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THE IMPACT OF THE CLASSROOM FLIP ON STUDENT MOTIVATION

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ABSTRACT

One of the hardest aspects of teaching a course is tailoring the teaching techniques to satisfy all students. Some students are bored and apathetic, while others have difficulty keeping up with the material and give up. In an effort to understand how to individualize a class to motivate students, a specific instructional technique known as the flipped classroom will be considered. The flipped classroom is an instructional technique that has been gaining considerable attention lately. The traditional lecture component of technical information is provided through online modules, which frees up class time for active learning and innovative activities. This thesis will consider the impact that implementing the classroom flip has on student motivation.

To assess the impact that the classroom flip has on student motivation, three levers from the literature will be considered: (1) the subjective value of a goal, (2) the expectations for successful attainment of that goal, and (3) the perceived supportiveness of the classroom environment. Evaluation of the impact of the classroom flip on the three levers of student motivation was conducted using both quantitative and qualitative measures. These included using self-efficacy questionnaires to identify changes in self-efficacy, student surveys and focus groups to assess student perception of value, and the College and University Classroom Environment Inventory (CUCEI) to assess the classroom climate in both the flipped class and various control courses. Based on this evaluation, it is proven that implementing the classroom flip improves student motivation by increasing the subjective value of a goal, increasing students’ self-efficacy, and increasing the perceived supportiveness of the environment. A discussion of the impact of the classroom flip on student motivation is provided, including limitations of the study and future possibilities in this field.
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Most of all, I would like to thank Stephanie Velegol and Sarah Zappe for their guidance, support, and, above all, their patience.
Chapter 1 - Introduction

The average engineering course runs the gamut of student interest. There are students who think the material is too difficult and have given up. There are students who think the material is too easy and boring, and don’t care. There are students who think the professor is out to get them, and resist learning. I have been all of these types of students in various courses throughout college. It is for that reason that I am so interested in a new teaching method called the classroom flip (also known as the inverted classroom), and how it can impact student motivation.

The classroom flip refers to an instructional technique where instructors move the traditional lecture component of a course out of class time. Students are asked to watch an online, virtual lecture, which has been prepared by the professor, prior to coming to class. Then, during class time, the students are able to engage in more active learning. By moving the lecture outside of class, the instructor is able to include new activities, such as in-class problem solving, field trips, guest speakers, and group projects.

I took a large (80-90 students) Introduction to Environmental Engineering course in Spring 2011. This course was being flipped for the first time. The instructor had previously taught the course as a traditional lecture, and had been motivated to flip it by her students’ use of office hours. During office hours, the students would ask questions regarding the problem sets. By being able to see the material and applying it, the students understood the material much better than they had by passively sitting in class. In addition, the students also used office hours to teach each other.

This first version of the flipped course (Spring 2011) had several ineffective components, but I saw the potential offered. For one of the first times, I was personally motivated to do well in
a class. I enjoyed the control I had over my own learning, and got a lot more out of the in-class activities (especially field trips) than I had in any of my other courses. Since the flipped course worked so well for me, I wanted to help it evolve into a better version, and see how well it could work for other students. For this reason, I became a teaching intern (TI) and assisted the instructor in the evolution of this flipped course.

However, adjusting the instructional environment is only as effective as the effort students put into the course. Students’ motivation is just as important when considering student success. Ambrose et al (2010) discuss many of the theories that have been offered to explain motivation. The three core concepts, or levers, which impact motivation that come out of this discussion are: (1) the subjective value of a goal, (2) the expectations for successful attainment of that goal, and (3) the perceived supportiveness of the classroom environment.

The purpose of this thesis is to analyze the impact that adjusting the instructional environment by means of implementing the classroom flip has on student motivation. This analysis is based on theories from the literature, and both empirical evidence and quantitative measures from a case study presented here. First, the thesis will describe the classroom flip method, and provide a literature review on the current use of the classroom flip technique in engineering education and on the different aspects related to student motivation. Then, a case study of the implementation of the classroom flip in a large introductory environmental engineering course will be discussed. A description of what activities students are required to do both outside and during class time and information on class assessment strategies used to encourage student preparation are provided. Evaluation of the impact of the classroom flip on the three levers of student motivation was conducted using both quantitative and qualitative measures. Based on this evaluation, a discussion of the impact of the classroom flip on student motivation is provided, including limitations of the study and future possibilities in this field.
Chapter 2 - Background and Literature Review

I. Description of the classroom flip

A traditional lecture class has the instructor acting as the leader and information provider of the course. While teaching techniques can vary in traditional lectures, the most passive versions have little interaction between the students, the instructor, and the course material. Velegol, Zappe, and Mahoney (2013) expressed the typical passage of information in a traditional class as compared to a flipped class as shown in Figure 1. As shown on the left side, in the traditional classroom, information passes primarily from the instructor to the students. Many instructors resist using active learning techniques in a traditional class as it takes away time from the general passage of information.

![Figure 1: The tradition vs. flipped classroom. In a traditional classroom (left) the instructor is the sage on the stage while a flipped classroom allows the instructor to be the guide on the side. The flipped classroom also allows for more peer interaction in the classroom. (Velegol et al, 2013)](image)

Implementing the flipped classroom removes this constraint. In the flipped class, students watch online video lectures outside of class, and then complete an online assessment to ensure that the students are prepared to participate in the in-class activities. These in-class activities can be tailored to the course. In engineering classes, students can work on problem solving in class. Problem solving in class allows the students to work both with one another and with the
instructor. One benefit of this is that if similar problems arise in several students, the instructor can then address the entire class regarding the issue. Velegol, Zappe, and Mahoney (2013) provide a comparison of different course characteristics between the traditional lecture and flipped classes, shown in Table 1.

Table 1: Comparison of traditional lecture and inverted classroom in engineering (Velegol et al, 2013)

<table>
<thead>
<tr>
<th>Course characteristics</th>
<th>Traditional Lecture</th>
<th>Flipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of instructor during class</td>
<td>Information provider</td>
<td>Guide</td>
</tr>
<tr>
<td>Role of student during class</td>
<td>Information recipient</td>
<td>Active participant in class</td>
</tr>
<tr>
<td>Out-of-class activities</td>
<td>Solving problems, reading textbook, projects, preparing for quizzes/exams</td>
<td>Watch online lecture or read assigned material (before class), complete problem sets &amp; preparing for quizzes/exams (after class)</td>
</tr>
<tr>
<td>In-class activities</td>
<td>Instructor-led lecture</td>
<td>Varies (i.e. problem solving, projects, discussion, brainstorming, field trips)</td>
</tr>
<tr>
<td>Role of assessment</td>
<td>Primarily summative in nature</td>
<td>Formative “gate checks” to ensure preparedness; Both formative and summative assessment</td>
</tr>
</tbody>
</table>

There are many benefits of implementing the classroom flip, which Velegol, Zappe, and Mahoney (2013) discuss in detail based on information from the literature. One benefit of the flipped class is that the instructor is able to cover all of the important material through the shifting of the lecture to outside-of-class time, which leaves time in class to use active learning exercises and focus on experiential learning. Students are able to have control of their own learning when using the online video lectures. Students are able to watch videos at their own pace and in their own time, re-watch portions that are unclear, and review videos when preparing for later course assessments. This control of their own learning and behavior increases a student’s likelihood of doing well and achieving at higher levels (Pintrich, 2003). The final and most important benefit
of implementing the classroom flip is that students are able to receive help from the instructor during critical periods of learning during class time.

