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Published

2015

Conference Title

EdMedia: World Conference on Educational Media and Technology

Version

Version of Record (VoR)

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EdMedia 2015 - Montreal, Quebec, Canada, June 22-24, 2015

Flipping a Programming Course with Low Lecture Attendance

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Abstract: Low lecture attendance has been a serious concern for many university courses. This paper describes how low lecture attendance was solved in our Web Programming course by adopting the flipped class teaching method. In making the change to a flipped course, we replaced all live lectures (except for week 1 lecture) with pre-recorded lectures, that were made available on the course website each week. But we retained the face-to-face, and must attend laboratory classes, which were essential for student-teacher interaction and active learning. Two studies over three course offerings were carried out to compare the traditional teaching method with flipped class. In both studies, students in the flipped course offerings had better learning outcomes than students in the traditional course offerings. In addition, the flipped course offerings scored better in the end of semester student experience survey, both in terms of the perceived quality of the teaching and student engagement.

Introduction

Poor lecture attendance has been an issue with many university courses for quite some time (Khan 1997). Researches have been conducted to explain why students do not attend lectures (Dolnicar, 2004), (Dolnicar, 2009), (Khan 1997), (Oakley et al, 2011). The results indicate it is not a single reason but a combination of reasons for low attendance.

The 2012 offering of our Web Programming (WP) course also suffered from poor lecture attendance. Similar to the attendance pattern described by Khan (Khan 1997), the attendance of these courses is good at the start of the semester, but then it quickly drops down to around 30%. From past experience, the students that do not attend lectures are usually the ones that perform poorly in the course. The teaching team has tried to entice students into the lectures by revealing some quiz questions and answers during the lecture. However, this did not appear to have much impact in getting better attendance.

With low attendance, one would usually ask, was it because of poor lecture quality? In the case of WP, this does not appear to be the case, as poor lecture quality was not mentioned in the student experience survey at the end of the semester. The teaching team has identified the following potential reasons why students are not attending lectures, and the link to poor performance:

- Many students are not fully committed to their study. They have multiple commitments competing for their time. A significant proportion of our students are working part-time to support their study. Some have full-time or multiple jobs. These students would rather spend their time directly on tasks that can earn marks directly (e.g. writing assignments) instead of attending non-assessed lectures.
- Detailed lecture notes are available online, as a result some students do not feel it is critical to attend live lectures to be able to pass the course. However, for weaker students, they could benefit from the extra explanation and demonstration performed in live-lectures. Additionally it is usually the weaker students that do not attend the lectures.
- The material presented in a live lecture is usually sequential. If a student did not understand or misunderstood a point, then s/he may be lost for the rest of the lecture due to a limited ability to receive a repeat explanation.
- Some students arrive late. It would be almost impossible to continue to follow the rest of the lecture.

Starting from the 2014 offering of WP, the teaching team took a different approach to delivering lectures. Instead of having the traditional live/in-person lectures, lectures were only delivered as a pre-recorded video online. Students were expected to review the lecture outside of classroom before attending the weekly laboratory class. In

the laboratory classes, students apply what they have learnt to solve practical programming problems. Teaching staffs were present during laboratory classes to help and answer students' questions. This method of course delivery is better known as *flipped class room* (Bull, et. al, 2012, Brame, 2013, Hughes, H. 2012, Lage et. al., 2000, Sams, et. al. 2012, Sankey et. al. 2013, Zappe et. al. 2009).

Existing research in flipped class room have shown that this approach increases student satisfaction (Goh et. al. 2012, Zappe et. al. 2009). However, there is currently not enough hard evidence to suggest that flipped classroom has improved students' learning outcomes (Goodwin and Miller 2013). This research compared course offerings before and after making the transition to flipped class. The comparison encompassed both students' learning performance and satisfaction.

This paper is organised as follows: the next section describes in more detail the teaching methods that were used in the case studies. Then the two case studies that compared the impacts of the change to flipped course are presented, followed by a discussion of the findings. Finally the conclusion is presented.

Teaching Methods

This section first presents the common teaching methods used in both the traditional course offerings and flipped course offerings for WP. Then it discusses the details of the changes to flipped course offering.

