The use of flipped learning in an Engineering Technician Management course

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Structured abstract

BACKGROUND
Flipped learning is an approach to teaching that essentially reverses the traditional teaching approach where the tutor delivers the content in class and then the students do exercises at home to provide a better understanding of the content and its application. In flipped learning this traditional approach is changed so that students learn the content in their own time before the class session and the class session is used to develop a better understanding of the content and its application.
Flipped learning is already widely used and is becoming more popular in higher education. Research has indicated that it improves student performance and leads to better student engagement. However much of this research relates to arts and humanities courses which may benefit more from the approach.

PURPOSE
The purpose of this research was to determine whether using the flipped learning approach improved performance and student engagement in an engineering technician management course.

METHOD
An engineering management course has been delivered using flipped learning in 2013. The performance of the students in this flipped class in controlled assessments was compared with the performance of students who were taught the same content using a traditional lecture- based format in 2011 and 2012. Student views on the flipped learning approach were assessed from a questionnaire administered at the end of each course.

RESULTS
There was no difference between student performance in the flipped classes and the traditional classes. However the questionnaire indicated that a significant number of students preferred the flipped learning approach and felt that it was more effective and interesting than the traditional lecture-based approach.

CONCLUSIONS
The research indicated that the flipped learning approach used in the engineering management classes did not produce the performance improvements claimed by other research. This may have been due to how the approach was implemented or it may be that the approach does not yield improvements in engineering management type subjects. The course is still being developed and experience with the 2013 class has indicated possible improvements in the online presentation of the course content and in the class activities.
Student engagement in the class has improved as a result of the use of the flipped learning approach as evidenced by the significant number of students who indicated their preference for the approach in the questionnaire and in student engagement in class activities.

KEYWORDS
Flipped learning, flipped classroom, blended learning

Introduction

Flipped learning is a teaching methodology that reverses the traditional way of structuring classes where the tutor delivers the content in class and then the students do exercises at home to provide a better understanding of the content and its application.In flipped learning, students review the course content before class-time so freeing up the class-time to be used for discussion, exercises and other activities designed to enable them to understand and be able to apply the content. Flipped learning is also known as flipped classrooms, reverse learning, reverse teaching, hybrid learning and inverted learning.

The Department of Civil Engineering at Unitec teaches the New Zealand Diploma of Engineering (NZDE) and Bachelor of Engineering Technology (BEngTech) courses to a roll of approximately 400 students. As is the case with most tertiary institutions, the department faces a variety of challenges. In particular:

- students have a wide range of maturity, cultures and backgrounds;
- about half of the students have English as a second language;
- class sizes are increasing as the demand for graduates with these qualifications increases due to development needs in both Unitec and overseas; and
- the engineering industry is requiring graduates who are able to quickly become productive technicians.

Together these factors mean that the department is looking for better ways of educating the students and improving the quality of the services the students can provide when they graduate. One possible way of achieving an improvement in the quality and efficiency of current educational practices with the current resource and financial constraints is to use the flipped learning approach instead of the current traditional approach.

Changing from the traditional approach to the flipped learning approach involves a significant amount of additional work and disruption. Therefore the benefits that would be brought about by any changes to the existing approach would need to be justified by probable improvements in the efficiency of the course delivery and in student outcomes. Therefore the flipped learning approach has to be compared with the existing traditional approach to determine what, if any, advantages the flipped learning approach has.

This paper sets out the results of a study of an engineering management course which was delivered using the flipped learning approach. The purpose of the study was to determine whether the flipped learning approach yielded improved outcomes such as students becoming more engaged in the subject, being more motivated to complete the course, being better able to demonstrate an understanding of the course content and being able to apply the course content to real world engineering practice.

The study cohort was an existing compulsory introductory engineering management course that was taken by second year BEngTech students. This course had been taught by the researcher for the previous two years. In the first year (2011) it was taught using a traditional approach. An attempt was made to apply the flipped learning approach in the second year (2012) but it was not properly implemented and the approach ended up being more simular to the traditional approach rather than the flipped learning approach. The course material was improvedto allow it to be presented using the flipped learning approach in the first semester of 2013.