II. Student motivation

As previously discussed, many factors affect student motivation. Of these, the three key concepts are: (1) perceived subject value, (2) expectations for successful attainment of a goal, or self-efficacy, and (3) the perceived supportiveness of a classroom environment, or classroom climate.

Value

Value can be derived from many different sources. Three broad determinants of subjective value are suggested by Wigfield and Eccles (1992, 2000, as cited in Ambrose et al, 2010). These are attainment value, which represents the satisfaction gained from mastery of a goal or task, intrinsic value, which represents the satisfaction gained merely from completing a task as compared to an outcome of the task, and instrumental value, which represents how completing one activity can help to accomplish other goals, such as gaining extrinsic rewards. In many cases, these three sources of value operate in combination.

Self-Efficacy

When people believe they can successfully achieve a goal or outcome, they are more motivated to pursue it (Ambrose et al, 2010). The measure of a person’s belief in one’s ability to complete tasks and goals is referred to as self-efficacy. Efficacy expectancies represent the confidence that one is even capable of following a course of action that will bring about a desired outcome (Bandura, 1997). There are many factors that influence a student’s expectation for success. These expectancies in turn determine how motivated a student is. Students who have high expectations and believe that they are able to do well are more motivated in terms of effort, persistence, and behavior (Litzinger et al, 2011).
Classroom Climate

Value and expectancies interact within the environment in which they exist. How students perceive this environment affects their motivation. The environment can be perceived along a continuum from supportive to unsupportive. Many factors influence this perception. Fraser and Treagust (1986) developed an instrument, known as the College and University Classroom Environment Inventory (CUCEI), to assess students’ perceptions of seven psychosocial dimensions of classroom climate. These seven dimensions are: personalization, involvement, student cohesiveness, satisfaction, task orientation, innovation, and individualization. Personalization refers to the opportunities for individual students to interact with the instructor and has emphasis on instructor’s concern for students’ personal welfare. Involvement refers to the extent to which students participate actively and attentively in class discussions and activities. Student cohesiveness refers to the extent to which students know, help, and are friendly toward each other. Satisfaction refers to students’ enjoyment of classes. Task orientation refers to the extent to which class activities are clear and well organized. Innovation refers to the extent to which the instructor plans new, unusual class activities, teaching techniques, and assignments. Individualization refers to the extent to which students are allowed to make decisions and are treated differentially according to ability, interest, and rate of working. These dimensions were chosen to provide coverage of the three general categories of dimensions identified by Moos (1974 as cited by Fraser and Treagust, 1986), which include Relationship Dimensions, Personal Development Dimensions, and System Maintenance and System Change Dimensions. This inventory will be further discussed in the Evaluation Methods chapter as it was used to analyze an aspect of the flipped course case study.

All three of these core components interact to affect student motivation. The student needs to perceive value in the subject, have high self-efficacy, and feel that the environment is
supportive in order to be motivated. Ambrose et al (2010) illustrate the interactions between these three concepts in Figure 2.

**Figure 2: Interactive Effects of Environment, Efficacy, and Value on Motivation**

This figure shows that each of the three concepts, or levers, can influence motivation, and that neglecting any of three can cause motivation to suffer substantially.

Several patterns emerge from this figure and are elaborated on by Ambrose et al (2010). Students who don’t see value in a goal can behave in two different ways, depending on their self-efficacy. Students who don’t see value in a goal and have low self-efficacy related to achieving that goal behave in a rejecting manner, regardless of whether or not the environment is supportive. These students may experience alienation, apathy, or general passivity. Students who don’t see value in a goal but have high self-efficacy related to achieving that goal behave in an evading manner, regardless of whether or not the environment is supportive. These students are typically preoccupied by social distractions or daydreaming and have difficulty paying attention.

Students who see value in a goal but have low self-efficacy can act in two ways, depending on the classroom climate. Students who are in an environment that they perceive as unsupportive tend to be hopeless. They have no expectation of success and have very low levels of motivation. Those who are in an environment that they perceive as supportive tend to be
fragile. They want to succeed, but are doubtful about their abilities and typically make excuses to explain poor performance, avoid situations that require overt performance, and feign understanding.

Finally, students who see value in a goal and have high self-efficacy can act in two ways. Students who are in an unsupportive environment act in a defiant manner. They take an “I will prove you wrong” attitude. Students who are in a supportive environment in comparison are truly motivated. All three levers that influence motivation are positive, and students therefore try to learn, integrate, and apply new knowledge. They tend to view learning situations as opportunities to extend their understanding.
Chapter 3- Research Questions

There is no single variable that can determine student motivation. Rather, there is a wide array of distinctive student behaviors that arise from the interaction of value, efficacy, and climate. However, each of these three levers is important as changes in any one of them result in changes in a student’s level of motivation. This thesis aims to evaluate how implementing the classroom flip as a method of increasing active learning impacts each of these three levers related to student motivation. To this end, the following research questions will be considered:

1. How does the classroom flip enhance students’ perception of value?
2. How does the classroom flip aid in increasing students’ self efficacy?
3. How does the classroom flip affect students’ perception of classroom climate?
Chapter 4 - Flipped Classroom Case Study Description

The semester that I took this course was the first time the course had been flipped, and was referred to as Version 1 in Velegol, Zappe, and Mahoney (2013) in their analysis of the course. There were several ineffective components which were adjusted in later versions of the flip. Velegol, Zappe, and Mahoney (2013) provide a thorough comparison between the initial version (Version 1) and the version considered here for analysis (referred to as Version 2 in Velegol, Zappe, and Mahoney, 2013).

The second version of the flipped class will be considered in this thesis. This version occurred during the Fall 2012 and Spring 2013 semesters. In this version of the flipped course, the online lecture component was recorded in the format of several short video segments which varied from a few minutes to up to 20 minutes long. Series of these short video segments fit within a larger online module which consisted of one week’s worth of lecture material. There were 11 modules total.

After watching the online video lectures, students would take a short online assessment to make sure they were adequately prepared to participate in class. This online assessment functioned as a gate check and held the students accountable for watching the videos, but also allowed the students to ask questions on topics they had difficulty understanding, and allowed the instructor to check in with student learning.