Common Teaching Methods

All the course offerings of WP had lectures and laboratory classes. The differences were in how lectures were conducted, which is explained in the next section. Nevertheless, for all offerings, detailed lecture notes were available online as PDF files.

How the laboratory classes were conducted is the same for all course offerings. There were two hours of in-person **laboratory classes** per week. In most weeks, there were small laboratory exercises students need to complete. Students may complete the exercise in class (and ask the tutor for help), or they can complete it at home. The exercise for one week was due the following week. Students needed to attend the laboratory classes to have their solution marked. Marking of the exercises involved students first demonstrate their work to the tutor, and then orally answer questions from the tutor about their submission. Students may lose marks for incorrect answer. If they cannot answer any questions at all, they may receive 0 for that exercise. After a mark is awarded to the student, the tutor provided feedback to the student and explained the reasons for the awarded mark. Each exercise was worth a small amount of marks (2%).

These laboratory classes were the active learning part of the course, which were also a vital component of the flipped class. Hence, how the laboratories classes were ran was retained when the courses were redesigned to follow the flipped model.

Differences in Lecture

The main difference between traditional and flipped courses was how the lectures were presented. The traditional WP course offerings have two hours of in-person lectures per week. With the flipped course offering, only the week 1 lecture was in-person for one hour, where students were told how the course will be run. The rest of the lectures, including the week 1 course material, were presented online via video recording. The recordings were in mp4 format, and were downloadable. The recoded materials for each week were around one hour in length. The lecture recordings consisted mostly of screen captures of lecture slides/notes with voice explanation. The voice explanations of the recording were of better quality and more concise than live/in-person lecture, as when recording, sub-standard explanations can be re-recorded. The recording for one slide was usually the result of several takes.

In both in-person and pre-recorded lectures, code walk-through of examples were conducted when appropriate. But in addition, pre-recorded lectures contained demonstration of the lecturer writing code snippets and explaining the code as they go. Furthermore, during the demonstration, syntax or logical errors may have been made, so the demonstration also contains how the errors were found and resolved. Pre-recorded lectures were more concise than live lectures, this allowed more content to be presented in a shorter period of time.

The lecture material contained information students needed to know to do their laboratory exercises. Sometimes, snippets of code in the lecture notes can be directly used for their laboratory exercise. In the traditional offerings, students received detailed written instruction on how to do the laboratory exercises. In the flipped course offering, where video recordings were widely used, students only received written instructions on what they need to do, but not how to do it. However, for each exercise, there was usually a video recording (as part of the lecture or a separate laboratory instruction video) explaining what students have to do, and how to do them. In some cases, the videos contain a demonstration of how the tutor does part of the laboratory exercise; the full solution is never demonstrated in video.

Traditional vs Flipped Course Offerings

This section presents two case studies that compared the results of traditional and flipped courses. These case studies compared different offerings of the WP course. WP is a second year level course on building dynamic websites using PHP backed by a relational database. This course runs once a year in Semester 1 on two campuses. The same course on different campuses are regarded as different offerings as they are taught by different staff members. There are around 70 to 90 students enrolled in each offering of this course.

The first study compared the 2012 and 2014 offering of WP in Nathan campus. The second study compared 2014 offerings of WP in Nathan and Gold Coast campuses. In these studies, the 2014 Nathan offering of WP was the flipped course offering, and the other offerings of WP were run in the traditional mode. For each of these studies, the difference between the course offerings is first discussed, then the results of these offerings are compared.

Case Study 1: Cross year comparison

This study compared the 2012 Nathan and 2014 Nathan offering of WP. There are 97 students in the 2012 Nathan offering, and 79 students in the 2014 Nathan offering. The reason 2012 offering was used, instead of 2013, is because the 2012 and 2014 offering are taught by the same staff, and the 2012 offering was more closely aligned with the 2014 offering than the 2013 offering.

As these are real course offerings, there are differences between course offerings. Table 3 compares the teaching method and assessments between the 2012 and 2014 offering in Nathan. The main change in terms of teaching method is that in 2012, the traditional 2 hours of in-person lecture per week was used, whereas the 2014 offering the online video recording was used instead of the in-person lecture. In 2014, a drop-in class was added to allow students to ask questions, however, the attendances for these classes was very poor. With the assessment structure, 2012 had a final exam, but in 2014, the exam was replaced with 4 quizzes conducted throughout the semester during the laboratory class.

