Teaching Tip:
The Flipped Classroom

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ABSTRACT

The flipped classroom has been gaining popularity in recent years. In theory, flipping the classroom appears sound: passive learning activities such as unidirectional lectures are pushed to outside class hours in the form of videos, and precious class time is spent on active learning activities. Yet the courses for information systems (IS) undergraduates at the university that the author is teaching at are still conducted in the traditional lecture-in-class, homework-after-class style. In order to increase students' engagement with the course content and to improve their experience with the course, the author implemented a trial of the flipped classroom model for a programming course with pair programming as the predominant in-class active learning activity. Student feedback on this pedagogy was generally very positive with many respondents considering it effective and helpful for learning. One of the biggest advantages mentioned by students is that they had the option to watch each video lecture as many times as required to be prepared for class. The author also observed that students were more engaged and empowered to take on more ownership for their learning. He recommends that other instructors consider rolling out their own trials of the flipped classroom incrementally for courses that would benefit the most from this pedagogy.

Keywords: Flipped classroom, Active learning, Blended learning, Computer programming, Programming, Teaching Tips, Web-based learning

1. INTRODUCTION

In a traditional instructor-centered classroom, the teacher delivers lectures during class time and gives students homework to be done after class. In a flipped, or inverted, classroom, things are done the other way round: the teacher "delivers" lectures before class in the form of pre-recorded videos, and spends class time engaging students in learning activities that involve collaboration and interaction. Passive learning activities such as unidirectional lectures are pushed to outside class hours, to be replaced with active learning activities in class. The term "inverted classroom" appeared in the literature as early as 2000 (Lage, Platt and Treglia, 2000) and was made popular by Chemistry teachers Bergmann and Sams in recent years (Bergmann and Sams, 2012, 2012a). With successful similar implementations of web-based lecture technologies – the often quoted success stories being the Khan Academy and Massive Open Online Courses – the flipped classroom gained traction at educational institutions in North America across a spectrum of disciplines and at different levels of instruction. This pedagogy has also been consistently rated as one of the top trends in educational technology (for example, Watters, 2012). Some educators have reported lower failure rates (Michigan Radio, 2013), greater flexibility, lesser stress (NBC, 2013), improved student attitudes and even better test scores (Flipped Learning Network, 2012) for classes that adopted this model.

However, being a relatively new trend, most implementations of the flipped classroom are reported in blogs, online magazines and newspapers instead of academic papers and conferences. There seems to be little rigorous research done to measure the effects of this pedagogy (Goodwin and Miller, 2013), and what has been published so far seems far from conclusive. Whilst a 3-year long study of flipped learning for a pharmaceutics course reported a 5.1% improvement in student performance (Meyer, 2013), contradictory preliminary data from another 3-year study at Harvey Mudd College suggest that flipping may not cause any difference in student outcomes (Atteberry, 2013). Adding to the debate, a recent study (Schneider, Wallace, Blikstein and Pea, 2013) concludes that students who engage in open-ended exploration first outperformed those who used traditional textbook materials first, and implies that video lectures and textbooks should come after exploration, and not before (Plotnikoff, 2013).

Despite the controversy, this pedagogy's raising popularity has motivated the author to run a trial on a class of 46 Information Systems (IS) undergraduates during a special term in 2013. The course that this class was taking is a second course in programming that covered object-oriented design and advanced programming. In previous years, this course was usually conducted in "interactive seminar" style: instructors taught a new concept and reinforced what they had just taught via short hands-on programming exercises performed on students' laptops. Instructors then moved on to the next concept and the cycle was repeated. Longer programming exercises would then be given as optional homework that could be submitted for feedback from teaching assistants. Whilst such interactive seminars were more effective than traditional monologue-style lectures (Steinert and Snell, 1999), the author observed that some students were still not engaged. Many students were updating their Facebook pages during the teaching sessions. Students who visited the washroom could miss a critical part of the lecture. Slower students who had difficulty picking up the concepts during the "first parse" were consequently unable to successfully complete the hands-on exercises that followed. For these students, the course rapidly snowballed into a vicious cycle of disengagement, poor performance, lack of confidence, and further disengagement.