The use of the online modules and class time are shown in the schedule in Figure 3.
<table>
<thead>
<tr>
<th>Format</th>
<th>Sunday</th>
<th>Monday &amp; Wednesday</th>
<th>Friday</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Traditional</strong></td>
<td></td>
<td>Lecture</td>
<td>Homework; Study for Quizzes/Exams</td>
<td>Lecture; Homework; Study for Quizzes/Exams</td>
</tr>
<tr>
<td><strong>Flipped</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Homework/Quiz Weeks</strong></td>
<td></td>
<td>Watch Short Video Segments; Take On-Line Assessments</td>
<td>Review Material; Work on Homework Problems</td>
<td>Problem Sets (If Necessary), Study for Quiz; In Class Quiz</td>
</tr>
<tr>
<td><strong>Other Weeks</strong></td>
<td></td>
<td></td>
<td>Field Trips/Guest Speakers</td>
<td>Field Trips/Guest Speakers</td>
</tr>
</tbody>
</table>

**Figure 3: Comparison of Flipped Class with a Traditional Class.** The shading represents time the students spent in class with the instructor.

Students attended class three times a week, Monday, Wednesday, and Friday, for 50 minutes each. The activities used during these class times varied depending on the goal for that week. During homework/quiz weeks, students worked on the problem sets during class on Mondays and Wednesdays, and then had an in-class quiz on Fridays. On other weeks, the class time was split up between field trips and guest speakers.
Chapter 5 - Evaluation Methods

The evaluation of the effect of the classroom flip on student motivation was conducted using both qualitative and quantitative measures. The qualitative measures included surveys and focus groups. The quantitative measures included a self-efficacy questionnaire and a classroom climate questionnaire. Several guiding questions were used to understand the impact of the classroom flip on student motivation. These questions follow:

1. *How does the classroom flip enhance students’ perception of value?*

For this research question, students were asked in several formats to reflect on the different aspects of a flipped class and how these aspects related to their perceived subject value. The surveys were administered anonymously online using a commercial surveying software tool called Qualtrics. The survey focused on students’ preferences regarding the flipped class, and perceived impact on interest. The format of the items varied, including both closed and open-ended questions. See Appendix A for questions used. The results from the surveys were coded using Qualtrics, and specific quotes were extracted relating to students’ perceived subject value.

Several focus groups were conducted to gather additional in-depth information on students’ perceptions of the flipped course. During Fall 2012, three focus groups were run, each consisting of eight students currently enrolled in the flipped course. To encourage participation, students were offered extra credit points for their attendance. Each focus group ran approximately 45 minutes. A partially structured format was used to initiate the discussion, with questions primarily concerning their perceived value of the course and the instructional methods. All sessions were audio recorded and summarized for analysis. See Appendix B for questions used.
The audio recordings of the focus group were summarized and examine for key ideas. Specific quotes were extracted relating to students’ perceived subject value.

During Spring 2013, an additional focus group was held. This focus group consisted of four students who had enrolled in two separate environmental engineering courses with the instructor, one of which was taught traditionally and one of which was taught using the classroom flip. This focus group ran approximately one hour, with students discussing their perceptions of the classroom flip and which instructional method they preferred, given the same instructor. See Appendix C for questions used. The audio recordings of the focus group were summarized and examine for key ideas. Specific quotes were extracted relating to students’ perceived subject value.

2. *How does the classroom flip aid in increasing students’ self efficacy?*

For this research question, students were asked to complete a self-efficacy questionnaire several times to judge their confidence levels after specific checkpoints in the flipped course. This questionnaire was used to analyze students’ self confidence. The questions used were based on what is typically the most difficult concept in the course: weak acids. There are some limitations to these questions. As the questions were generated based on the course, further analysis is needed to measure the reliability, such as through finding the Cronbach’s Alpha coefficient of internal consistency. When first used in Fall 2012, the questionnaire was administered before class and after class in the flipped course. See Table 2 for a visual representation of this schedule. Prior to coming to class, the students had watched online lectures regarding the current topic, weak acids. The pre-class questionnaire (Q1) was used to evaluate students’ self-confidence in solving several aspects of a weak acid problem using only the knowledge learned from passively watching the lecture. The post-class questionnaire (Q2) was used to evaluate students’ self-
confidence on the same problem using the knowledge learned from passively watching the lecture in addition to the experience of actively solving similar problems during class time with the help of the instructor and TA. In addition to asking students to report their self-confidence, they were also asked to agree or disagree to several questions regarding their ability to solve the same problem after various aspects of the flipped course. See Appendix D for the questionnaire used. The results of the two questionnaire responses were put into graphical form using Excel. A limitation of this data is the level of analysis done based on the software available. Future analysis of this data should utilize a repeated measures ANOVA.

Table 2: Schedule of Self-Efficacy Questionnaire Administration Fall 2012

<table>
<thead>
<tr>
<th>Location</th>
<th>Sunday</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Class</td>
<td></td>
<td>Review Material, Work on Problem Sets</td>
<td>Review Material, Work on Problem Sets</td>
<td>Quiz</td>
</tr>
<tr>
<td>At home</td>
<td>Watch Short Video Segments, Take Online Assessment</td>
<td>Problem Sets (If Necessary), Study for Quiz</td>
<td>Problem Sets (If Necessary), Study for Quiz</td>
<td></td>
</tr>
</tbody>
</table>

The self-efficacy questionnaire was refined and administered again in Spring 2013. See Appendix E for the revised questionnaire used. During this semester, the questionnaire was administered a total of five times. See Figure 5 for a visual representation of this schedule. It was first administered on a Friday class (Q1), before the students had had a chance to watch the online lectures for the following week. This set of responses was used to analyze the students’ ability to solve different weak acid problems without any instruction. The questionnaire was next
administered the following Monday before class (Q2), to analyze the students’ ability to solve the same problem using only the knowledge gained from passively watching the lecture. The questionnaire was again administered at the end of class that Monday (Q3), to analyze the difference that actively solving problems in class with the help of the instructor and TA had on students’ self-confidence. The questionnaire was administered for the fourth time Wednesday after class (Q4), to analyze the effect that an additional day of in-class activities as well as any at-home problem solving had on students’ self-efficacy. The questionnaire was administered for the last time Friday before class (Q5). During the class period that Friday, there was a quiz to assess students’ grasp of the material. For this reason, the final self-efficacy questionnaire was used to assess the difference that additional studying at home outside of class time had on students’ self-confidence.

Table 3: Schedule of Self-Efficacy Questionnaire Administration Spring 2013

<table>
<thead>
<tr>
<th>Location</th>
<th>Friday Prior</th>
<th>Sunday</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Class</td>
<td></td>
<td></td>
<td>Review Material, Work on Problem Sets</td>
<td>Review Material, Work on Problem Sets</td>
<td>Quiz</td>
</tr>
<tr>
<td>At home</td>
<td></td>
<td>Watch Short Video Segments, Take Online Assessment</td>
<td>Problem Sets (If Necessary), Study for Quiz</td>
<td>Problem Sets (If Necessary), Study for Quiz</td>
<td></td>
</tr>
</tbody>
</table>

Q1 Q2 Q3 Q4 Q5
The results of the five questionnaires were put into graphical form using Excel. A limitation of this data is the level of analysis done based on the software available. Future analysis of this data should utilize a repeated measures ANOVA.

