. The book is also really bad at explaining things.
- The opaque written textbook and the frustratingly common wrong answers in the answer key, the group work (more suitable for a softer science than mathematics, what's the value of compromise in a subject where every disagreement means one of you must be right and the other must be wrong?), having to work alone through the lecture PPTs without someone explaining the concepts.
- The class time allotted. There is not enough time to address questions and then complete a class activity before the end of class. So extending the in-class deadlines is helpful. I like distance learning, but it takes more time because I need to work the problem on paper and then type it up.
- I find course expectations to be unclear. Not sure what to expect in the first exam.
- This book is not helping. I HATE IT. The slides help make up for the confusion.
- Nothing really but, i feel having two class activities in a week is being a little stressful and we are unable to concentrate on the concepts for a longer time, rather we are getting worried about the class activities as they account for 5% of the total grade.
- I'm perfectly okay with the classroom.
- I think after going through the course the first few weeks I would prefer a traditional classroom where we were lectured and take notes / worked out example problems on the board. Then on friday we would have an in class activity where we would go over some of what was covered that week. If groups did not finish then it would be due the next class time on monday or maybe wednesday.
- I am a distance learning student who works at WPAFB during the day and it is hard for me to make the collaborative classrooms all the time, especially since the filters on base prevent me from connecting from work.
- There are times when a lecture might help such as how to write out solutions in the proper format.
- Understand the question exactly
- What is hindering my learning, if any really, would be the fact that we have to learn everything on our own at home. there really is no lecture, just class activities and we ask questions about stuff that we didn't understand on our own earlier.
- The class has short time to do the activities
- Do take part in the discussion in the activity
- Some professional math words
- So much to do in 50minutes.
Do you have any additional comments, suggestions, or concerns?

- I would like to suggest a few points as follow: - Traditional lectures are better than the modern method. Giving two lectures instead of three lectures is better. I'm really concerned about the exams because we should know the methods that suppose to use in each question in order to solve the questions correctly. In other words, most of the time, I solve the exercise based on what I learned; however, I end up with error in my solution.
- I feel if the time limits of the class is increased on Fridays, it would be of great help to finish the class activities more comfortably.
- Do not provide problems that can only be solved by a method that has not been presented yet.
- I would suggest doing a traditional lecture on how/when to use certain equations and deriving where those equations come from. My biggest concern is being able to interpret the problem, so maybe something to help with that as well. I also am spending more time outside the classroom trying to learn the material, as opposed to the traditional lecture courses that I had where I would spend more time in class learning the material.
- I learn more from traditional lectures. Having to teach myself from a bad text is an exercise in frustration three nights a week.
- Thank you for extending the deadlines for the in-class activities.
- The powerpoints and problems on the isadore site are very helpful. I think it is important to have the approach of reviewing the material and doing some problems before class. This allows us to gain understanding ahead of time and ask meaningful questions in class. It also allows instructors to more quickly dive into tougher problems if the class is prepared. I believe if there is a small amount of lecture, lets say half an hour or so, in the beginning of the week to go over the concepts in the book, it will be very conductive to learning. This will help make up for the confusion the book caused. I would recommend for future classes that you dump this book and go elsewhere.
- I am happy with everything in the class.
- Just that for me personally, I think I prefer the traditional model, especially for a math based course, where we could go over major formulas and also work out problems. This would be a more effective use of time in my opinion. However, even though I would say I prefer this I still would not go as far as to say that no learning is occurring. I feel I am learning the material, but wonder if I could have a slightly stronger grasp of some of the material if taught in the traditional manner with a work day on Friday.
- I think you are doing a good job.
- There are times when I feel like the class activities take too much time to get done within the 50min class. Most times this isn't an issue, but there are times when I need to get back to work for a meeting. Also knowing how long the class activities take I feel less inclined to ask questions on the before class work that will take up time that needs to be spent working the class activity. Overall, I like the 3 times a week class, and the effort taken to create before class problem sets and reading. The addition of livescribe examples is really good, and that might be able to take the place of lecture on proper format of solutions.
- I still have difficulty for following professors.
- Give as more time to do the activities at the class, long problems with short time that is not help us to solve it.
- In the reality in the work, maybe do not know how to use the staff in the class to the reality work.
- I like this class and professors.
- It would be helpful if the class time is increased.
### Table 3. 15th Week Survey Student Response

