Flipping the Classroom: A Case Study

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Abstract

Flipped classroom instruction is growing in popularity in higher education. There is evidence that this approach can have a strong positive effect on student learning and student engagement.

Morningside College has been experimenting with two flipped classes for four years. Quantitative and qualitative data collected over these four years show a significant positive effect on student learning.

The quantitative data are drawn from IDEA Form evaluations of the two classes. The qualitative data comes from student focus groups.

This paper presents the data from the four-year experience and conclusions from the data regarding benefits. It also provides "lessons learned" during the past four years in the hope that it may help others.

As a result of this experience at Morningside, the computer science program has begun a multi-year project to move to flipped instruction to all of its classes.

1 Introduction

Flipped classrooms may be seen as an offshoot of the active learning movement. The key assertion of active learning proponents is that students will learn better when engaged in learning activities in class than they will while spending class time passively listening to a lecture. There is a large and growing body of research supporting this hypothesis (see, for example, the meta-study by Freeman, et al. [1])

Flipped classrooms are one of many vehicles for providing active learning. The distinctive feature of the flipped classroom approach is its focus on how students prepare for class. Although the nature of this preparation varies among different flipped classroom practitioners, it is common to hear the approached defined as a lecture before class (often via video created by the teacher) and homework (or homework-like) activities in class (hence the 'flipping' of what happens in and out of the classroom). This allows the teacher to spend class time helping students one-on-one or in small groups on an "as needed" basis. We should note that many flipped classroom practitioners also require some homework outside of class in addition to class activities.

Although the flipped classroom approach is newer than the active classroom one, a great deal of research into its efficacy has already been done and more is ongoing. Giannakos et al. [2] conducted meta-study on the applications of flipped classrooms to computer science, finding a variety of benefits. These benefits included: increased learning performance; more positive attitudes toward learning, increased student engagement, and development of better learning habits.

Four years ago, we, in the Morningside College computer science program, began experimenting with the flipped classroom approach. Initial efforts focused on two classes: a 100-level class that enrolls more non-computer science majors than it does computer science majors, and a 400-level class for majors focused on formal languages and automata. (The 100-level class is focused on HTML, CSS, and JavaScript.) Professors in the department have been learning as we go, both from the experiences of others and from our own. The results have convinced us to move to the flipped classroom approach in all of our computer science classes. This effort is underway and should be completed in about three years.

The Morningside College computer science program's experience with the flipped approach provides a case study that may help other computer science programs interested in experimenting with the flipped classroom approach.

2 Implementation

As noted in the introduction, our initial efforts with flipped classrooms were focused on two courses.

We created screencasts for both classes. Students had screencasts to watch prior to most class periods. In addition to the videos, students received additional resource materials to supplement what the videos provided. These were the primary common features shared by the two classes. There were also significant differences.

2.1 Implementation particular to the 100-level class

The purpose of the 100-level class is to help students learn how to create web pages using HTML, CSS, and JavaScript. Application is paramount in this class. Two sections of this class are offered every year.

There is no textbook for this class. The videos and other materials we provide are all the materials that the students use.

The general flow of the class follows this pattern:

1. Students prepare for class by watching the videos and reviewing other materials provided for preparation for a specific class period.
2. At the beginning of class there may be a brief question and answer period, or some brief additional information provided by the professor. However, students spend the majority of the class time working on an assignment that requires them to build a web page using techniques or other items provided by the preparatory material. It is not uncommon for students to come to class and immediately begin work on the assignment for the day.
3. The assignment for a day is usually due by the end of the following class period. In some cases, students pass off assignments in class. In others, they submit them electronically for grading.
4. The last week or so of the class is dedicated to working on a final project that integrates the various elements of HTML, CSS, and JavaScript that they have learned to use over the course of the semester.

2.2 Implementation particular to the 400-level class

This class is a fairly standard formal languages and automata class. Although application of what students are learning is required, this class is far more conceptual than the 100-level class. The flipped version of this course was taught one year after the lecture version had been taught. The next time it was offered was two years after the the first time it was flipped. It is now offered every other year.

Although there was improvement in student progress on course objectives the first time the course was flipped, the degree of improvement was not as much as we had desired. This motivated additional changes the next (and most recent) time the course was offered. This resulted in a significant difference in the course the two times it was offered after being flipped.