3. How does the classroom flip affect students’ perception of classroom climate?

For this research question, qualitative measures were used to analyze the effect of the classroom flip on student motivation through the College and University Classroom Environment Inventory (CUCEI). See Appendix F for the CUCEI. For information on reliability and validity of the CUCEI refer to Fraser and Treagust (1986). This questionnaire was used to measure the following subscales: Personalization, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and Individualization. The questionnaire consisted of 49 questions, with seven questions corresponding to each subscale. The responses to these questions were scored such that a lower value represented a more favorable score. Several other courses were also asked to complete this survey to serve as a control group. The questionnaire was administered to four separate groups of students. See Figure 6 for a visual representation of these groups and their differences. The first group (Group “A”) consisted of students who had just completed the flipped course. The second group (Group “B”) consisted of students who had just completed the same course, but taught in a traditional format. This was to control for the effect of the course material on students’ motivation and interest. The third group (Group “C”) consisted of students who had just completed a different environmental engineering course taught by the same instructor in a traditional format. This was to control for the effect of the instructor herself on students’ motivation and perceived classroom climate. The fourth group (Group “D”) consisted of the same students who were enrolled in the flipped course, but were asked to answer the questionnaire
based off of a similar required technical course in their major that was taught in a traditional format.

**Table 4: Student Groups CUCEI was administered to**

<table>
<thead>
<tr>
<th>Label</th>
<th>Course Students Were Enrolled In</th>
<th>Course Students were Analyzing</th>
<th>Analyzed Course Style</th>
<th>Instructor</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Required, Environmental Engineering</td>
<td></td>
<td>Flipped</td>
<td>Instructor 1</td>
<td>71</td>
</tr>
<tr>
<td>B</td>
<td>Required, Environmental Engineering</td>
<td></td>
<td>Traditional</td>
<td>Instructor 2</td>
<td>33</td>
</tr>
<tr>
<td>C</td>
<td>Elective, Environmental Engineering</td>
<td></td>
<td>Traditional</td>
<td>Instructor 1</td>
<td>41</td>
</tr>
<tr>
<td>D</td>
<td>Required, Environmental Engineering</td>
<td>&quot;Other&quot; Required, Large, Technical Course</td>
<td>Traditional</td>
<td>&quot;Other&quot; Instructor</td>
<td>74</td>
</tr>
</tbody>
</table>

Groups A, B, and C were analyzed using a one-way ANOVA, as these were three separate, distinct groups of students asked the same series of questions. The responses were analyzed based on each of the seven subscales within the CUCEI, as well as on an overall score combining all seven subscales.

Groups A and D were then analyzed using an independent t-test, as these were the same group of students asked the same series of questions regarding two separate courses. The responses were analyzed based on each of the seven subscales within the CUCEI, as well as on an overall score combining all seven subscales. The CUCEI questionnaire had been administered anonymously. For this reason, the results from Groups A and D could not be analyzed using a paired t-test, which would have provided more salient data.
Chapter 6 - Results

Value

The Surveys administered showed the following relationship between aspects of the flipped course and students’ perceived subject value: 78% of the students agreed or strongly agreed that “going on field trips increased my interest in Environmental Engineering,” 42% of the students agreed or strongly agreed that “doing problem sets in class increased my interest in environmental engineering,” and 92% of students agreed or strongly agreed that “viewing real life environmental engineering examples and stories in the online modules increased my interest in environmental engineering.”

The Focus Groups provided the following student quotes regarding their perceived subject value:

“You get a feel for what you’re actually doing [while on field trips]”

“…the field trips were interesting and let us see things we had been discussing in class”

Self-Efficacy

I. Fall 2012

The Fall 2012 administration of the Self-Efficacy Questionnaire resulted in the data shown in Figure 4.
In regards to the first question, students had an average increase in self-efficacy of 12.1 points, with a standard deviation of 15.5 points. For the second question, students had an average increase in self-efficacy of 14.8 points, with a standard deviation of 18.4 points. For the third question, students had an average increase in self-efficacy of 15.9 points, with a standard deviation of 21.4 points. For the fourth question, students had an average increase in self-efficacy of 25.4 points with a standard deviation of 19.0 points. For the fifth and final question, students had an average increase in self-efficacy of 25.8 points with a standard deviation of 19.3 points.

II. Spring 2013

The results of the Spring 2013 administration of the Self-Efficacy Questionnaire were separated based on individual questions for graphical purpose. The results are shown in Figures 5 through 10.
Figure 5: Finding the concentration of hydrogen ions in moles/L given the initial pH

For the first question, shown in Figure 5, students had an average increase in self-efficacy of 21.6 points between the administration of Q1 and Q2. Students had an average increase in self-efficacy of 10.4 points between the administration of Q2 and Q3. Students had an average increase in self-efficacy of 2.2 points between the administration of Q3 and Q4. Finally, students had an average increase in self-efficacy of 4.8 points between the administration of Q4 and Q5.

Figure 6: Calculating Ka given pKa
For the second question, shown in Figure 6, students had an average increase in self-efficacy of 25.5 points between the administration of Q1 and Q2. Students had an average increase in self-efficacy of 3.8 points between the administration of Q2 and Q3. Students had an average increase in self-efficacy of 6.0 points between the administration of Q3 and Q4. Finally, students had an average increase in self-efficacy of 1.9 points between the administration of Q4 and Q5.

**Figure 7: Setting up an equation for the equilibrium constant (K)**

For the third question, shown in Figure 7, students had an average increase in self-efficacy of 27.8 points between the administration of Q1 and Q2. Students had an average increase in self-efficacy of 4.5 points between the administration of Q2 and Q3. Students had an average increase in self-efficacy of 10.9 points between the administration of Q3 and Q4. Finally, students had an average increase in self-efficacy of 3.4 points between the administration of Q4 and Q5.
Figure 8: Solving for the equilibrium pH of a solution given the initial concentration of the weak acid

For the fourth question, shown in Figure 8, students had an average increase in self-efficacy of 31.4 points between the administration of Q1 and Q2. Students had an average increase in self-efficacy of 4.1 points between the administration of Q2 and Q3. Students had an average increase in self-efficacy of 11.4 points between the administration of Q3 and Q4. Finally, students had an average increase in self-efficacy of 5.6 points between the administration of Q4 and Q5.
For the fifth question, shown in Figure 9, students had an average increase in self-efficacy of 32.3 points between the administration of Q1 and Q2. Students had an average increase in self-efficacy of 5.1 points between the administration of Q2 and Q3. Students had an average increase in self-efficacy of 7.6 points between the administration of Q3 and Q4. Finally, students had an average increase in self-efficacy of 9.5 points between the administration of Q4 and Q5.
Figure 10: Average Total Score

For the overall average score, which aggregated all five questions, shown in Figure 10, students had an average increase in self-efficacy of 27.7 points between the administration of Q1 and Q2. Students had an average increase in self-efficacy of 5.5 points between the administration of Q2 and Q3. Students had an average increase in self-efficacy of 7.7 points between the administration of Q3 and Q4. Finally, students had an average increase in self-efficacy of 5.0 points between the administration of Q4 and Q5.