2012 (Nathan) - Traditional	2014 (Nathan) - Flipped
<i>In-person lecture – 2 hours per week</i>	<i>Online lecture video, plus Drop-in class – 1 hour per week</i>
In-person laboratory - 2 hours per week.	In-person laboratory - 2 hours per week.
Laboratory exercises totaling 20%	Laboratory exercises totaling 20%
Assignment 1 25%	Assignment 1 25%
Assignment 2 25%	Assignment 2 25%
<i>Final exam 30%</i>	<i>4 quizzes, totaling 30%, are conducted during semester under supervision in the lab classes.</i>

Table 3: Comparison of teaching methods and assessments between the 2012 and 2014 Nathan offering of Web Programming.

Some of the topics covered in this course have also changed between 2012 and 2014. In 2012, the first half of this course covered HTML/CSS, PHP, templating, relational databases, and SQL. The first assignment required students to write a basic CRUD web application based on what they have learnt so far. The second half of the course discussed the topics of how to do pagination, user authentication, handle date/time, upload files with PHP, and basic JavaScript. The second assignment required students to extend the first assignment by requiring students to implement the new features that were taught in the second half of the course.

In 2014, the first half of the course covered the same topics as 2012. In fact, the same lecture notes were used to record most of the lecture videos. In addition, the topics of using Git (version control), and using Bootstrap for creating responsive 2 column layout were also added to the first half. The same Assignment 1 as 2012 was used in 2014. But in 2014, the use of template inheritance is enforced and the submission procedure is change so that it would be quite difficult to submit the assignment without using Git.

The second half of 2014 was different to 2012. A PHP framework called Laravel was taught. Students were still required to do pagination, authentication, etc., but Laravel made these tasks less difficult. However, Laravel (and similar frameworks) introduces new concepts and there is a steep learning curve. Furthermore, the Object Relational Mapping (ORM) feature of Laravel makes simple querying a lot simpler than writing SQL, however, for slightly more complex queries, Laravel's ORM can be a lot harder to write than SQL. Assignment 2 for 2014 is based on 2012 except that Laravel is used instead of plain PHP.

The maturity of the material between 2012 and 2014 should also be mentioned. The material used in 2012 was mature as it has been used and improved over the past ten years. In contrast the new material introduced in 2014 was

immature and will be refined further for the next offering in 2015, especially on the topics of Git and Laravel.

The marking of Assignments was more stringent in 2014 compared to 2012. In 2014, oral assessments were added on top of “standard” assignment marking for both assignments. This oral assessment required students to explain and demonstrate their submission and answer questions about their submission.

The weekly laboratory exercises contained small tasks based on the topics covered in the previous week’s lecture. The code students wrote in these exercises can be either directly or indirectly used in their assignments. Eight of these exercises were assessed. The differences between the 2012 and 2014 laboratory exercises are consistent with the differences in lectures. The laboratory exercise in the first half of the course is almost the same between 2012 and 2014, with 2014 having additional exercise on Git and Bootstrap. But for the second half of the course, the exercises are different with the 2014 version turning to focus on Laravel.

Case Study 1: Results

After describing the difference between the 2012 and 2014 offerings in the same campus, the follow paragraphs will present the impact of changing from tradition to flipped offering.

One observation made throughout the semester is the difference in **student engagement** in the laboratory classes. In 2014, a lot more students attended the laboratory class and submitted their laboratory exercises. This observation is supported by student’s laboratory exercise result. In 2012, the median laboratory result was 14.5 out of 20. In 2014, the median result was 19.25 out of 20. This is an increase of 23.75%.

Figure 2: Comparison of results between 2012 and 2014 offerings of Web Programming, including labs, assignment 1, student evaluation of teaching, and student evaluation of engagement.

In terms of the difference in **learning outcomes**, the most important comparison in this study was with assignment 1 results as this assignment was the same in 2012 and 2014, with 2014 actually being more difficult having the additional requirement of using template inheritance for presentation and Git for submission. In 2012, the median result for Assignment 1 was 19 out of 25, and for 2014 it was 22.5. This is an increase of 14%.

