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Flipping the Classroom in a Large Chemistry Class-Research University Environment

Cherie L. Yestrebsky*

*Chemistry Department, University of Central Florida, 4104 Libra Dr. Orlando Florida, 32816, USA

Abstract

A study was done to ascertain the effectiveness of ‘flipping the classroom’ for very large, freshman chemistry classes at a large research university. The term ‘flipping the classroom’ refers to having recorded lectures available to students on-line and using class time for the instructor to work out extra examples and facilitate more interaction in problem solving. The study involved two very large classes (415 and 320 students) of second semester general chemistry. One class served as the control class and was taught in the traditional lecture format normally utilized within the department while the other class accessed all lectures on-line with class time devoted to instructor led problem solving and examples. Results show that the percentage of high final grades (‘A’ and ‘B’) increased in the test group compared to the control group but average performing students (final grade of ‘C’) decreased in the test group with little to no effect on the lower performing students. This indicates that the average performing students were aided by this teaching method compared to the traditional teaching format. A survey was administered to both classes at the end of the semester to determine their perception of instruction. A high percentage of students in the test class found the on-line instruction valuable and watched at least some recorded lectures more than once. The control class did not express a high evaluation of the on-line instruction even though they had the same slide modules available to them but without the audio lecture.

1. Introduction

The concept of ‘flipping the classroom’ has received considerable interest in recent years (Bergmann, 2012; Barrett, 2012a; Flipping Classroom, 2011; Shapiro, 2013). The term ‘flipping’ refers to the idea of having students
reverse the normal class routine of students sitting in class listening to a lecture and leaving to do homework on their own. In a flipped classroom, students listen to the lecture or other instruction on their own, often via some form of access to the internet, and class-time is used for discussion, independent work with teacher guidance, group work, peer instruction, teacher led examples, etc. Most published literature focuses on use of this method in K-12 education while much less has been published on college-level studies (Barrett, 2012b) of this mode of teaching even though they seem a logical testing ground for the concept. Fundamentals of Chemistry II are the second-semester course of a two-semester sequence of the pre-requisite chemistry courses for most science, health, and many engineering majors. The majority of the students who take this course do so in their first or second year at the University, so many students are 18-19 years of age. Most students enroll in this course in the semester immediately following Fundamentals of Chemistry I, which introduces students to many of the theories of chemistry but is not as mathematics-dependent as the second semester course. This requirement for mathematics readiness seems to be an obstacle for many students and increases the need for considerable help with problem-solving in the second-semester course. The course enrollment is very high and it is not uncommon to have 450 students enrolled in a single class at the beginning of the semester. The class is taught in a large, stadium seating auditorium with the use of computer and overhead projection onto at least one very large screen (sometimes two or more screens depending on the auditorium used), and with the instructor using a remote microphone for communication. This does allow for some instructor movement about the classroom but often the microphone range is limited. Since this is a first-year course for many students in science, health, and engineering majors, there are many students who are highly motivated and many students who begin to question their choice of major. The first course in the sequence requires a great time commitment both in and outside of class for students to achieve high grades but the second semester course takes this to an even higher level. Good grades in the course are definitely achievable and the University provides many tutoring and outside-the-classroom services to help students succeed. Nevertheless, many students come to realize that succeeding in one of these majors may not be what they really want or that the time investment is too high for their real academic or career goals. This can be seen in the grade distributions shown later in this chapter.

1.1 Aim

The focus of this study was to evaluate if flipping the classroom can be effectively used in a large lecture class. This was evaluated using two classes of similar enrolment, taught by the same instructor, with only one variable changed, and comparing the following:
- Distribution of final grades
- Responses from end-of-semester surveys

2. Method

The classes involved in this experiment were both large, second semester general chemistry classes. The population in Class 1 and Class 2 were 320 and 415, respectively. Students populated the classes without knowledge of the experiment and enrolled as they normally would for any class at UCF. The two classes were comprised of mostly first and second year college students, overwhelmingly science and engineering majors. The materials used for class were identical with the exception of the voice-recording over slides for the flipped class. The slides and time periods spent on each chapter were the same. The problems worked out during class time for Class 2 were scanned and made available to the students in Class 1. The quizzes and exams were of equal difficulty, covering the same topics from the chapters with the same number of calculation and conceptual problems. During the semester before the experiment, I familiarized myself with the recording equipment I had access to at the University. I didn’t feel comfortable with the idea of standing in front of a camera for a video recording so I used PowerPoint and recorded over my slides. One could argue both for and against the video recording in this case but the flexibility provided with the voice recording was an important aspect for my hectic schedule. I purchased a plug-in headset with microphone (less than $50) to allow me to do the recordings whenever I had extra moments to fit them in. I had never recorded over slides with PowerPoint but found the process to be very easy to set-up on my laptop and soon
learned how to adjust my voice volume and tone to be a bit easier on the ear. One piece of advice that is important before getting started is to really think about how long a recorded presentation should be. I was given the task of sitting through two TED talks (www.TED.com) of differing lengths. One was approximately 14 minutes and the other was almost 22 minutes. I was interested in both topics and both speakers were very good. I was fine getting through the 14 minute presentation but was definitely fidgety during the last five minutes of the longer one. If I was losing my concentration during a TED talk, how could I expect students listening to a general chemistry presentation to focus for more than 14 minutes? In a lecture hall students are in an environment where they are expected to sit for long periods of time and hopefully there are few distractions. When they are listening to my lectures at home (or in a restaurant, café, friend’s house, airport, etc.) there will likely be other things that can distract them. Therefore, I had to look for logical breaks in my normally 50 minute lectures to yield four lectures of 12-15 minutes. After recording the lectures, I saved them as swf files (which condensed video and audio into one file) and uploaded them to the University site for the class. Only Class 2 could access the recorded lectures. The slides without voice recording were made available to both classes. Each chapter was covered in seven to twelve recorded lectures. It was expected that students would view/listen to these lectures before the assigned dates. During class-time, either I or the class worked out problems from the chapter that corresponded to the material covered in the appropriate lectures.