Classroom Climate

I. Comparison of Groups A, B, and C

The data from Groups A, B, and C were analyzed using a one-way ANOVA. The results are reported based on each subscale of the CUCEI as well as based on an overall score and are shown in Figures 11 through 26.
Figure 11: Boxplot of Personalization Score by Course – Groups A, B, and C

Figure 11 shows a boxplot of the results from Groups A, B, and C based on the Personalization subscale. The confidence intervals and data summaries are shown in Figure 12. The one-way ANOVA analysis shows that there is no statistically significant difference between the three groups based on Personalization (P=0.099).

Figure 12: Personalization One-Way ANOVA Data Summary
Figure 13: Boxplot of Involvement Score by Course – Groups A, B, and C

Figure 13 shows a boxplot of the results from Groups A, B, and C based on the Involvement subscale. The confidence intervals and data summaries are shown in Figure 14. The one-way ANOVA analysis shows that there is a statistically significant difference between the three groups based on Involvement (P=0.003). Tukey post-hoc tests indicate that Group A differs significantly from Group C.

**Table:**

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
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<th>95% CI</th>
</tr>
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<tr>
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<td>2.1520</td>
<td>0.4428</td>
<td>(2.00-2.30)</td>
</tr>
<tr>
<td>B</td>
<td>33</td>
<td>2.3661</td>
<td>0.3982</td>
<td>(2.15-2.50)</td>
</tr>
<tr>
<td>C</td>
<td>41</td>
<td>2.4288</td>
<td>0.4404</td>
<td>(2.20-2.60)</td>
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</tbody>
</table>

Figure 14: Involvement One-Way ANOVA Data Summary
Figure 15 shows a boxplot of the results from Groups A, B, and C based on the Student Cohesiveness subscale. The confidence intervals and data summaries are shown in Figure 16. The one-way ANOVA analysis shows that there is a statistically significant difference between the three groups based on Student Cohesiveness (P=0.000). Tukey post-hoc tests indicate that Group A differs significantly from Group B.

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>Individual 95% CIs For Mean Based on Pooled StDev</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>71</td>
<td>2.6580</td>
<td>0.6882</td>
<td>(*)-----</td>
</tr>
<tr>
<td>B</td>
<td>33</td>
<td>3.4336</td>
<td>0.4835</td>
<td>(--<em>-</em>)</td>
</tr>
<tr>
<td>C</td>
<td>41</td>
<td>2.7449</td>
<td>0.6427</td>
<td>(*)-**</td>
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</table>

Figure 16: Student Cohesiveness One-Way ANOVA Data Summary
Figure 17 shows a boxplot of the results from Groups A, B, and C based on the Satisfaction subscale. The confidence intervals and data summaries are shown in Figure 18. The one-way ANOVA analysis shows that there is no statistically significant difference between the three groups based on Satisfaction (P=0.740).

**Figure 17: Boxplot of Satisfaction by Course – Groups A, B, and C**

**Figure 18: Satisfaction One-Way ANOVA Data Summary**
Figure 19 shows a boxplot of the results from Groups A, B, and C based on the Task Orientation subscale. The confidence intervals and data summaries are shown in Figure 20. The one-way ANOVA analysis shows that there is a statistically significant difference between the three groups based on Task Orientation (P=0.003). Tukey post-hoc tests indicate that Group A differs significantly from Group C.

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
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</thead>
<tbody>
<tr>
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<td>(1.50, 1.65)</td>
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<tr>
<td>B</td>
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<td>1.5518</td>
<td>0.3174</td>
<td>(1.50, 1.65)</td>
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<tr>
<td>C</td>
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<td>1.8585</td>
<td>0.4592</td>
<td>(1.70, 1.90)</td>
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</tbody>
</table>

Figure 20: Task Orientation One-Way ANOVA Data Summary
Figure 21: Boxplot of Innovation by Course – Groups A, B, and C

Figure 21 shows a boxplot of the results from Groups A, B, and C based on the Innovation subscale. The confidence intervals and data summaries are shown in Figure 22. The one-way ANOVA analysis shows that there is a statistically significant difference between the three groups based on Innovation (P=0.005). Tukey post-hoc tests indicate that Group A differs significantly from Group B.

Individual 95% CIs For Mean Based on Pooled StDev

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<tr>
<th>Level</th>
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<th>Mean</th>
<th>StDev</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
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<td>A</td>
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<td>2.3365</td>
<td>0.5138</td>
<td>2.24</td>
<td>2.40</td>
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<td>2.6670</td>
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<td>2.72</td>
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<tr>
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<td>41</td>
<td>2.5320</td>
<td>0.4802</td>
<td></td>
<td></td>
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</tbody>
</table>

Figure 22: Innovation One-Way ANOVA Data Summary
Figure 23 shows a boxplot of the results from Groups A, B, and C based on the Individualization subscale. The confidence intervals and data summaries are shown in Figure 24. The one-way ANOVA analysis shows that there is a statistically significant difference between the three groups based on Individualization (P=0.000). Tukey post-hoc tests indicate that Group A differs significantly from Group B. Tukey post-hoc tests indicate that Group A differs significantly from Group C.
Figure 25: Boxplot of Overall Score by Course – Groups A, B, and C

Figure 25 shows a boxplot of the results from Groups A, B, and C based on an overall score aggregating all subscales. The confidence intervals and data summaries are shown in Figure 26. The one-way ANOVA analysis shows that there is a statistically significant difference between the three groups based on Overall Score (P=0.000). Tukey post-hoc tests indicate that Group A differs significantly from Group B. Tukey post-hoc tests indicate that Group A differs significantly from Group C.

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>Individual 95% CIs For Mean Based on Pooled StDev</th>
</tr>
</thead>
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<td>0.3810</td>
<td>(--*--)</td>
</tr>
<tr>
<td>B</td>
<td>33</td>
<td>2.3342</td>
<td>0.2802</td>
<td>(--*--)</td>
</tr>
<tr>
<td>C</td>
<td>41</td>
<td>2.3056</td>
<td>0.3385</td>
<td>(--*--)</td>
</tr>
</tbody>
</table>

Figure 26: Overall Score One-Way ANOVA Data Summary
II. Comparison of Groups A and D

The data from Groups A and D were analyzed using an independent t-test. The results are reported based on each subscale of the CUCEI as well as based on an overall score and are shown in Figures 27 through 34.

