

Some observations of students' performance and attitudes towards a flipped classroom for introductory statistics

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Abstract:

Flipped classroom is a variant of 'student-centered' approach by extending the learning beyond classroom environment. Such a model is becoming popular in the recent years owing to the fast development of advanced technology and high speed Internet. The purpose of this presentation is to share the experience of teaching an introductory statistics course using the flipped classroom approach. Students' attitudes and experiences towards this approach and their performance will be discussed. Moreover, the instructor's reflection of the experience will be shared. The data were collected from two semesters of implementing the flip class taught in an active learning class environment. In general, students' performances are improved, especially the DEW rates are reduced from 25% down to less than 5%. However, students' attitudes and their experiences about flip class approach are more negative than positive.

Key Words: Flip Class, Active Learning, Student Attitudes, Student-Centered

1. Introduction

Flipped classroom pedagogy is a buzzword in the recent years. This approach, however, has been implemented in various disciplines for over a decades. For example, the so-called "inverted class" proposed by Lage et al. (2000) in which students are asked to 'expose the new materials prior to the class, and focus on the process of analyzing and synthesizing the concepts and problem-solving using activities.' The theoretical framework for the flipped classroom can be traced back to the constructivism theory advocated by Piaget (1967) and Vygotsky (1978). Various innovative teaching pedagogies have been developed based on the constructivism learning theory. In general, these pedagogies can be considered as 'student-centered learning pedagogy'. Flipped classroom is a variant of 'student-centered' approach by extending the learning beyond classroom environment. Such a model is becoming popular in the recent years owing to the fast development of advanced technology and high speed Internet. One may refer to Strayer (2007) and Bishop and Verleger (2013) for reviews and the references therein.

"How do students learn statistics?" This question has been asked by statistics educators for years. Garfield (1995) pointed out students learn by 'constructing knowledge', 'active involvement in learning activities and practice doing', and they learn better by 'receiving consistent and helpful feedback and assessment of what they learn'. The GAISE Report (2005) and the updated 2016 GAISE College Report recommended the pedagogical approach for teaching statistics by 'integrating real data with a context and a purpose', 'fostering active learning', 'using technology to explore concepts and analyze data', and 'using assessments to improve and evaluate student learning'. The 2016 GAISE suggested two new emphases: (a) teaching statistics as an investigative process of problem solving and decision making' and (b) give students experience with multivariable thinking' that reflect modern practice and take advantage of widely available

technology. Flipped classroom approach appears naturally incorporating these components when it is properly executed. Statistics educators have also been using the flipped classroom approach as it is seen that several workshops given in this conference are related flipped classroom approach.

2. Design of the Flipped Class

The purpose of this presentation is to share the experience of teaching an introductory statistics course using the flipped classroom approach. Students' attitudes and experiences towards this approach will be summarized. Moreover, the instructor's reflection of the experience will be shared. The framework of the flipped class implemented is based on the work by Verleger (2013) as shown in Figure 1. A flipped class requires two components; one is human interaction by student-centered learning by implementing interactive classroom activities and adopting teaching pedagogy by utilizing proper computer technology.

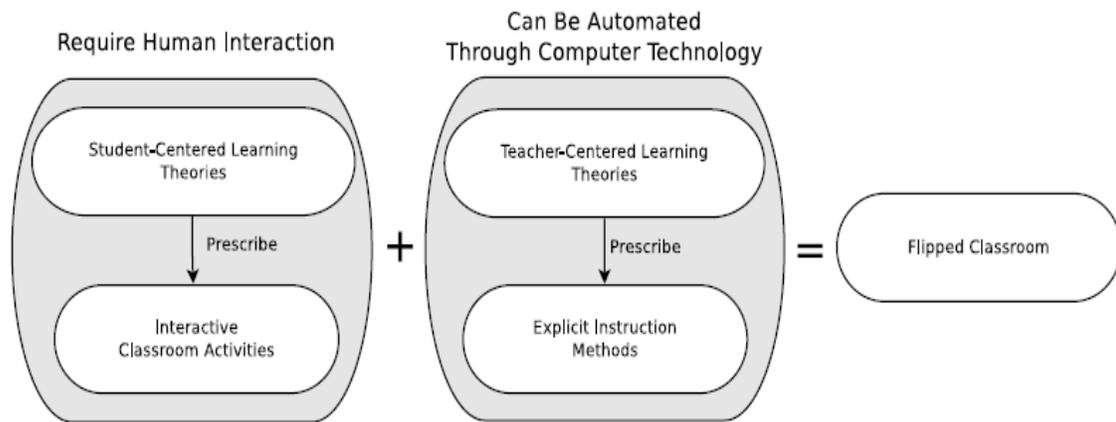


Figure 1: Flipped Classroom.

