How Does a Flipped Classroom Impact Classroom Climate?

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Abstract

This research paper describes an investigation into the impacts of a flipped pedagogy on student-perceived classroom climate. We used the College and University Classroom Environment Inventory (CUCEI) to assess the classroom climate in both the flipped class and various control classes that were not flipped. This inventory includes seven psychosocial dimensions of classroom climate: personalization, involvement, student cohesiveness, satisfaction, task orientation, innovation, and individualization. Our specific research questions were:

1. Do students perceive a more positive classroom climate in a flipped classroom vs. a traditional lecture-based course when controlled for course content and instructor?
2. What psychosocial dimensions were most impacted by the flipped pedagogy?
3. What do these results indicate about student motivation in a flipped classroom?

One group of students (Group "A") 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 student's motivation and interest. The third group (Group "C") consisted of students who had just completed a different engineering course taught by the same instructor in a traditional format. This was to control for a different instructor. The groups were analyzed using a one-way ANOVA. 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 results show that overall the flipped class results in a higher score in both overall classroom climate and for the individualization subscale. In addition we found higher averages for task orientation when controlled for instructor. When controlled for the course content, the flipped course is more innovative and students get to know each other more. The implications of these findings on flipped classrooms are important to those faculty wishing to flip their course.

How does a flipped classroom impact classroom climate and student motivation?

Introduction

Faculty have known for some time that learning gains can be made by introducing a more active learning environment.[1,2] However, some faculty struggle to incorporate active learning with the concern that technical content may not be covered. Recently, more faculty have turned to the flipped, or inverted classroom. In this pedagogy, technical material is presented outside of class while class time is used for active learning. The technical material is typically presented through online lectures created by the faculty member but can also be presented through other video (such as Khan Academy) or through readings. In-class time can be used for problem solving, brainstorming, design work and even field trips. This teaching technique has many benefits such as student preference[3,4], self-efficacy[5] and student engagement[6]. Although most studies have found no differences in measured learning gains [4,7,8] a few have[9,10].

Although our previous work showed no differences in learning gains as measured by final exam scores[4], we wondered if a flipped classroom could create a more motivating classroom climate. One motivation theory[11] states that a student's motivation to learn is based on three levers. The first levers is value. Do students see value in the content? The second lever is self-efficacy. Do students believe they can do well in the class? Specifically, if a student has high efficacy expectancies, they believe that they are "capable of identifying, organizing, initiating and executing a course of action that will bring about a desired outcome."[11,12] The final lever is having a supportive environment. "If students experience the classroom as a caring, supportive place where there is a sense of belonging and everyone is valued and respected, they will tend to participate more fully in the process of learning." [13]

Our goal of this research study was to investigate if a flipped classroom resulted in more motivated students, especially in terms of a more supportive learning environment and self-efficacy. We chose to use the CUCEI (College and University Classroom Environment Inventory) to investigate the effect of the classroom flip on classroom climate. This instrument was developed in 1986 to address the need for an instrument to assess students' perception of classroom climate at the College and University level.[14,15] This inventory has seven subcategories: Personalization, Satisfaction, Innovation, Student cohesion, Task orientation, Involvement and Individualization as shown in Table 1.

We hypothesized that the interactive class time in a flipped format would afford more opportunities for students to interact with and receive support from faculty (Personalization subscale) and other students (Student cohesion subscale). These higher scores in Personalization and Student cohesion would indicate a more supportive classroom climate.

We were particularly interested in the Individualization and Task orientation subscales, especially as they could relate to self-efficacy. As shown in Table the individualization subscale represents the extent to which students are treated differentially and are able to make their own decisions based on their interests and abilities.[14] An increase in this subscale may indicate higher efficacy expectations since the students learn that they are capable of executing a successful course of action. In a flipped class students get more differentiated instruction since they can chose when they watch the videos and how they watch the videos while in class they can get their questions answered more easily. In addition, students will have a higher level of self-efficacy if the course of action is clear. This can be measured using the Task orientation subscale. That is, we hypothesized that a flipped classroom would result in higher scores in both the

Individualization and Task orientation subscales and that increases in these two scores may indicate higher self-efficacy.