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The flipped classroom is more engaging than traditional classroom instruction</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>1</td>
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<tr>
<td>I find value in communicating with other students in the flipped classroom</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>I regularly complete the class prep tasks (reading the text, viewing the slides, completing the exercises BEFORE the scheduled class meeting)</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>I am confident about the materials after the class prep tasks but BEFORE coming to class</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I am confident about the material AFTER coming to class and completing the in-class activities.</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>1</td>
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<tr>
<td>I would NOT recommend the flipped classroom to a friend.</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>I would rather have a traditional lecture than the flipped classroom.</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>I am spending less total time mastering the material in the flipped classroom than I would in a traditional class.</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>The materials on the Isidore course site are presented in a useful manner.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

What is helping your learning in this course?

- The class prep materials are very helpful. In class examples are also very helpful, especially those based on the class prep problems.
- I think the textbook is helpful. Also, when I have questions, the teachers can help me.
- Pre-class homework and answer.
- Reading the book, reading the class slides, working problems are what is helping me learn. A lecture is not necessarily needed but there are times when an overview or walkthrough of key concepts or problem solving methods is necessary. Classes before the second test and now the final have been better with the "not a lecture" lectures on specific topics. The slides for chapter 10 "2 sample inferences" (week 11 I believe) that were on Isidore were terrible, because they were just a copy from the book. All the other class slides were quite good, giving slightly different explanation of the concepts which aided in understanding. Overall, I like the in class activities as it forces discussion with peers and the professors which really aids in understanding through verbally explaining what one thinks should be done or what something means. What I dislike about the in class activities is the time they take. Walking through use of Excel and any other software to be used is very helpful as well. Many of the stat and probability functions I've never used and how they are implemented is often not clear. Discussion of what the results of various statistical tests and analyses mean has been quite useful. This is something that the book isn't really clear on at times. The quizzes are sometimes time consuming, but I do feel like I have a better handle on what I should be understanding after completing the quizzes, and I use the quizzes as a way to study for the exams.
- Class activities.
- The ability to actually work the problems in class is better than sitting there and watching the teacher do it for you. I have learned so much more in this class than previous statistics courses because of that fact.
- Class Activities. But, it would be great if we can have two long classes instead of 3 short classes.
- Class prep materials and online quiz
- The homework problems assigned to do before class, the group projects and the quizzes.
• Completing exercises from the textbook.
• Group work with in class helps me in improving and sharing the ideas with my group mates. Flexible group work makes to get in touch with every person in the class.

What is hindering your learning in this course?
• The time to complete the class prep problems is sometimes hard to come by.
• No, not in this class.
• Not prepare lessons and materials before class.
• The slides for chapter 10 "2 sample inferences" (week 11 I believe) that were on Isidore were terrible, because they were just a copy from the book. The other slides were good because the presented the concepts in a different way which provided insight into what was to be learned that the book didn't have. I dislike the write intensive in class activities as the writing doesn't aid in our understanding of the probability and statistical concepts. If writing intensive assignments are to be done an example should be given of the expected format and required information to be included, and feedback should then be given on how the report conveyed the results. This would be make it a much better learn exercise for real world data reporting.
• The lack of traditional lectures and the textbook.
• The book is OK. I'm just wondering if there's something better than it because there are many times that I'm relying on the PowerPoints but the PowerPoints don't always have everything either.
• Group activities. Most of the time I get to do the entire class activity myself. There is least support from my group.
• Nothing you guys have done. No classroom lectures or working examples during the class. Doing examples in class and explaining what is going on as part of the process would have greatly helped my learning.

Do you have any additional comments, suggestions, or concerns?
• It may be helpful to start class on Monday with a lecture then do class activities with the remainder of the week.
• No, I am ok with this class.
• A cumulative final exam is exceptionally challenging given the breadth of material we've covered and the fact that we've used very little of the probability concepts covered in the first test since the first test. More information to narrow the scope of material to be covered would help immensely. Examples of how to perform analyses from the last chapters in R would be very welcome in order to be able to use R for analysis after the class ends.
• I suggest more traditional lectures and supplement with class activities.
• I would suggest a mix of traditional and flip class room strategies for this course.
• It would be more helpful if you discuss the topics in depth in class.