2.1 The infrastructure of the active learning classroom

The active learning classroom is a modern active learning classroom for group learning. It is equipped with eight group learning tables connected to a TV monitor for each table, which is connected to and controlled by the instructor's station. Each table can sit up to eight students; working in two teams. The instructor's station, located at the center of the classroom, is a state of the art projection system connecting to every table monitor screen and two sophisticated cameras that can be zoomed in to any table for students to show and talk about their work. The entire classroom is equipped with high speed WiFi. Needed software can be accessed through Citrix server in and out of the class. Figure 2 shows the layout of the classroom.

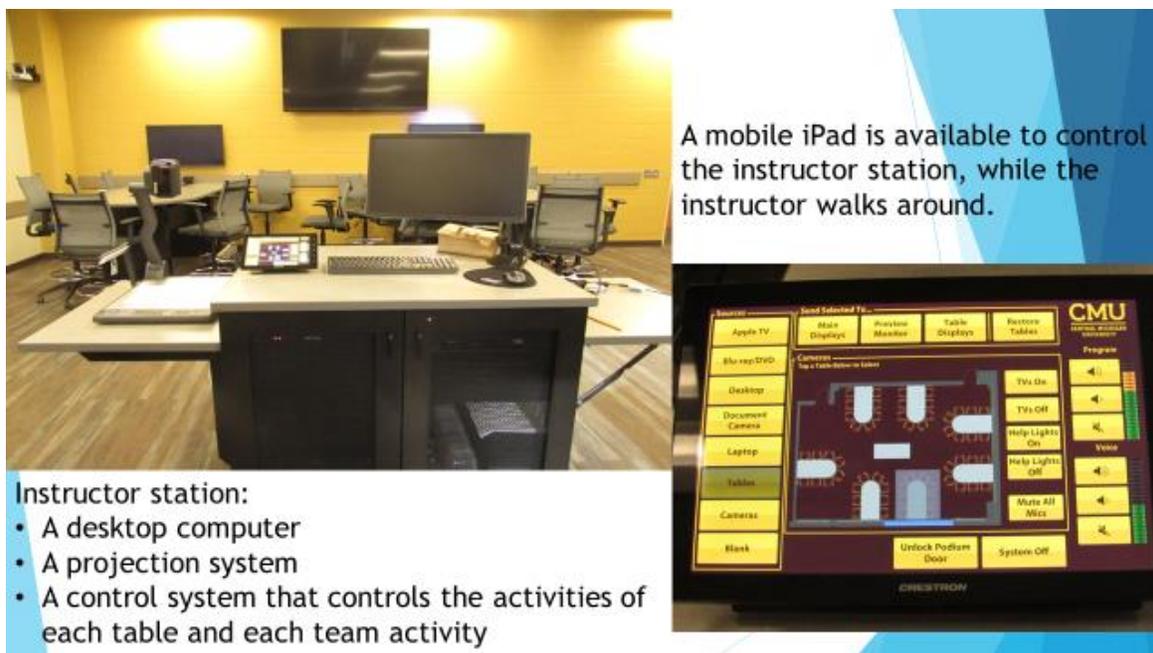


Figure 2: Infrastructure of the Active Learning Classroom

2.2: The design of the flipped class

This introductory statistics course is required. A flipped class approach to teach the introductory statistics course was implemented in fall 2014 and fall 2015. The class size was 35 in both classes. 37 out of 70 students were female. Students were from non-science colleges with majority from College of Business. Majority are sophomore and junior. The class was organized as follows.

Required tasks prior to the class: Students were required to study online instructional materials in the format of online e-book, power points and video clips, and completed an online quiz prior to each class period. Students were given unlimited attempts to work on a pre-class online quiz.

The in-class activities: During each class period of 75 minutes, the instructor spent about 25 minutes to review the topic and emphasized the important concepts with an activity or example. For the remaining 50 minutes, students were teamed up to work on hands-on activities that take students to collect, clean and analyzed, and synthesize and answer a sequence of problems. The instructor acted as a facilitator and walked around the classroom to answer questions from different teams. At a certain point, a group was called up to show and to discuss their solution for a question in the entire class.

Tasks after the class period: The in-class activities in each class period may or may not be completed. Student teams were required to complete their unfinished activities after the class period, and submit the report sheet at the beginning of the next class period.

The determination of grouping was another important task. The team grouping was determined after the first quiz at the end of the second week. Student groups were formed by making sure there were quantitatively strong and weak students in the each team. As a result, it was noticed that the team discussions and student engagements were much more active.