It was hoped that the flipped classroom could increase students' engagement with the content and improve their overall experience with the course. The student feedback from this trial could also determine the relevance of this pedagogical approach for future batches. Figure 1 is a graphical depiction of the differences between the traditional classroom and the flipped classroom for this context.

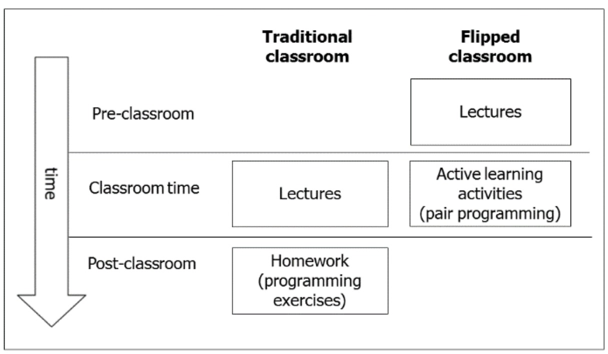

Figure 1. The traditional classroom and flipped classroom juxtaposed

2. IMPLEMENTATION

As part of the preparations for this trial, two-thirds of the course's content was converted into 400 minutes of video lectures. The author, who was also the sole instructor for this term, chose to record the programming topics and left the design topics to be covered in interactive seminar style, because the latter afforded more opportunities for class discussion. The author recorded screencasts on his tablet PC using the free version of CamStudio Recorder. These screencasts were almost identical to what would have been projected on the screen during a classroom teaching session: a mash-up of short notes scribbled on Microsoft Journal pages, code walkthroughs, "live" compilation and execution of sample programs. Videos were kept below 20 minutes and were uploaded to YouTube for public access, with the links made available via the e-learning portal. For each video, the author also prepared a corresponding self-check quiz comprising five multiple-choice or fill-in-the-blank questions. These were simple questions that students should be able to answer if they had understood the content of the video lectures, and were to be used as formative assessment. Students were able to attempt them at the e-learning portal as many times as desired with immediate feedback about the questions that were incorrectly answered.

For this course, the author decided to let students pair-program during classroom time. Pair programming has been recommended by researchers as an effective way to teach coding to beginners (Nagappan et al, 2003, Williams, Kessler, Cunningham and Jeffries, 2000) and is an active learning activity with intense collaboration. In pair programming, two students share a laptop, and one of them is the "driver" who types in the code. The partner – known as the "navigator" – does not handle the keyboard, but gives verbal feedback as they work on the problem together. The partnership for each session was randomized so that students got to be exposed to more classmates and programming styles. The in-class programming exercises and the longer homework programming exercises used in previous terms were merged into problem sets to be used for pair programming.

During the first lesson, the author explained how the flipped classroom and pair programming work, and set expectations about attendance and pre-class preparation. None of the students in this class had heard of "flipped classroom" and only a small number were familiar with "pair programming". At the end of each lesson, the links to the video lectures and self-check quizzes for the next session were put online. Students were expected to prepare for the next class by watching all the assigned videos and attempting the corresponding self-check quizzes until they got a perfect score. They were also told to note down any questions that arose when watching the videos.

Two things are critical for the flipped classroom to work: (i) students are physically in class for the active learning activities, and (ii) students must come prepared for each session by watching the assigned video lectures. To ensure the latter, students were warned that they would not be able to contribute to the pair programming effort if they came unprepared. The self-check quizzes were also used as a yardstick for preparation: students who failed to attempt them by the time the lesson started would get a warning email from the author as well as a penalty on their class participation marks. Initially a few students needed reminders, but by the third lesson, this problem had been virtually eradicated.