Table 1: Description of seven subscale in the CUCEI

CUCEI subscale	Description	Example item
Personalization	Opportunities for individual interactions between faculty and student, especially on concern for student's welfare.	*The instructor goes out of his/her way to help students. (+)*
Satisfaction	Do student enjoy the class?	*Classes are boring. (-)*
Innovation	Does the faculty plan unusual activities, teaching techniques and assignments?	*New and different ways of teaching are seldom used in this class. (-)*
Student cohesion	Are students friendly and helpful towards each other?	*Students in this class get to know each other well. (+)*
Task orientation	Are activities clear and well organized?	*Students know exactly what has to be done in our class. (+)*
Involvement	Are students actively participating in class?	*The instructor dominates class discussions. (-)*
Individualization	Are students treated differentially? Are they able to make their own decisions based on their interests and abilities?	*Students are allowed to choose activities and how they will work. (+)*

The CUCEI has been use previously to investigate classroom climate in STEM flipped classes. Strayer[16] compared a flipped statistics class with 23 students to a traditional class of 28 students. He found that compared to a lecture-based course, a flipped classroom results in higher values for Innovation and Involvement but lower values for Task-orientation. That is the students recognized that the flipped class was innovative and were actively involved in their own learning but they lacked clarity of the activities. This points out the importance of making the expectations and activities even more clear in a flipped classroom.

There are a few studies that have used the CUCEI in flipped engineering courses but we did not find any work comparing the flipped course to a lecture-based course. Clark *et al.* [17] used this instrument in a flipped freshman engineering programing course while Marks and Ketchman[18] used it in a flipped elective in sustainable engineering. Both studies found the highest score for Personalization and lowest scores for Individualization. This would indicate that the flipped classroom has a supportive classroom climate but doesn't indicate if it is *more* supportive than a traditional lecture-based class.

In this paper we report on the use of the CUCEI to assess the classroom climate in both the flipped class and various control classes that were not flipped. Our specific research questions were:

1. Do students perceive a more positive classroom climate in a flipped classroom vs. a traditional lecture-based course when controlled for course content and instructor?
2. What psychosocial dimensions were most impacted by the flipped pedagogy?
3. What do these results indicate about student motivation in a flipped classroom? Specifically, an increase in Individualization and Task orientation may indicate an increase in self-efficacy while

an increase in Personalization and Student cohesion would indicate an increase in supportive climate.

Materials and Methods

The research took place in the College of Engineering at Penn State University. The instrument we used to assess the classroom climate is the CUCEI (College and University Classroom Environment Inventory). This instrument was developed to cover Moos categories[19] for conceptualizing all human environments. The three general categories are: the Relationship dimension (covered by Personalization, Satisfaction, Student cohesion and Involvement), the Personal development dimension (covered by Task orientation) and the System maintenance and system change dimension (covered by Innovation and Individualization). The instrument is a survey that contains 7 items per scale and includes both negative and positive scoring. The students are asked to state their level of agreement on each statement on a 5 point scale. The internal consistency for the CUCEI has been measured in several studies and shown to be acceptable with Cronbach's alpha coefficients ranging from 0.70 to 0.90.[Error! Bookmark not defined.20]

The CUCEI survey was administered during the same semester to three separate groups of students, as shown in Table 2. The students were enrolled in one of two Civil Engineering courses. Course R was a required third year Introduction to Environmental Engineering course. Course E is an elective course in Water and Wastewater Engineering for third or fourth year students.

Group A students were enrolled in Course R taught using a flipped format by Instructor 1. Group B students were also enrolled in Course R but this course was taught using a lecture-based method by Instructor 2. This comparison was made to control for course content. Group C represents students enrolled in Course E. This course was taught by Instructor 1 using a lecture-based method. This comparison was made to control for instructor. Instructor 1 is one of the authors and had flipped Course R five times before this course. Instructor 2 has never taught a flipped course before but had taught Course R one time before this class.

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 data was analyzed using a one-way ANOVA and then using a Tukey post-hoc test to determine the significant differences between the groups.

Table 2: Description of three separate groups of students used for comparison of flipped to traditional teaching format. Instructor 1 is one of the authors.

Group	Environmental Engineering Course	Teaching Style	Instructor	N (% response)	% CE students in study	% women enrolled	GPA in this course for all students enrolled
A	R: Required	Flipped	1	71 (89%)	58%	22%	3.2 ± 0.97
B	R: Required	Traditional	2	33 (53%)	58%	12%	2.9 ± 1.13
C	E: Elective	Traditional	1	41 (83%)	80%	33%	2.8 ± 0.97