Assessment components: In addition to the pre-class quiz and the in-class hands-on activities, there were weekly in-class quizzes, three exams and a semester long team project. The in-class quiz had two components. First, individual students took their own quiz (70% of the score). Then, the same quiz was distributed to the group to work together as the group quiz (30% of the score). Two project reports were required. The mid-term report consists of describing the chosen project, data sources and summary statistics. The final project report was due at the end of semester. There was also a project presentation during the last week of the semester. The final grade was computed based on the following percentages. Online-quiz (10%), in-class quiz (10%), in-class activities (10%), project (10%), Test 1 (20%), Test 2 (20%) and Final (20%).

3. The evaluation of the flipped class approach

Various sources of data were collected to evaluate the effectiveness of the flipped class approach. The data collected from students included: (1) university student opinion survey and written comments, (2) a separate survey of 12 multiple choice questions with written comments that are designed to learn about students' opinions of out-of-class activities, classroom infrastructure, computational technology, in-class activities, group dynamics and assessment activities, (3) a survey of 45 multiple choice questions related to student attitudes towards statistics, learning styles and quantitative background, and (4) an assessment instrument of 15 questions given as part of final exam. This paper summarizes the survey results of the 12 items questions. Table 1 provides a summary of the survey results. Table 2 provides a summary of students' comments from some survey items.

Table 1: Summary of the 12 item survey regarding students' opinion and attitudes towards flipped class approach in an active learning environment

	Survey Question	St. Ag. ^a	Ag.	Neu.	Disag.	St. Disag.
1	By asking me to study and do some online homework prior to the class, it helps me prepare for the class activities	3 (4.48) ^b	22 (32.84)	16 (23.88)	17 (25.37)	9 (13.43)
2	By using individual Quiz & Group Quiz helps me learn the contents of this course	17 (25.37)	38 (56.72)	8 (11.94)	3 (4.48)	1 (1.49)
3	By using projects helps me learn the contents of this course	1 (1.49)	13 (19.40)	24 (35.82)	17 (25.37)	12 (17.91)
4	By using group hands-on activities helps me to learn the contents of this course	13 (19.70)	32 (48.48)	14 (21.21)	5 (7.58)	1 (3.03)
5	By using group hands-on activities helps me to learn how to work with others	18 (26.87)	30 (44.78)	13 (19.40)	4 (5.97)	2 (2.99)
6	Active learning classroom is a good environment to learn statistics	13 (19.40)	19 (28.36)	15 (22.39)	13 (19.40)	7 (10.45)
7	The problems on the hands-on activities worksheets are directly associated with the topic contents	10 (14.93)	34 (50.75)	16 (23.88)	5 (7.46)	2 (2.99)
8	The overall activities throughout the semester challenge me intellectually	9 (13.43)	37 (55.22)	13 (19.40)	5 (7.46)	3 (4.48)
9	My team members worked together well	25	27	9	4	2

		(37.31)	(40.30)	(13.43)	(5.97)	(2.99)
11	Comparing with traditional lecture/note taking method, this active learning strategy helps me to learn the contents better.	6 (8.96)	20 (29.85)	12 (17.91)	19 (28.36)	10 (14.93)
12	I will recommend others to take a flipped class taught in an active learning environment similar to this one.	7 (10.45)	16 (23.88)	19 (28.36)	12 (17.91)	13 (19.40)

		Require Students to BRING THEIR OWN LAPTOP to the class.	University provides computer station for every STUDENT.	University provide ONE computer for every TEAM.
10	How should the computer technology be prepared?	11 (18.64)	10 (16.95)	38 (64.41)

a: St. Ag.: Strongly Agree, Ag.: Agree, Neu.: Neutral, Disag.: Disagree, St. Disag.: Strongly Disagree.

b: in percentage.

Table 2: Summary of students’ comments of some survey items

1. By asking me to study and do some online homework prior to the class, it helps me prepare for the class activities:

- I rather do the assignment after the activities because I did not know how to do the homework.
- We were not aware how much extra time was expected when we registered for this class Most College students don’t have the extra time available.
- It was difficult to complete the homework without learning the subject beforehand.
- It'd help to do the activities before the homework.
- There are a lot of things in stats that I don’t understand by assigning homework without clarity, sets me up for failure.
- How're we supposed to do homework on material we're not qualified to teach. Also, I am taking classes to be taught information not teach myself.
- I just wanted to get it over. I didn't feel prepared.
- I learn better by being taught first then having to do my homework.
- Sometimes it is difficult and just frustrating to be graded on home works I had to do before I was even taught the material.