![Boxplot of Personalization by Course](image)

**Figure 27: Boxplot of Personalization by Course – Groups A and D**

Figure 27 shows a boxplot of the results from Groups A and D based on the Personalization subscale. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Personalization (P=0.000).
Figure 28 shows a boxplot of the results from Groups A and D based on the Involvement subscale. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Involvement (P=0.000).
Figure 29 shows a boxplot of the results from Groups A and D based on the Student Cohesiveness subscale. The independent t-test analysis shows that there is no statistically significant difference between the two groups based on Student Cohesiveness (P=0.150).
Figure 30 shows a boxplot of the results from Groups A and D based on the Satisfaction subscale. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Satisfaction (P=0.001).
Figure 31: Boxplot of Task Orientation by Course – Groups A and D

Figure 31 shows a boxplot of the results from Groups A and D based on the Task Orientation subscale. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Task Orientation (P=0.000).
Figure 32: Boxplot of Innovation by Course – Groups A and D

Figure 32 shows a boxplot of the results from Groups A and D based on the Innovation subscale. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Innovation (P=0.000).
Figure 33: Boxplot of Individualization by Course – Groups A and D

Figure 33 shows a boxplot of the results from Groups A and D based on the Individualization subscale. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Individualization (P=0.000).
Figure 34: Boxplot of Overall Score by Course – Groups A and D

Figure 34 shows a boxplot of the results from Groups A and D based on an overall score aggregating all subscales. The independent t-test analysis shows that there is a statistically significant difference between the two groups based on Overall Score (P=0.000).
Chapter 7 - Discussion/Summary

Findings

The analysis of the data provided in the previous section show that implementing the classroom flip causes students to perceive higher subject value, increase their self-efficacy, and perceive a more supportive environment.

Several aspects of the classroom flip cause students to perceive higher subject value. As shown by the results reported from the student surveys, the three aspects that caused the greatest impact were going on field trips, doing problem sets in class, and viewing real life environmental engineering examples and stories in the online modules. A traditional lecture is able to utilize some of these aspects. For example, a traditional lecture can discuss real life environmental engineering examples and stories. However, the flipped class opens up class time to put more emphasis on these examples and stories. A traditional course typically cannot take any field trips as the instructors are preoccupied with transmitting all required information. The flipped class opens up class time to allow for these field trips, as well as other activities such as in class problem solving and guest speakers.

The flipped classroom causes students to increase their self-efficacy. The Fall 2012 administration of the Self-Efficacy Questionnaire showed consistent increases in self-efficacy between Q1 and Q2 as the students had the ability to work on problems in class. Being able to practice important application skills increases students self confidence in being able to repeat these applications at a later time.

The Spring 2013 administration of the Self-Efficacy Questionnaire also showed consistent increases in self-efficacy between each of the 5 questionnaires (Q1, Q2, Q3, Q4, and
Q5) for all aspects of the weak acid problem presented to the students. The greatest increases in self-efficacy were seen between Q1 and Q2. At this point, the students had watched the online lectures and completed the online assessment. Since they had originally had little prior knowledge regarding the topic, observing the greatest increases at this point in the instructional method follows logic. The students are introduced to the theories and concepts, and have a chance to watch some problems being solved, which increases their self-efficacy. Their self-efficacy continued to increase throughout the week, showing that in-class problem solving, as well as at-home problem solving and studying help to increase self-efficacy. A traditional lecture does not typically have the opportunity to allow for this in-class problem solving. Each of the questions asked regarding the weak acid problem showed a similar ceiling effect as they approached the Q5 administration. Many students became fully confident (score = 100 points) in solving these aspects of the problem, which limited the increase in self-efficacy that could be observed.

The flipped classroom caused students to perceive the environment as more supportive. First we will consider the comparison of Groups A, B, and C. The one-way ANOVA analysis of the CUCEI data for Groups A, B, and C showed statistically significant differences in several of the CUCEI subscales, although not all. The subscale of Personalization did not show statistically significant differences between the three groups. This was a surprising result in the research, as personalization refers to the opportunities for individual students to interact with the instructor and has emphasis on instructor’s concern for students’ personal welfare. It had been hypothesized that a flipped course would increase personalization, as a flipped course frees up class time and increases student-instructor interactions. These results show that the instructors for all three groups (Instructor 1 and Instructor 2) had similar levels of concern for students and provided opportunities for the students to interact with the instructor.

The subscale of Involvement showed a statistically significant difference between the three groups. Tukey post-hoc tests indicated that this difference was due to the significant
difference between Group A and Group C. Group C had been chosen to control for the same instructor, so these results show that the flipped course allows students to participate more actively and attentively in class discussions and activities as compared to a traditional lecture taught by the same instructor.

The subscale of Student Cohesiveness showed a statistically significant difference between the three groups. Tukey post-hoc tests indicated that this difference was due to the significant difference between Group A and Group B. Student cohesiveness refers to the extent to which students know, help, and are friendly toward each other. These results show that when teaching the same material (as Group B had been chosen to control for the same course material), students are better able to interact in a positive manner. One possible reason why there was not a statistically significant difference seen between Groups A and C is that Group C consisted of higher level students, who may have already developed deeper student-student interactions and relationships with their peers.

The subscale of Satisfaction did not show any statistically significant differences between the three groups. These results show that flipping the course does not make a difference in students’ enjoyment of classes. While the goal for some instructors may be for students to enjoy flipped courses more, this shows that implementing the flipped classroom does not increase students dislike of the classes.

The subscale of Task Orientation showed a statistically significant difference between the three groups. Tukey post-hoc tests indicated that this difference was due to the significant difference between Group A and Group C. These results show that when controlling for the same instructor, task activities are clearer and better organized when utilizing the classroom flip.

The subscale of Innovation showed a statistically significant difference between the three groups. Tukey post-hoc tests indicated that this difference was due to the significant difference between Group A and Group B. Innovation refers to the extent to which the instructor plans new,
unusual class activities, teaching techniques, and assignments. These results show that when controlling for the same course material, the flipped classroom is better able to use new and innovative techniques. This is one of the main goals of the classroom flip – to free up class time to use active learning techniques and activities, such as field trips, guest speakers, and in-class problem solving.

The subscale of Individualization showed a statistically significant difference between the three groups. Tukey post-hoc tests indicated that this difference was due to the significant difference between Group A and Group B, as well as the significant difference between Group A and Group C. Individualization refers to the extent to which students are treated differentially according to ability, interest, and rate of working. These results show that the flipped classroom allows instructors to tailor their teaching techniques to all students better than traditional classrooms, regardless of instructor or course material. One of the greatest difficulties in teaching is differentiating the instructional technique to satisfy all students, so these results show one of the key benefits of the flipped classroom.

When aggregating all seven subscales of the CUCEI, an Overall score showed statistically significant differences between the three groups. Tukey post-hoc tests indicated that this difference was due to the significant difference between Group A and Group B, as well as the significant difference between Group A and Group C. This shows that the flipped classroom does improve classroom climate as a whole, and allows students to perceive their environment as more supportive.

Next we will consider the comparison of Group A and Group D. The independent t-test showed statistically significant differences in almost all of the subscales of the CUCEI except for student cohesiveness. Group D was chosen to compare a similar large, required, engineering class that students had taken previously. These results show that at similar course levels, student-student interactions are not improved through the classroom flip.
Once again, aggregating all seven subscales into one overall score showed statistically significant differences between the two groups, indicating that the classroom flip improves classroom climate as a whole and allows students to perceive their environment as more supportive.