For completeness, the median Assignment 2 result is 19 out of 25 in 2012 and is 19.25 in 2014. However, it was observed that in 2014, some students did not put in their best effort in completing assignment 2. This was because being the final assessment item, students knew how much marks they need from this assessment to pass the course. Hence, some students only put in the minimum effort they need to pass this course. In contrast, in 2012, students still had to do the final exam after Assignment 2. In any case, it is difficult to make a direct comparison between the Assignment 2 in the two offerings as they cover different content with Laravel being use in 2014 instead of plain PHP.

Overall, the failure rate was reduced, and the number of students that obtained the grades of 6 and 7 (with 7 being the highest grade) has increased in 2014. However, this result could be affected by the change from a final exam to quizzes.

In terms of **student satisfaction**, each offering had conducted a student experience survey at the end of the semester. The participation rate in 2012 was 26.8% (or 26 students). In 2014, it was 57% (or 45 students).

The quantitative section of the survey used five-level Likert scale. The most relevant question on that survey regarding the teaching method was:

“The teaching (lecturers, tutors, online etc) on this course was effective in helping me to learn.”

In 2012, the mean score was 4.0. In 2014, the mean score was 4.6.

Another relevant question on the survey is:

“This course engaged me in learning.”

In 2012, the mean score was 3.9, in 2014, the mean score was 4.7.

In the qualitative section of the 2014 survey, there were two questions. The first question was “What did you find particularly good about this course?” There were several comments regarding the structure of the course:

“The structure was excellent - recorded lectures, highly practical labs...”
“Online segmented video lectures with relevant titles viewable at any time.”
“Though online lectures were used, the material and teachings were concise. This is my first online lecture course, but was very pleased with it, and can only recommend continuing it online.”
“At first I really didn't like the idea of online videos but I later came to like them. It fits well with the assessment as well ...”
“The assistance with the laboratory exercises in both video and in-person form.”
“Lecture videos and lab videos. I can go back and watch it as many times as I like. I can pause and

rewind if it was too fast or part the I don't quite understand. The lecturer is always there for you and really focus when the students need help when they raise their hands during lab.”

In fact, 20 out of 35 comments mentioned the video recording contributed positively to this course.

For the second written question: “How could this course be improved?” In 2014, the response was mixed. But in relation to the lecture, 3 comments out of 29, mentioned the course could be improved with having live lecture.

“... Would much rather prefer on campus lectures. ...”

“Have live lectures. ...”

“Possibly hold 1 regular face to face lecture a week instead of all videos, even if it's just for an hour”

Overall, from the Laboratory Exercise and Assignment 1 results, it can be concluded that the change to a flipped course had improved student engagement and also learning outcomes. Furthermore, from the student experience survey, it is clear that flipped course contributed positively to the student experience for most of the students.

Case study 2: Cross campus comparison

In 2014, the WP was also run in the Gold Coast campus. This course offering had 89 students. This course ran like a traditional course, but the pre-recorded lectures, taken from the Nathan offering, were also made available on its course website. This offering was taught by different staff than Nathan. Also this offering did not have the drop-in class. Other than these differences, these two offerings were the same, i.e. they used the same lecture notes and assessments.

2014 (Gold Coast) - Traditional	2014 (Nathan) - Flipped
<i>In-person lecture – 2 hours per week, plus online lecture videos.</i>	<i>Online lecture videos, plus Drop-in class – 1 hour per week</i>
In-person laboratory - 2 hours per week.	In-person laboratory - 2 hours per week.
Laboratory exercises totaling 20%	Laboratory exercises totaling 20%
Assignment 1 25%	Assignment 1 25%
Assignment 2 25%	Assignment 2 25%
4 quizzes, totaling 30%, are conducted during semester under supervision in the lab classes.	4 quizzes, totaling 30%, are conducted during semester under supervision in the lab classes.

Table 3: Comparison of teaching methods and assessments between the 2014 offerings of Web Programming in Gold Coast and Nathan.