The first time this class was flipped, students had a textbook in addition to the videos (and other materials) provided by the professor. Students were expected to read parts of the book and watch videos provided by the professor.

The next (and most recent) time that this course was offered, there was no textbook. Students used only materials provided by the professor.

The general flow of the class was similar both times that we used a flipped approach.

The general flow of the class follows this pattern:

1. Students prepare for class by watching the videos and reviewing other materials provided for preparation for a specific class period.
2. At the beginning of class there is a question and answer session. It's not uncommon for this to consume the first 25% - 35% of the class time.
3. The question and answer time is followed by a significant quiz.
4. Following the quiz, we debrief on the quiz, answering any additional questions prompted by the quiz.
5. Once every week or so there is a homework assignment that addresses topics covered by the quizzes.

3 Results

During the past four years we have gathered both quantitative and qualitative data. The primary source of quantitative data is the IDEA course evaluation results. Among other things, it provides a measure of progress on outcomes relevant to the course. The IDEA results for "progress on relevant objectives" were more positive for the flipped versions of the courses than they were for the traditional versions of the course. Direct assessment of student work also tracked IDEA form results reasonably well.

In addition to IDEA data, we've also held focus group discussions with students. These discussion have yielded helpful feedback.

3.1 Quantitative Results

The "progress on relevant objectives" measure of the IDEA form is a t-score comparing results from a given course to results in the IDEA database of courses. For the purposes of this paper, it is the change in scores after flipping a class that is important.

3.1.1 Results for the 100-level class

Figure 1 shows the t-scores for the "progress on relevant objectives" measure. The first year that we flipped the 100-level course was the 2013-2014 academic year.

Note that the year we flipped the course "progress on relevant objectives" moved up by about one standard deviation and was in the same neighborhood the following year. In the

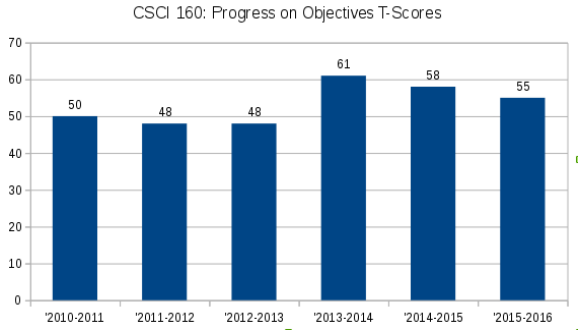

Figure 1: Results for the 100-level class

most recent year, one of the professors was on sabbatical. The professor teaching the 100-level class had a teaching load exceeding 16 credit hours during the semester that he was teaching the 100-level class. This may explain the slight drop in the most recent year.

3.1.2 Results for the 400-level class

Figure 2 shows the t-scores for the "progress on relevant objectives" measure for the 400-level class. The first year that we flipped the 400-level course was the 2013-2014 academic year. The course was only taught once more after we began flipping it.

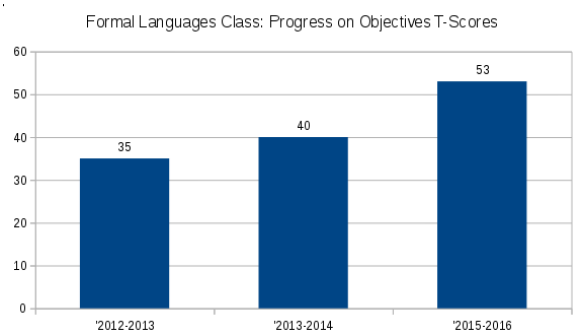

Figure 2: Results for the 400-level class

The year we flipped this course the "progress on relevant objectives" moved up by about one half standard deviation. As noted previously, we were unsatisfied with the amount of improvement. The next time we taught the course we replaced textbook readings with additional materials provided by the professor. We also provided low-stakes exercises as additional preparation for the quizzes. These two changes are likely the most significant cause of the large increase in the last year the course was taught.

One other result, more quantitative than qualitative, is that in flipping the 100-level class we found that we were able to add content to it. The class now has about twice the content that it had four years ago.

3.2 Qualitative Results

In addition to using IDEA "progress on relevant objectives" t-scores, we had focused conversations with students about the flipped classes. The enrollment of the 400-level course was relatively small each time so the focus group for that class was the entire class. Enrollment in the 100-level course is larger, so conversations with students from those classes were with subgroups of the class.