**Limitations**

There were several limitations in this study in regards to all three levers of student motivation. No quantitative data was found to analyze the impact that implementing the classroom flip had on students’ perception of value. The self-efficacy surveys did not have a control group to act as a comparison. The values obtained from the self-efficacy surveys merely show differences between different aspects within the flipped course, but not the flipped course as a whole compared to a traditional class. As previously mentioned, the CUCEI questionnaire had been administered anonymously and the results from Groups A and D could not be analyzed using a paired t-test, which would have provided more salient data.

**Future Recommendations**

There are several future recommendations for continuing this study. It is recommended that a quantitative assessment be utilized, and created if necessary, to determine quantitative data to analyze the impact that implementing the classroom flip has on students’ perception of value. Possible considerations with this are analyzing which aspects of the flipped class had the biggest impact on student value, such as comparing student preferences on field trips versus guest speakers. This quantitative data measure should also be administered to a control group to better understand the relationship between the classroom flip as opposed to the course material or instructor influence.

It is recommended that the self-efficacy surveys also be administered to the same course when taught as a traditional lecture to better understand the impact that the flipped class has on self-efficacy. Another possible direction this research could take would be considering how well
students’ self-efficacy acts as a predictor of actual success. In this case, student test scores could be used to compare to students’ reported self-efficacy scores.

It is recommended that the CUCEI be administered again to another section of the flipped course. The requirements for Group A and Group D would be recreated. However, this time it is recommended that the surveys not be administered anonymously. This would allow for the data to be analyzed using a paired t-test, which would provide more salient data.

Other possible directions that this research could take would be considerations of gender and demographics when considering the impact of the classroom flip on student motivation. In addition, a major issue found in engineering courses is attrition. One possible direction that this research could take would be seeing if implementing the classroom flip has an impact on attrition rates.
Appendix A

Post-Semester Reflection Survey

1. If Dr. Velegol were teaching another course in your major both as a traditional course and as a flipped course, which one would you choose?
   Traditional
   Flipped

2. Please briefly explain your reasons for this choice.

3. For CE 370 with Dr. Velegol, which is a better use of class time?
   Reviewing Online Lectures
   Problem-Solving

4. How long should Dr. Velegol spend on reviewing the modules in class?
   0 min, 1-10 min, 11-20 min, 21-30 min, 31-40 min, 41-50 min

5. What other things would you have preferred to do during classtime?

6. Given the choice, which module schedule would you prefer?
   Four - 30 minute videos
   Six - 20 minute videos
   Twelve - 10 minute videos
   Twenty-four - 5 minute videos

7. How many of the 11 modules did you watch completely? (0, 1-2, 3-4, 5-6, 7-8, 9-10, 11)

8. How many of the 132 video sections did you watch more than once? (0, 1-10, 11-30, 31-60, 61-100, 101-132)
9. What were your reasons for re-watching the video sections (select all that apply)?
   a. Review for quiz
   b. Help with problem sets
   c. To clear-up a misunderstanding
   d. Other

10. We met as a group (without quizzes) about 20 times for in-class problem solving. How many of these class times did you miss during the semester?

   0, 1-2, 3-5, 6-9, 10 – 15, 16-20

11. What were your reasons for missing class?
   
   Was able to finish problem set on my own
   Prefer to work on the problems at home
   Illness
   Interviews
   Didn’t feel like coming
   Other

12. How many class times did you miss in other courses in your major this semester?
   Much less than in this class
   Less than in this class
   About the same as in this class
   More than in this class
   Much more than in this class

13. How many times were you able to complete your homework during classtime?
   0 (I did not attend class to work on homework)
   0 (I attended class but was not able to complete my homework)
   1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Please indicate your level of agreement/disagreement with the following statements

(Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree)

14. I feel confident in my ability to use the material learned in this course to solve course problems.
15. I feel confident in my ability to use the material learned in this course to solve problems in my future career.

16. I feel confident in my ability to use the material learned in this course to solve problems in my other courses.

17. I feel confident in my ability to use the material learned in this course to solve important problems in the field.

18. I feel more comfortable taking an online course having taken this flipped course.

19. I feel more comfortable taking a flipped course having taken this flipped course.

20. I feel more comfortable taking a MOOC having taken this flipped course.

21. This course is more structurally organized than my other courses.

22. The format of this class makes me feel more comfortable asking questions/interacting with my professors.

23. The format of this class makes me feel more comfortable asking questions/interacting with my peers.

24. Open Comment Box
Appendix B

Focus Group Questions Fall 2012

- Why are you taking this class?
  - Would you take this class if you weren’t required to? Why?
- What were your goals going into this course?
  - What was your primary motivation to achieve this/these goals?
- What value do you see in this course?
  - Value definition: in other words, what do you feel you might be getting out of this course either personally or professionally?
- From a professional standpoint, which part of this course has the most value (ie you’ll be most likely to use in the future)?
  - Was this what you initially thought?
- How has this course changed your opinion on Environmental Engineering, if at all?
- What other CE classes have you taken/are you currently taking?
  - Describe the structure of this/these courses.
  - What aspect of 370’s flipped structure has been most beneficial to your learning in comparison to this other course?
  - What aspect of 370’s flipped structure has been least beneficial to your learning in comparison to this other course?
  - Pretend this course is taught in the same format by another professor. If students mention teacher attitude.
- How would you describe the classroom environment in CE 370?
  - For example, how do you feel that the instructor interacts with students in the class?
  - Do you feel that the environment is support or unsupportive to your learning? Describe why you feel this way.
- Open Forum ending
Appendix C

Focus Group Questions Spring 2013

- Why are you taking this class?
  - *Would you take this class if you weren’t required to? Why?*
- What were your goals going into this course?
  - *What was your primary motivation to achieve this/these goals?*
  - Value definition: in other words, what do you feel you might be getting out of this course either personally or professionally?
- From a professional standpoint, which of these courses has the most value? Why?
- In which course do you feel more able to do well? Why?
- What aspect of 370’s flipped structure has been most beneficial to your learning in comparison to 371?
- What aspect of 370’s flipped structure has been least beneficial to your learning in comparison to 371?
- How would you describe the classroom environment in CE 371 compared to CE 370?
  - For example, how do you feel that the instructor interacts with students in the class?
  - Do you feel that the environment is support or unsupportive to your learning? Describe why you feel this way.
- *Open Forum ending*
Appendix D
Self-Efficacy Questionnaire Fall 2012

Name:________________________________________

A weak acid is added to water (assume the water is initially at neutral pH). You are given the following information about the resulting solution:

- The pH at equilibrium
- The pKa of the acid
- The molecular weights of each component in the chemical equation

Rate your degree of confidence in your ability to complete the following tasks at this moment by recording a number from 0 to 100 using the scale given below:

Cannot do at all               Moderately certain can do               Highly certain can do
0     10    20    30    40    50    60    70    80    90    100

1. Finding the concentration of hydrogen ions before the weak acid is added to the water.
   a. In moles/L: ________
   b. In mg/L:_______

2. Finding the concentration of hydrogen ions after the weak acid is added when the solution is at equilibrium.
   a. In moles/L:_______
   b. In mg/L:_______

3. Setting up an equation for the equilibrium constant (K):_______

4. Solving for the initial mass of the weak acid added in order for the solution to reach the equilibrium pH: _________
Appendix E

Self-Efficacy Questionnaire Spring 2013

Name: __________________________________________

Have you watched the videos for Module 2 (Weak Acids)? ____________

Have you started working on the problem set for Module 2? ____________

A weak acid is added to water (assume the water is initially at neutral pH). You are given the pKa of the acid and the molecular weights of each component.