As the assignments and laboratory exercises were marked by a different teaching team, it should be pointed out that the same detailed rubrics were used in both campuses. The rubric was predominantly focused on functionality, so there was very little subjective influence by the markers. Furthermore, the quizzes were multiple answer questions that are automatically marked. So the marking between the two offerings was reasonably consistent.

Case Study 2: Results

Before the **learning outcomes** between the two campuses is compared, it should be noted that historically (prior to 2014) students in the Gold Coast offering of WP have obtained better overall percentage on average than Nathan students¹. The historical results for WP between the two campuses are as shown in Figure 3. In 2014, this trend was reversed. Nathan students obtained better overall percentage (average of 72.6%), compared to Gold Coast (average of 61.8%).

Figure 3 – Average of student’s final percentage for both Gold Coast and Nathan campuses between 2010 and 2014.

In terms of 2014 results for each assessment item, with the laboratory exercises, the mean for Gold Coast was 8% less than Nathan. For assignment 1, Gold Coast was also 8% less than Nathan. For assignment 2, Gold Coast was 1.5% less than Nathan. For the quizzes, Gold Coast was 8.2% less than Nathan. Other than assignment 2, Nathan students consistently out-performed Gold Coast student by 8% for every assessment item. The results of assessments also directly translate to grades. This time, Nathan had lower failure rate, and more students obtained the grades of 6 or 7 than Gold Coast.

¹ This is because our Gold Coast campus is the only public university in that city, whereas the Nathan/Brisbane campus is competing with two other well-known public universities.

Figure 4: Comparison of results for the 2014 offering of Web Programming between the Gold Coast and Nathan campuses, including labs, assignment 1, student evaluation of teaching, and student evaluation of engagement.

This result for student's learning outcomes is surprising given that Gold Coast students also had access to the same lecture videos. We were able to obtain the data on the number of accesses of week 2 lecture videos. Despite having more students, Gold Coast students accessed the Week 2 video page 756 times for the whole semester, whereas Nathan students accessed it 1120 times²³. Due to the availability of in-person lectures, Gold Coast students utilised the recordings less. Unfortunately, we were not able to retrieve access data for other weeks of the semester.

In Gold Coast, we observed that towards the end of the semester, there was a large drop-off in in-person lecture attendance. Lecture attendance drop-off towards the end of semester is expected, however this drop-off is a lot more noticeable than usual (for that campus). We suspect this is due to the impact of the availability of pre-recorded lectures.

In terms of **student satisfaction**, the end of semester student experience survey for Gold Coast had a participation rate of 52% (or 47 students). For the quantitative question:

"The teaching (lecturers, tutors, online etc) on this course was effective in helping me to learn."

The score was 4.5

For the question: "This course engaged me in learning."

The score was 4.4

In the qualitative section of the survey, out of the 61 comments for the two questions, there was only one comment regarding the pre-recorded lecture:

"I found the lectures and lab videos easy to follow and they helped a lot with completing tasks"

This would indicate that the Gold Coast students placed less emphasis on the pre-recorded lectures.

Overall, with access to both in-person and pre-recorded lectures, Gold Coast students performed worse than Nathan students that only had access to pre-recorded lectures. Furthermore, having access to both did not result in higher student satisfaction.

Discussion

In our WP course, the main difference between the tradition and flipped course offering is that in the flipped course there is no live/in-person lecture. So by adopting the flipped teaching model, we can claim we have also solved our problem of low lecture attendance if the student learning outcomes and satisfaction is equal or better in the flipped course than the traditional course. As showed by the two case studies, both the learning outcomes and satisfaction have increased in the flipped course offering.

In terms of learning outcomes, the results of both case studies showed that the flipped class offering produced better learning outcomes. This research result provides data to backup many practitioner's/teacher's views regarding the positive impact of flipped class on learning (Flipped Learning Network, 2012).

In Case Study 2, the Gold Coast offering of WP had the same lecture videos and laboratory classes as the flipped course in Nathan, in addition, it also had the live lectures. Yet, the learning outcomes were not as good as the flipped course. As lecture attendance was not required and the lecture videos were available, Gold Coast students could have taken the course in a flipped mode. However, due to live lectures being available, students treated this course like a traditional offering, and obtained a similar level of learning outcomes as a traditional offering. This result is consistent with a previous study (Smith & Fidge, 2008), where pre-recorded lectures were provided on top of the existing live-lectures, and there was no visible improvement to the learning outcome.