3. Results

3.1 Limitations: Challenges, Benefits, and Helpful Hints

The biggest challenge for me was to convey the same information using slides and voice that I was providing in-person to Class 1, but without the physical motion such as arm-waving, jumping, running, swaying and any other antics I usually use in class to get my point across. It must all be done using words, the correct words, to clearly communicate the material. I quickly learned to ‘hear my own words’ from a different perspective, and realized this mode of teaching put my students in a position of vulnerability. Where students would otherwise be able to depend on what was said and visual cues (my exaggerated movements) in a normal lecture, these students would be dependent on me to explain the topics clearly and every word counted. When your words are recorded mistakes such as using incorrect terminology, forgetting a word, or skipping a phrase, can easily be used by students as an excuse for not learning the material. Many, many slides were recorded multiple times before I was satisfied with the clarity of the message. Some links were incorporated for students to view videos of demonstrations from the internet and were made available to both classes. The recording process was definitely more difficult than I had anticipated but it was also a very useful exercise in self-awareness of my communication style. Increased planning time for the flipped lecture is absolutely necessary. It also takes some time to learn to control your voice for recording. Many people do not like the sound of their own voice when listening to a recorded version. If your voice is too soothing or monotone, you will certainly lull your students to sleep! However, if you are too animated in your tone, you will lose the effectiveness of changing your tone to make a point. As for the mechanical/computer/software usage, the software used was very intuitive so learning to use the headset/microphone or saving the file as swf were not really a challenge. Students had very few problems with the system, even at the beginning of the course. Early in the semester, students in both classes each thought the other class was getting the best deal. Despite assuring Class 1 that they were getting the same general chemistry class that my students had always had, some students were sure that they were slighted in some way. The students in Class 2 were apprehensive at first but eventually realized they were getting the same lectures on-line. These were expected responses from both classes. This obviously would not be an issue unless a professor chose to utilize both modes of teaching in the same semester. I strongly recommend weekly quizzes when using the flipped mode for a chemistry course. Any assessment that encourages students to stay up to date with the lectures is beneficial. For this particular course, if a student gets behind by even one week it will likely alter the level of his/her success. I started keeping a detailed calendar on-line showing when they should have each lecture finished (for Class 2) and which lectures (or Chapter sections for Class 1) would be covered on the weekly quiz. Many students commented on how much they appreciated the calendar. For similar reasons as those in the previous paragraph, problem solving in class was focused on material covered in the most recently assigned lectures. This encouraged students to keep up with the lectures since they wouldn’t understand the material we
worked in class without viewing those lectures. This allowed more time to have students work problems and do peer instruction of the problems as well. While this provides for a chaotic environment in a large class, my observations were that students asked questions and engaged in discussion more after peer instruction than when I worked out the problem. A benefit from both my perspective and that of the students is the flexibility that recorded lectures allow. As a very active research professor in Chemistry, I usually have a few days of travel every semester to present at other universities or research conferences, or for field-testing of new research methods developed by my team. When I’ve traveled in past semesters, I would ask one of my more experienced doctoral students, a postdoctoral associate, or another faculty member to present my lectures. I am more confident in someone taking a problem-solving session for me than I am with someone else giving my lectures so this reduced my stress. Students can listen to lectures any time night or day and, as long as they have a computer and internet connection, they can listen almost anywhere.

![Figure 1. Comparison of final grades for both classes without points for attendance included.](image1)

![Figure 2. Comparison of final grades for both classes with points for attendance.](image2)

Another measure of student learning was analyzed using standardized testing. An American Chemical Society standardized final exam was used for both courses and the results showed no significant difference between the classes. Two surveys on student perception were administered at the end of the semester. One survey was the standard Student Perception of Instruction survey (SPOI: 387 responding) offered to all UCF students enrolled in a class. The other survey (done in-class) was developed specifically for this research with 403 students responding.