Rate your degree of confidence in your ability to complete the following tasks at this moment by recording a number from 0 to 100 using the scale given below:

<table>
<thead>
<tr>
<th>Cannot do at all</th>
<th>Moderately certain can do</th>
<th>Highly certain can do</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>0</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>0</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>0</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>0</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>0</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>0</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>0</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>0</td>
<td>90</td>
<td>100</td>
</tr>
</tbody>
</table>

5. Finding the concentration of hydrogen ions in moles/L given the initial pH: __________

6. Calculating Ka given pKa: ________________

7. Setting up an equation for the equilibrium constant (K): __________

8. Solving for the equilibrium pH of a solution given the initial concentration of the weak acid: ______

9. Solving for the initial concentration of the weak acid added given the equilibrium pH: ______
Appendix F

CUCEI Questionnaire

CE 370 Spring 2013 Pre-Assessment

College and University Classroom Environment Inventory

The purpose of this questionnaire is to find out your opinions about a required technical course in your major that you have taken in a previous semester. Examples within Civil Engineering include CE 332, 340, 335, 336, 360, etc.

This questionnaire is designed for use in gathering opinions about classes

For research purposes, please indicate:

Your academic major: ____________  Today's date: ________________________________

Current year: Fresh.  Soph.  Junior  Senior  Course you are evaluating: ________________

Approximate size of course: ____________  Semester you took course listed above: ________________

This form of the questionnaire assesses your opinion about what this class was actually like. Indicate your opinion about each questionnaire statement by selecting one of the following options:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The teacher considers students’ feelings.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>2.</td>
<td>The teacher talks rather than listens.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>3.</td>
<td>The class is made up of individuals who don't know each other well.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>4.</td>
<td>The students look forward to coming to classes.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>5.</td>
<td>Students know exactly what has to be done in our class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>6.</td>
<td>New ideas are seldom tried out in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>7.</td>
<td>All students in the class are expected to do the same work, in the same way and in the same time.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>8.</td>
<td>The instructor talks individually with students.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td></td>
<td>Students put effort into what they do in classes.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>10.</td>
<td>Each student knows the other members of the class by their first names.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>11.</td>
<td>Students are dissatisfied with what is done in the class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>12.</td>
<td>Getting a certain amount of work done is important in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>13.</td>
<td>New and different ways of teaching are seldom used in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>14.</td>
<td>Students are generally allowed to work at their own pace.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>15.</td>
<td>The teacher goes out of his/her way to help students.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>16.</td>
<td>Students 'clockwatch' in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>17.</td>
<td>Friendships are made among students in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>18.</td>
<td>After the class, the students have a sense of satisfaction.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>19.</td>
<td>The group often gets sidetracked instead of sticking to the point.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>20.</td>
<td>The instructor thinks up innovative activities for students to do.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>21.</td>
<td>Students have a say in how class time is spent.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>22.</td>
<td>The teacher helps each student who is having trouble with the work.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>23.</td>
<td>Students in this class pay attention to what others are saying.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>24.</td>
<td>Students don't have much chance to get to know each other in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>25.</td>
<td>Classes are a waste of time.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>26.</td>
<td>This is a disorganized class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>27.</td>
<td>Teaching approaches in this class are characterized by innovation and variety.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>28.</td>
<td>Students are allowed to choose activities and how they will work.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>29.</td>
<td>The instructor seldom moves around the classroom to talk with students.</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>30. Students seldom present their work to the class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>31. It takes a long time to get to know everybody by his/her first name in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>32. Classes are boring.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>33. Class assignments are clear so everyone knows what to do.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>34. The seating in this class is arranged in the same way each week.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>35. Teaching approaches allow students to proceed at their own pace.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>36. The instructor isn't interested in students' problems.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>37. There are opportunities for students to express opinions in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>38. Students in this class get to know each other well.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>39. Students enjoy going to this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>40. This class seldom starts on time.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>41. The instructor often thinks of unusual class activities.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>42. There is little opportunity for a student to pursue his/her particular interest in this class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>43. The teacher is unfriendly and inconsiderate towards students</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>44. The instructor dominates class discussion.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>45. Students in this class aren't very interested in getting to know other students.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>46. Classes are interesting.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>47. Activities in this class are clearly and carefully planned.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>48. Students seem to do the same type of activities every class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>49. It is the instructor who decides what will be done in our class.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY


ACADEMIC VITA
Emily Mahoney
ezm5067@gmail.com

EDUCATION
August 2009-December 2013
The Pennsylvania State University
University Park, PA
Schreyer Honors College
Bachelor of Science – Civil Engineering
Minor: Environmental Engineering

EXPERIENCE
May 2012-August 2013
Site/Civil Intern
Langan Engineering and Environmental Services
Doylestown, PA
• Efficiently aided in land development process for multiple, diverse projects.
• Developed and edited site, grading & drainage, soil erosion & sediment control, and utility plans and details using AutoCAD and Civil3D.
• Collated and organized hard copies of plan sets.
• Delivered plans to various contracting and permitting authorities.

Awards/Achievements
• Schreyer Honors College Orientation Mentor 2010, 2011
• Summers by Design Program: Ecole Centrale Nantes, France 2011
  • Engineering Design Program, Student Coordinator
• International Engineering Envoy 2011-Present
• CE 370: Introduction to Environmental Engineering
  • Teaching Intern, Spring 2012, Fall 2012, Spring 2013, Fall 2013
• Annual Academic Merit Scholarship Recipient 2009-2013 (Schreyer Honors Scholar)
• Samuel Walton Community Scholarship Recipient 2009
• Bucks First Federal Credit Union Scholarship Recipient 2009
• NACUFS Nancy W. Carrier Scholarship Recipient 2011
• Wolf Trustee Scholarship Recipient 2012
• Stan and Flora Kappe Scholarship Recipient 2012, 2013
• Charles A. and Linda E. Sorber Trustee Scholarship 2013
• Walter J. Kinsey Honors Scholarship 2013
• SCAR Derby Student Organization Founder/President

Language/Technical Skills
English and German Fluency
• AutoCAD
• Advanced Microsoft Office
• Civil3D
French and Chinese Proficiency
• WhentoWork
• Basic MATLAB
• Minitab