As we listened to students, several interesting themes emerged.

1. **The flipped classroom approach provides a very natural way to provide at least some degree of differentiated instruction.**

   Students used the materials we provided very differently, based on their needs. Some would go through videos and companion materials multiple times until they understood what was going on. Others could look at the printed material and get what they needed from that. The remaining students were spread across the continuum between these two poles.

   Note that a standard lecture format would have left the the first group (those who went through videos multiple times) lost, would have left the second group bored, and would have had varied effectiveness for the rest.

2. **Video is a more natural way to teach process than the printed page.**

   Many students commented on how watching a process unfold in real time made it much easier to understand than tracing through a static example in a book. We should note that the videos were often more detailed than book examples.

3. **The ability to pause and rewind is a very helpful feature that live lecturers lack.**

   There were quite a few students who commented on how useful it was to pause and go back when they realized they had missed something important. They pointedly noted that they couldn't do that with a lecturing professor.

4. **Getting help in class decreases the frequency of midnight desperation.**

   The ability to get help in class was a plus for many. Some contrasted it with what happens when trying to do an assignment at midnight, hitting a conceptual brick wall, and knowing that they're not going to be able to get the help they need before turning something in.

5. **Students tend to be more engaged**

   Students expressed a greater willingness to prepare for class when they could see that their preparation would help them efficiently complete activities in class. When the activities were posted prior to class, some students would begin (and in some cases complete) activities prior to class.

4 Lessons Learned

In addition to the things we learned from the quantitative and qualitative data we gathered, there were things we learned from experience. We pass these on in the hope that they may also be useful to others.

1. Flipping a class can a require a *lot* of time - especially when creating a lot of new materials. Creating a lot of new video can take a lot of time, but so can creating other supporting resources.
2. Once new materials have been created, the time it takes to teach the class will likely be about what it was before. The difference is in what the teacher does with that time. Instead of spending class time delivering a lecture, the teacher spends it interacting with students individually and in small groups, helping them with questions when they are ready to hear the answers.
3. Incremental flipping is possible. Creating materials and video for some class sessions but not all is a good way to get started. It may happen that some topics are easier to help students understand without flipping that class period.
4. Don't tie preparation materials, especially videos, to a particular edition of a particular textbook. In fact, don't tie it to the textbook at all. Publishers regularly break professorial hearts when they make significant changes in a new edition of a beloved book. This effect is multiplied many times when it involves redoing a whole raft of videos containing references to the book that no longer apply.
5. With regard to creating videos:
   (a) Each video should be short and tightly focused. Try to never go longer than 10 minutes for a given video. Aim for 5 minutes and under if possible. Five 10-minute videos are much more helpful for students than one 50-minute video.
   (b) It is common, especially when first starting out, to accidentally provide 20-30 seconds or more of talking with little or nothing happening visually on the screen. If there is audio, there needs to be visual movement as well. Visual change without audio can be OK at times. Audio without visual change is a video that should be a podcast.
   (c) With regard to production values, don't let perfect be the enemy of good. The first year we started flipping classes we spent way too much time editing video. The first set of videos will probably be replaced by a second set within a few years (based on experience with the first set). For a first set of videos in particular, good is good enough - in fact our students are impressed by more by the fact that it's our voice on the video than they are by production quality. They don't expect Hollywood-grade video from us.
   (d) A fairly detailed outline (perhaps with notes here and there about what should be happening on the screen) is good. A script read word for word is not.

(e) It's more difficult for jokes to work on video than when standing in front of the class - but sometimes students will give the professor points for trying.

5 Conclusion

Our Morningside College computer science program's experience with flipped classrooms has demonstrated that flipped classrooms help our students learn better. In some cases, such as the 100-level course where we were able to add content, it also helps them to learn more. Additionally, it increases student engagement. Although flipping courses requires significant time, the results observed at Morningside have been sufficient to motivate us to undertake the effort to flip all of our classroom courses.

References

[1] Scott Freeman, *et al.*, “Active learning increases student performance in science, engineering, and mathematics”, *Proceedings of the National Academy of Sciences of the United States of America*, vol. 111, no. 23, pp. 8410-8415, Jun. 2014.

[2] Michail N. Giannakos, *et al.*, “Reviewing the flipped classroom research: reflections for computer science education”, Proceedings of the Computer Science Education Research Conference, Berlin, Germany, 2014, pp. 23-29.