- Results from the SPOI on-line survey:
  - Overall evaluation of the course: Class 1: 72% very good or excellent; Class 2: 66% very good or excellent
  - Open-ended question: What did you like most about the course?
  - Most frequent response: Class 1: 78% professor characteristics; Class 2: 54% on-line component

- Results from in-class course survey:
  - Question: What did you like most about the course? Class 1: most frequent response (43%) was ‘the professor; Class 2: most frequent response (50%) was ‘on-line lectures’ with the answer ‘the professor’ getting only 8%.
  - Open-ended questions from Class 2:
    - 69% watched at least some videos more than once
    - 74% of students watched at least most of the videos in the week the material was covered
4. Discussion and Conclusion

Figure 1 shows the distribution of final grades without attendance credit for both classes involved in this experiment. Excluding the points for attendance depicts data that solely represents student performance based on the different teaching modes tested. The percentages of D and F grades in both classes increase to approximately 23 and 21 respectively and the number of C grades is nearly unaffected. The percent of students in Class 2 making a final grade of A or B is also increased in comparison to Class 1 indicating that students who would otherwise have a B or C at the end of the semester may have improved their grade to a B or A. This supports the notion that more highly motivated students earn higher scores on quizzes and exams using the flipped mode of instruction and there seems to be little to no effect on students earning lower grades. When the maximum of three percent for attendance is added to the analysis, a slightly different view of the results begins to emerge (Figure 2). The three additional percent that students can earn for attending class can be construed an indicator of motivation for doing well in the class. With the exception of the percentage of students earning a C grade, the distribution appears to have moved towards higher grades with a decrease in D and F grades and an increase in A and B grades. The fact that the differences between the two sets of data are mostly greater than three percent suggests that many of the students whose grade improved with the attendance credit were close to a higher grade without the added point(s). The largest difference between the two graphs is shown in the students scoring a B or a D in Class 1. With the maximum of three percent attendance points included, there was a 5.8 percent increase in the percent of students earning a B and a 5.6 percent drop in the number of students earning a D. These data indicate that these students were closer to the next higher grade (C to a B, D to a C) than the lower grade (C to a D, D to an F). Another point to note from the effect of the added points is that the change in grades from both classes was fairly consistent across all of the grades A through F. This could be taken as evidence that students experiencing varying levels of success were still coming to class, whether they were coming for lectures or problem solving sessions, and that being in class was viewed as being a valuable tool for the course. Some aspects of the student surveys seem predictable but other responses were somewhat surprising. I expected the overall evaluation of the course from the SPOI survey to be more similar than the 72% (Class 1) and 66% (Class 2) very good or excellent. Upon further consideration, it does seem a logical result since more of Class 2 time in class is spent in problem solving, a task that isn’t very exciting. Class 1 experienced a professor giving energetic lectures so in effect they got to know me better and maybe the class was not so boring. Class 2 had the opportunity to use the on-line lectures, enjoy the flexibility of them, as well as listen to the lecture more than once for difficult concepts. This is supported by the response data to the open-ended question on both the SPOI and the in-class survey on what they liked most about the class which showed only 8% of Class 2 listing ‘the professor’. Responses to the in-class survey by Class 2 were encouraging in that most of the students were making good use of the recorded lectures. One great benefit of having recorded lectures is that the student can listen to them over and over if they wish. For some, listening, then reading and trying to work problems, then listening again could be an effective means of studying. Over 2/3 of those surveyed watched some of the videos more than once. They seem to appreciate having that option. Almost 3/4 of those surveyed in Class 2 were listening to the recorded lectures during the appropriate time period for the material covered in class. This was one of the aspects of this teaching method that concerned me since it requires more self-discipline on the part of the student than showing up for your class. No one was checking to see when they watched the videos but they recognized the importance of staying up to date with the material.

5. Suggestions

Very clear teaching goals should be determined before embarking on any change in teaching mode and this is no exception. Very large classes require careful organization to avoid the classroom falling into chaos and confusion so preparation for the transition is imperative. This was a worthwhile effort and students benefitted from this first effort but it did require considerable time to implement in an organized manner. Students in the early stages of their college experience often suffer from a lack of self-discipline so some effort to force them to keep up with the recorded lectures is useful. This can be done quite simply using weekly quizzes and a detailed on-line calendar. The recorded lectures should be kept short, 15 minutes or less. Students have many distractions vying for their time and attention so short bursts of information will more likely be viewed than the normal 50 minute lecture they
experience in the classroom. Incorporating interesting video demonstrations added to the interest of the recordings.

Get a good headset/microphone. Most computer microphones are not adequate and it would be very frustrating to listen to a poorly recorded lecture, even for 15 minutes. Make efforts to keep the in-class portion of the class interesting. For a subject like chemistry, simple instructor led problem-solving for long periods of time can be tedious. I find peer-instruction to be beneficial where students work out problems individually and then the students who had the correct answer teach the others how to do the problem. It is chaotic in the large classroom for a few minutes but it encouraged discussion afterward.

References

https://chronicle.com/article/Physicists-Who-Flip-Their/134100/