The first 15 minutes of each class were reserved for clarifications about the content covered in the videos. Using statistics collected automatically from the self-check quiz attempts, the author identified and went through quiz questions with poor scores. The problem sets for that session were then uploaded for pair programming. These problem sets were deliberately not made available earlier so that students could not attempt them beforehand. Giving access to these problems in advance would have confounded the objectives of collaborative problem solving. During the pair programming sessions, teaching assistants – who had been specifically instructed to provide suggestions that scaffold learning instead of "model solutions" – would go around the classroom to answer questions. Each pair programming session lasted about 90 minutes, after which the author would spend 15 minutes debriefing the class on common mistakes that were observed. The remaining time would be used for an interactive seminar on a design topic, trial exams or debrief sessions on their written and programming tests. The last two lessons were dedicated to revision and exam preparation. During these sessions, pair programming was replaced with trial exams that were attempted individually.

The adoption of the flipped classroom model did not affect the assessment criteria for this course. Written tests and programming tests taken individually accounted for 70% of the students' final grade. 20% came from a programming project that had to be completed in small teams. The self-check quizzes and in-class pair programming exercises were not directly used for assessment although quiz attempts and the quality of interaction during class time were taken into consideration for a participation component of 10%.

3. OBSERVATIONS AND EVIDENCE

The author observed a very high level of student engagement during pair programming sessions. The class was energized with relevant debate as students worked on the problems together. When a pair got stuck or wanted a third opinion, they spoke to one of the teaching assistants. Students were less likely to engage in non-relevant activities unless both partners decided to take a break. Previously, students were less inclined to ask their peers for help for their programming homework. This time round, they were obliged to work together and were hence more willing to seek or provide assistance. As the term progressed, it became quite apparent that a close community of learners was gradually forming as students became acquainted with one another through the exercises.

The author also observed a change in the learning culture compared to previous batches: students were more inclined to take ownership for their learning because the availability of the video lectures empowered them to do so. In previous terms, weaker students who were usually lost in class when they were unable to comprehend the mini lectures were unable to complete the hands-on exercises that followed, and the diligent ones could only catch up by reviewing the lecture slides and text books after class. This time round, weaker but diligent students had the option to prepare for class by re-watching the videos until they were convinced that they had understood the content. Several students told the author that they had the opportunity to come to class as prepared as their stronger counterparts and were hence more confident of their ability to tackle the problems during the pair programming sessions.

A few students admitted to the author that they had not attempted the homework programming exercises given to them in the previous term. However this time round, they had to do the questions in class, and as a consequence, benefited greatly because they actually spent much more time coding. With lectures out of the way, the author also had much more classroom time for other useful activities such as trial exams and debriefs.

37 of the 46 students responded anonymously to the course evaluation survey conducted before their final examinations. Besides the standardized set of teaching evaluation questions, an additional open question was inserted into the questionnaire: 'What are your opinions about this (flipped classroom) pedagogy?' Every single response to this question was positive and implied a good learning experience. Common terms used in their answers include "effective", "efficient", "helpful" and "useful". Students loved the idea of being able to repeat the video clips as many times as needed. Several respondents commented that viewing the videos at home "saved time" so that more could be done in class. In fact, some respondents were glad that they were "forced" to come to class prepared. Students like the self-check quizzes because they alerted them of knowledge gaps and prompted them to review the corresponding videos again with clear objectives. There were no negative comments about flipping the classroom, although there were two responses that criticized pair programming (and some of the partners whom they had to work with). These students were likely to be stronger programmers who preferred to challenge themselves individually when it came to problem solving exercises, or who were less inclined to work in groups. There were no complaints about technical problems or accessibility to the videos. This could have been an issue a few years back, but the technological infrastructure that enables fast video streaming to laptops, tablets and cellular phones is ubiquitous and affordable in most modern cities today.

4. TEACHING SUGESTIONS AND DISCUSSION

Despite the strong positive student feedback, this trial has a few limitations. First, this class was offered during the special summer term. In a usual term, students attend one 3-hour long classroom session every week for 14 weeks before taking their examinations. Although the syllabus and number of classroom contact hours were identical, this special term was a compressed version: students attended three classroom sessions per week and completed the course in five weeks. Secondly, the student make-up for this special run is atypical: students in this class had either failed the first programing course (a pre-requisite course) or this second programming course at least once. In a usual term, there could have been a larger population of strong programmers who might have different viewpoints about the flipped classroom. These two factors may affect the external validity of the results. The survey was also not designed to distinguish feedback about the flipped classroom structure or pair programming, which was the predominant in-class active learning activity. When a student praised the "flipped classroom" as "effective", it was not possible to determine if it was the pair programming, or the video lectures or a combination of both that was being referred to. Quantitatively, it was also not meaningful to compare the grades obtained by students in this class to previous batches because the examination questions were not identical. Hence this trial cannot determine if flipping the classroom would result in better student scores.