From the above results and analysis, we would say that the WP flipped class "forcefully" adjusts student's mentality and method of study. With traditional classes, turning up to a live lecture does not guarantee students are paying attention. Students may have other motivations such as social interaction or a sense of wanting to be seen (by him/herself, parents, peers, or teach staff) to be putting in the required efforts towards study without being fully

2 As students can download the video, if a student downloaded the video and then only watch their downloaded copy, then they will only access the video page once.

3 These numbers also indicate that students prefer to stream the video rather than downloading the video. As the number of page access is a lot more than the number of students.

engaged. In contrast with flipped classes, when students watch recorded lectures they are making a conscious choice to focus and learn, otherwise there is no other way for them to obtain the knowledge they need to do the laboratory exercises and all the other assessments. It is also possible that when students watch the lecture videos there are less distractions from their surroundings. In addition, when students were watching the lecture videos, they were also actively thinking about how to apply what they are learning (to the laboratory exercises). Some students were also watching (hopefully re-watching) the lecture videos during the laboratory classes while attempting the exercises. Furthermore, since there is only one type of class (the laboratory) in a flipped class, if students do not attend the laboratory classes, they might as well not take this course, hence, the increased laboratory attendance in the flipped offering.

In terms of student satisfaction, if the majority of the students were not attending live lectures, one would expect the transition from live to pre-recorded lectures (flipped course) would be met with little opposition. Almost all of the students coming to the Nathan offering of WP in 2014 were experiencing flipped course for the first time, and they were used to the traditional, live-lecture, method of teaching. The teaching team was concerned that some students might have the perception/misconception that live is better than recorded lectures, or they are not getting what they have paid for with only pre-recorded lectures. Therefore in week 1, during the only live-person class, the benefits of video lectures were discussed, in addition, these points were reinforced during some of the laboratory classes. As it turned out, it was apparent (from the surveys and talking to students) that some students were skeptical about having only pre-recorded lectures at the start. But most students tried out the recordings, and were later convinced that this was a good teaching method. This is reflected in the good scores and overwhelming positive comments in the end of semester course experience survey.

In the three course offerings discussed in the case studies, the laboratory classes all ran in the same way. These weekly laboratory classes required each student to talk to their tutor. We feel that this intense one-on-one interaction in laboratory classes is very important. Without such type of laboratory classes, it would be difficult to achieve the positive same outcome for the flipped class.

Lecture recordings took a lot longer time to make compared to the time required to prepare and present an in-person lecture. However, once made, the recordings can be reused in the next offering with little or no modification. Furthermore, using pre-recorded online lectures allow the same recordings to be used for cross campus teaching.

Conclusion

In trying to solve the low lecture attendance problem we have converted our 2014 Nathan campus offering of Web Programming course to a flipped course. In this flipped course, live lectures were replaced with pre-recorded lectures, but the existing laboratory classes, which support active learning, is retained. Without live lectures, the low lecture attendance problem was resolved. Furthermore, studies were performed to determine the impact of this change.

Two case studies, involving three course offerings across two campuses, were performed to assess the impact of this change. The first study compared the results from of 2012 and 2014 offering of WP in Nathan campus. The second study compared the results of the Gold Coast and Nathan campuses offering of WP in 2014. The results of both studies indicate that students in the flipped course offering had better learning outcomes and student satisfaction than the traditional course offerings.

The limitation for this type of cross cohort study regarding learning outcomes is that the base level learning performance between cohorts can vary. However, to get a better understanding of cohort differences, this study provided the historical data to show the performance between different cohorts from 2010 to 2014. This data showed that the performance of cohorts has been fairly steady since 2010, with Gold Coast cohort consistently outperforming Nathan cohort. But with the introduction of flipped class in Nathan in 2014, Nathan students outperformed Gold Coast students in that year.

With the positive results we have obtained in switching to flipped class room, we are flipping other courses we are teaching, and we would recommend others to do so.

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