2. By using individual Quiz & Group Quiz helps me learn the contents of this course:

- Individual Quizzes help me see where I'm at, group quizzes help me realize my mistakes & how to fix them.
- The group quiz didn't really help me much.
- Group quiz gives me knowledge I may not have known.
- Group quizzes are unfair and we all just rush through them anyway.
- Sometimes I make a silly mistake on y quiz and the group quizzes allows me to fix it
- Having both is very beneficial.
- Group quizzes can be helpful as long as a discussion takes place.

3. By using projects helps me learn the contents of this course:

- The group project was so random and did not really fit with what we were doing.

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- The project is completely useless.
 - The projects helped. But there was too many of them. Maybe a few less projects would help.
 - The project was consuming and in no way helped us to learn the material.
 - You barely even spoke about the group project, how can it be that important to the class?
 - It helped me learn how to use Statcrunch a little more. But not much else.
 - The project didn't really teach me anything, it was just another assignment I had to get done.
 - It allowed me to apply it to the real world.
 - Only had one project and I don't feel it is an important one.
 - The project seemed too confusing. Better teach learning might help.
 - The project was very vague and I didn't get much valuable use out of it.
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4. By using group approach for hands-on activities helps me to learn the contents of this course:

- This class is very stressful & does not prepare students for Business Statistics.
 - keep us busy is better than a full lecture.
 - I learned somethings from my group members, but I don't always feel like helping and explaining things to another student.
 - Students teaching students is a poor substitute for professor instruction.
 - I am a vary passive team member.
 - Yes because I have others to help me learn the things I have trouble understanding.
 - Yes as long as everyone participates and discusses about people can be an issue with tests.
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11. When comparing with more traditional lecture/note taking method, this active learning strategy help me to learn the contents better.

- Does not teach anything, waste of time. Why am I Paying for a class to teach myself? RIP OFF.
 - I would much rather take notes at a lecture.
 - I found myself a lot more confused more often.
 - I just like learning in class, not on my own.
 - I am big note taker. I do better with notes I practice problems.
 - I personally like traditional lecture better although I do like group activities.
 - I learn better traditionally because that's what I've been done my whole life.
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4. Reflections from teaching an active learning flipped class

Flipped class has becoming more popular during recent years owing to the development of advanced and mobile technology. A quick google search of 'flip class' results in about 60 million hits. A review of flipped learning can be found in Hamdan et al. (2013) and Yarbrow et al. (2014). The summary of the students' attitudes and opinions survey gives some insights about implementing the flipped class to teach introductory statistics course.

4.1: Some observations from using a flip classroom to teach an introductory statistics course

Based on the above survey and comments, it shows that majority of students did not against active learning using team approach (Items 4,5,6,7, and 8). The percent of 'Disagree' and "Strongly disagree" is about 10% to 25%. However, when asking about "study the new material prior to the classes" and "asking them to do a team project" (Items 1,3 and 6), this percentage is about 40% to 50%. When asking "The flip/active learning class is helps to

learn the concepts better” (Q11), over 40% chose “Disagree” and “Strongly disagree”. When asking “recommend the flipped class to other students” (Q12), there are about equal percentage of students in the “Agree + Strong agree” group and “Disagree + Strongly disagree” group, which is about 35%.

Students’ written comments, however, showed a quite different story. Most comments were quite negative. Students who felt positive did not provide much comments. These comments can be summarized into the following major categories:

- Students felt the course took too much of their time.
- Students felt it was not fair that they had to study themselves prior to class.
- Students did not think they were capable of learning statistics prior to the class lecture.
- Students were costumed to lecture/note taking learning style.
- Students felt doing team project did not help them. They thought it was just another assignment.

4.2: Are there any positive outcomes from the flip/active learning approach?

Although students’ opinions and attitudes were quite negative about flip/active learning, there were some positive observations and outcomes.

- When comparing the student performance between flip/active learning class and the non-flip/active learning class that I have taught, it is clear that student’s performance in the flip/active learning classes was indeed better than the non-flip/active learning classes in terms of the rate of D, E and W grades. The percentage of (D,E,W) grades were decreased dramatically from 25% down to less than 5%. Part of the reasons was due to the same score of the team work for every member in the same team. These team scores brought up the final grades of students who might have received D, E, or W grades in a class without team work components. Thus, further assessment will be needed in order to investigate how the team work scores play the role of reducing the (D,E,W) rates and to investigate the effectiveness of the flip/active learning approach.
- When observing the classroom atmosphere and students’ engagements during class periods, it was clear that students were much more engaging in working on the in-class hands-on activities, and contributing to the team work.
- Through facilitating the active learning in-class activities, I was able to quickly get to know each student and identify students who had strong quantitative skills, and who needed more assistance.
- There were much more student interactions in and out of the class, since they had to work together as a team in and out of the class.