Nevertheless, because of the encouraging observations and affirmative student feedback, it is likely that the author would roll out similar implementations in the future. A reasonable suggestion by some students that could be implemented is to make available supplementary materials used in the video lectures (such as source code and

PowerPoint slides). For this study, the main in-class active learning activity was pair programming. For variety, the author recommends considering other types of active learning activities such as games and competitions. (Barkley (2009, 2004) is an excellent source of ideas for active learning activities.) Another recommendation is to limit the length of each video to shorter 10-minute clips with more streamlined objectives. Captions should be included in the video clips as well to facilitate hearing impaired students and foreign students who may not be accustomed to the instructor's accent. Although the quality of the videos is important, the author suggests that instructors do not spend too much time creating the "perfect" video. It is more important that the content is coherent, concise and clear, rather than free of background noise or be professionally edited. The immediate priority should be to get the initial batch of videos ready; improved versions can be prepared for the next round if time permits. It may also be worth the time searching for existing and free video resources that could be used instead.

The author encourages trials of the flipped classroom for suitable courses. These are courses with "stable" curriculums which make it more likely that the videos produced could be reused without editing in subsequent terms. They could be knowledge-intensive courses or "technical" courses that require students to know a lot of facts. Courses such as algorithms or mathematics that require a "digestion period" are suitable as well. These topics are not easy to grasp immediately during a lecture and the opportunity for students to revisit the videos and spend some time thinking about the content will certainly help tremendously. It may also be a good idea to extend the flipped classroom with other proven pedagogies such as differentiated instruction for students of different abilities (Mok, 2012). For example, additional video clips and optional exercises that cover advanced topics can be prepared to cater to top-tier students who may want to explore beyond the syllabus.

The downsides of flipping include the need for more preparation. Significant time was required to prepare the videos and classroom materials, but this disadvantage is ameliorated by the fact that these resources can be reused for future runs of the same course. Most active learning activities done in teams will usually need close monitoring and supervision for them to be effective. In this case, it was necessary to ensure that the teams were really working in accordance to pair programming rules during the pair programming sessions. The author discovered a few students who were coding independently instead of in pairs, and had to intervene immediately to get them back on track. This pedagogy fails if students come to class without preparation. For this trial, the author relied on self-check quizzes and peer pressure to motivate students to watch all the videos before class, but these may not work on other student groups. Perhaps the biggest obstacle of all is psychological in nature: converting a conventional class to a flipped class is a major change, and most people – including faculty members – are generally resistant to changes. Student expectations need to be appropriately set during the first lesson, and some amount of buying-in needs to be done to convince students and faculty colleagues that flipping is beneficial. It may also be preferable to convert part of a course instead of gunning for a "big-bang" revolution when rolling out a pilot.

5. CONCLUSION

This trial has shown that students in an undergraduate IS course exposed to the flipped classroom had enjoyed the experience with a significant number believing that it was an effective pedagogy. The repeatability of the videos at any time and place allowed students to prepare thoroughly for class, and the displacement of classroom lectures meant additional contact time for more useful and engaging learning activities. This model enabled weaker but diligent students to study at their own pace and come to class as prepared as their stronger contemporaries. This could have helped build up their confidence and enjoyment of the subject matter. "Forcing" students to be engaged in programming activities in class benefited students who would otherwise not have attempted the programming problems if they had been doled out as homework. Depending on the active learning activities chosen for classroom time, there could also be more opportunities for students to interact and learn from one another. The author observed that flipping had brought about a positive change to the students' ownership and responsibility toward learning. He observed much higher engagement during class time and recommends that the flipped classroom model be incrementally introduced to other courses that are likely to benefit from this pedagogy.

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