The description of the flipped version of Course R (Group A) is described previously.[4] Approximately every week student were required to watch a module that consisted of short (~10 minute) video segments. Each module length varied from 87 – 143 minutes for a total of 22 hours of video during the semester. The students would take an online quiz before coming to class to serve as a "gate check" and would use this quiz to ask a question about the content. The instructor would review these questions at the beginning of the class along with a brief review on Monday during class. Students met for class with the instructor three times a week for 15 weeks for 50 minutes each. About 50% of these class periods were used for problem solving – students would bring their homework to class and work on it during class. The instructor and a teaching intern (undergraduate student) would walk around the room and help the students. The students could chose to work together or along. About 25% of the class periods were used for summative assessments in the form of an in-class quiz. The other 25% of the class periods were used for field trips, discussions and guest speakers. There were 80 students enrolled in this course (59% civil engineering students, 22% women). The average GPA of the grades in the class was a 3.2 as shown in Table 2. Seventy-one students (89%) completed the survey and 58% of these students were civil engineering students.

Students in Group B also took Course R but with a different instructor. This instructor taught in a lecture-based style. In this course students met twice a week for 80 minutes for 15 weeks. The instructor used 75% of the class periods for lecturing. Approximately 15% of the time was used for 4 in-class quizzes and the other 10% was used for field trips and discussions about documentaries. The students had 9 homework assignments. The content covered was very similar, but not identical, between this course and the course taken by Group A. There were 63 students (59% civil engineering students, 11% women) enrolled in this course. The average GPA of the grades in the class was a 2.9 as shown in Table 2. Thirty three students (53%) completed the survey and 58% of these students were civil engineering students.

Students in Group C had the same instructor as Group A but a different course (Course E) and the instructor taught in a lecture-base style. The instructor had taught this course 4 times previous to this course. In this course students met twice a week for 80 minutes for 15 weeks. The instructor used 75% of the class periods for lecturing. Approximately 20% of the time was used for 6 in-class quizzes and the other 5% was used for field trips and guest speakers. The students had 6 homework assignments. There were 49 students (79% civil engineering students, 33% women) enrolled in this course. The average GPA of the grades in the class was a 2.8 as shown in Table 2. Forty one students (83%) completed the survey and 80% of these students were civil engineering students.

Results

We had three specific research questions that could be answered by analyzing the results of the student's responses from the CUCEI instrument:

1. Do students perceive a more positive classroom climate in a flipped classroom vs. a traditional lecture-based course when controlled for course content and instructor?
2. What psychosocial dimensions were most impacted by the flipped pedagogy?
3. What do these results indicate about student motivation in a flipped classroom?

Table 3 shows the average and standard deviation of the responses for each subscale and overall in the CUCEI instrument on classroom climate. The results show that overall the flipped class resulted in a statistically higher overall positive classroom climate when compared to the two lecture-based courses (2.93 vs. 2.66 for Group B and 2.93 vs. 2.69 for group C with a p=0.000).

For both Group A and C (same instructor), the highest average of the subscales occurs for Personalization although the difference between the groups is not significant. The lowest average of the subscale for Group A and B (same class) occurred for Student cohesion. The highest average for Group B was Task orientation while the lowest average of Group C was in Individualization.

Table 3: Results from one-way ANOVA of CUCEI results for each subscale score and for the overall score. Results are reported as mean and standard deviation. Tukey post-hoc tests results indicate the significant difference for each test. This is also indicated by the shaded cells. Note that the negative questions were

*inverted so that the highest score is a 5 and the lowest is a 1. The highest average for each Group is indicated by * while the lowest is indicated by **.*

	Group A Course R Flipped Instructor 1 n = 71	Group B Course R Lecture Instructor 2 n = 33	Group C Course R Lecture Instructor 1 n=41	*p*	Tukey post-hoc results
Personalization	**3.55±0.52***	3.38±0.35	**3.41 ± 0.35***	0.099	No difference
Satisfaction	2.96±0.58	3.06±0.56	2.99±0.58	0.74	No difference
Innovation	2.66±0.51	2.33±0.46	2.47±0.48	0.005	A > B (same course)
Student cohesion	**2.34±0.69****	**1.57±0.48****	2.26±0.64	0.000	A > B (same course)
Task orientation	3.40±0.47	**3.45±0.32***	3.14±0.46	0.003	A > C (same teacher)
Involvement	2.85±0.44	2.63±0.40	2.57±0.44	0.003	A > C (same teacher)
Individualization	2.74±0.48	2.23±0.45	**2.01±0.51****	0.000	A > C (same teacher) A > B (same course
Overall	2.93±0.38	2.66±0.28	2.69±0.34	0.000	A > C (same teacher) A > B (same course)

We next asked what psychosocial dimensions were most impacted by the flipped pedagogy. The flipped course score was significantly higher than both the lecture-based courses in the Individualization subscale as shown in Table 3. In addition we observed higher scores between flipped and traditionally taught courses in all but two of the subcategories.