4.3: Lesson Learned from using the flip class in an active learning environment

The outcomes seem to suggest it is worthy of using flip/active class approach, even though I have clearly suffered from much lower university student opinion survey result in both semesters. However, various improvements will need to be implemented.

- To get students to buy in. Generally speaking, the most difficult problem that I face is that most students have never experienced learning new topics themselves, especially quantitative subjects. They are costumed to learning quantitative subjects by “following steps”. Several tasks that may be implemented to get student buy in include (a) constantly informing students the difference between a flipped class and a typical class prior to and during the early stage of the semester, (b) stressing that employers want team players, self-learners, and good quantitative problem solvers, and (c) inviting statistical practitioners to make presentations of using statistics in their everyday life and/or their work, as well as on the importance of team work and self-learning.
- To provide better guidelines to students on how to study the new topic prior to the class. Most students complained that it took too much to study and felt that they were not capable to studying the new contents themselves. A better guided learning is important in order to guide students to “walk” through a learning path to reduce their anxiety and feeling of losing direction. One strategy that I plan to implement is to carefully tie the pre-class learning activities with the in-class activities and the learning

objectives with the hope that this will increase student's motivation and reduce the overwhelming feeling of learning new contents themselves. Another task that I plan to take is to provide a summary sheet of important concepts of each topic and chapter at least a week ahead in order to give students more directed guidance when they are asked to study the new topic.

- To improve group dynamics. As described in Section 2.2, the team groups were formed by making sure the team members are mixed with quantitatively strong and weak students. This group setting worked well and team work performances were more balanced among teams. However, there is a clear tendency that most work was done by the quantitatively strong students. The quantitatively weak students did not participate much, but received the same score. Some complaints were noticed. I plan to implement a strategy to distinguish between high and low degrees of participation with different scores.
- To make an attempt to know students better. This seems to be simple and easy task. However, there is a tendency that I can quickly learn about quantitatively strong and weak students, but ignore the remaining. I plan to give more opportunity for students to share their personal interests and discuss the in-class activities, I plan to provide more opportunity for each team member to talk about their work.
- To provide more guidance regarding projects. Team project was a difficult task for most teams due to the difficulty of finding time to work together and difficult to determine the project. I provided several large data sets and several project examples that students may choose to do. I asked each team to make an appointment to discuss their interest and choice of projects. However, students tended to ignore it until the last minutes, and started asking questions regarding projects in class. I plan to spend more time in class to explain how to conduct a quantitative project during some class periods, instead of asking each team to make an appointment to come to see me in office.

4.4: Some uncontrollable infrastructure problems when implementing a flip/active learning approach

Although I am not worried much about the end semester's student opinion survey (SOS), the fact that one full-point decrease of SOS (from 3.5 out of 4.0 to 2.5 out of 4.0) is a concern, but not a surprise. After all, four out of seven questions in our university's student opinion survey questions are about if the instructor's in-class teaching: "was well prepared", "presented material well", "organized the course well", and "Teaching in class help learning". Students' immediate responses to these questions were easily a 'No'. If flip/active learning class is an effective approach to engage students in class, to create opportunity for students spending more time on the course work, and to experience team work, and the same time,. It decreases the (D,E,W) rate, then, it indicates that this should be a successful pedagogy and the instructors should have been rated better than the traditional lecture/note classes. Instead, it was a quite opposite. Such a negative SOS is out of the instructor's control. However, it is essential that the university should consider changing the questions for students to evaluate the effectiveness of the instructor who adopts a flip/active learning approach.

The active learning classroom setting is another uncontrollable factor by the instructor. Whatever the classroom was originally designed, it is all the instructor has to implement the flip/active learning approach. If the classroom setting does not provide the active learning environment, implementing a flip/active learning may create unexpected hurdles for students and instructors.

Statistics courses always involves with collecting and analyzing data. It should be a hands-on course. Thus, intuitively, active learning should be a natural approach to teach statistics courses. However, it usually takes more time to cover the same materials using active learning approach when comparing with traditional lecture/note taking methodology. As a consequence, it is not possible to cover the same number of topics, unless a flip class is also implemented. On the other hand, most college students are not ready to study the new contents without instructions for quantitative subjects. As educational technology becomes more sophisticated, the flip/active learning approach will become more effective and will be accepted by more instructors and students.

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