Compared to a course that had the same instructor, there were differences in:

- Involvement (*Students participated more in a flipped class.) (p = 0.003)*
- Task orientation (*Students are clearer about what activities they need to do in a flipped class*.) *(p = 0.003)*
- Individualization (*Students are treated differentially in a flipped class*.) (*p = 0.000)*

When we controlled for the course content (but had a different instructor), we found differences in:

- Innovation (*The flipped course was more innovative.) (p 0.005)*
- Student cohesion (*The students in the flipped course knew each other more*.) (*p = 0.000)*
- Individualization (*Students are treated differentially in a flipped class*.) (*p = 0.000)*

We did not see differences between the flipped and traditional course in terms of personalization and satisfaction. That is, *students in all the classes were interacting their instructors and were satisfied with the course.*

Discussion

We hypothesized that a flipped classroom would result in higher averages in Personalization and Student cohesion, indicating a more supportive classroom climate. We did observe high average values for all the classes in the Personalization subscale but there were not any significant differences within the groups.

This indicates that students feel supported in both the flipped and lecture-based courses but not more supported in a flipped classroom. Strayer[20] also found high values for personalization but no difference between a flipped and a lecture-based classroom.

A flipped classroom did result in a higher average for Student cohesion when controlled for the course content (2.34 vs. 1.57). This indicates that the more interactive class time in a flipped classroom provides more opportunity for students to interact with their peers and increases student cohesiveness. Note that, even though the flipped course was significantly higher than one of the lecture-based courses, all the scores were low (below 2.5). These students are at a large research-based University. Because of this, the students do not take all the same classes at the same time and therefore do not get to know all the students in their classes and are not accustomed to working together.

We also hypothesized that a flipped course would result in higher averages in Individualization and Task orientation and that this may indicate higher self-efficacy. We did observe that the flipped class resulted in higher averages for Individualization when compared to both lecture-based courses. A higher score here indicates that students are able to make their own decisions. We previously reported that students prefer the flipped classroom because they have more control over the way they learn.[4] These results both show that students in a flipped classroom may be more autonomous, leading to higher self-efficacy.

When we controlled for the same instructor we observed significantly higher averages in the Task orientation subscale. Note that Strayer[20] found the opposite - the flipped classroom resulted in a lower average for the Task orientation subscale. In the flipped course in this study, the due dates for all homework and the dates for all quizzes were established at the beginning of the semester. When the same instructor taught using the lecture-based approach, the pace was not as predictable. This may lead to confusion about what is expected in the course. It is the author's (and Instructor 1's) opinion that this increase in organization of the course is one of the main benefits of the flipped classroom.

Finally, we found that, given the same instructor, the averages are higher for the Involvement subscale (2.85 vs. 2.44). Involvement is an indicator of active learning as it measure how involved the students are in their own learning. This is confirmation that a flipped classroom will increase active learning. This was also confirmed by previous studies.[8]

Challenges to this study

We did not have the opportunity to control for both instructor and course content due to scheduling constraints. Although Group A and Group B took the same course, there are differences between the courses. Although the overall topics were similar, the instructors had different approaches to the same topics. In addition, only 53% of students from Course B participated in the survey while 89% of the students from Course A participated. While the two groups had the same percentage of Civil Engineering students, Group A had a higher GPA in the course and more female students. Instructor 1 had taught the course 5 times previously while Instructor 2 taught the course only 1 time previously. Both the lower GPA and the experience of the instructor could result in lower overall scores found in this study. Although it is interesting to note that the Satisfaction subscale in both classes are the same.

We controlled for the effect of the instructor by analyzing two different courses taught by the same instructor. Both courses are technical courses but one is a required course and one is an elective course. In addition the GPA in the elective course was lower than that in the required course. Instructor 1 was also more experienced teaching Course E. These difference in student grades and instructor experience could also explain some difference we observed here.

Conclusions:

The results show that overall the flipped class results in a higher overall classroom climate and that students are treated more individually in a flipped classroom. In addition we found higher averages for task orientation when controlled for instructor. That is, when one instructor flips a class, they may be able to provide more clear directions for assignments. This may lead to higher student agency and self-efficacy.

In addition, when controlled for instructor, the students participate more, are clearer about what activities they need to do and are treated differentially. When controlled for the course content, the flipped course is more innovative and students get to know each other more. This could lead to a more supportive classroom climate and increase student motivation.

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