There were 44 students in the study cohort covering a wide range of nationalities, ages and engineering experience. About half of the students had English as their second language (ESL) which had posed problems in the past with this subject as it does require a reasonable competency in English. The ages in the class were well spread with a third being 20 years or under, another third being 20 to 26 and the last third being older than 26. Most of the class were male with only6 females in the class.

Previous Research

Strayer (2007) compared classes using a flipped learning approach and a traditional approach in a university level introductory statistics course. The traditional class received the course content using a lecture format however the tutor did make the classes as varied and interactive as possible. The flipped learning class received the course content through an intelligent tutoring system, which provided an interactive environment for students to learn the course content. He found that students are evenly split over whether they preferred to have course content presented in class or video lectures. Further investigation revealed that many of the students that did not like the video lectures had had trouble getting the technology to work as they had older computers. Also the students found it frustrating that they were not able to ask questions that arose when they were viewing the videos.

Frederickson, Reed and Clifford (2005) studied a class of 16 graduate-level statistics students who were split into two groups. The groups were selected at random; they studied the same content and had the same test however the traditional group listened to the tutor delivering the content in person while the computer-based group reviewed the same content on a Web-based presentation. The results of the study were that both groups did just as well in the tests. The students were also given an open-ended questionnaire that sought to collect their views on the two methods. One finding from this questionnaire was that students doing the Web-based format said that they wanted the learning goals more clearly defined and were unsure whether they were on the right track with their learning. The traditional group students did not report this problem despite both groups receiving exactly the same learning goals and explanations. Strayer (2007) also notes this difference between the lecture-based and web-based classes. He noted that his web-based class seemed "always on edge, never feeling completely comfortable with how to engage the material or the class time." Frederickson et al (2005) suggest that this is because the Web-based students no longer had the crutch of the tutor being there in person presenting the course content. They concluded that this was a positive learning outcome as the students personal growth had expanded by having to take more responsibility for their own learning.

Lage, Platt and Treglia (2000) report a case study where flipped learning was used on a micro-economics course of 80 students. On this course students were required to read sections of the textbook or view the same content on either videotaped lectures or PowerPoint screencasts before class time. The use of different media to present course content allowed students to choose how they would learn and when. The class sessions started with the tutor answering questions about the content students had learnt before class. The rest of the class consisted of activities designed to explore the topic. Student response to this approach was generally positive with most preferring the flipped classroom approach over the traditional lecture classes. The study also indicated better interaction and communication between students.

Pinder-Grover, Green and Millunchick (2011) used screencasts to supplement lectures in a materials course. The course was composed of students from a variety of courses and engineering disciplines. They recorded the lectures and produced screencasts on assignment answers and on topics that the students were having troubles understanding (the "muddiest points" as they put it). They noted a correlation between the number of times a student used the screencasts and their performance with performance improving as the screencast use increased. However this varied between cohorts with the cohorts that had the best background in the course getting the least benefit and those on a steep learning curve gaining most. They also found that non-US citizens used the screencasts more than US citizens and performed about the same. They noted that traditionally the non-US citizens did not do as well as US citizens and they conclude that the screencasts provided a way for the non-US citizen to lift their performance. They conclude that the use of screencasts helps to "level the playing field" where there is a wide range of academic and cultural backgrounds amongst the student group.

Course Implementation

The general format of the course started with the posting of screencasts, readings and quizzes to Moodle a week before the related class session. The screencasts consisted of MP4 videos of narrated PowerPoint presentations. The content of each screencast was the same as would have been presented in class with a traditional approach. However they did not include the discussion points and exercises that were used in the traditional class to break up the content presentation. The screencasts were restricted to less than 10 minutes in duration to reduce file size and to allow students to break up their viewing of the content. Therefore each topic had 3 to 5 screencasts that had to be viewed.Relevant readings and videos were also posted on Moodle to provide additional information or an alternative approach to the content presentation.

The online quizzes were multi-choice Moodle based quizzes. The questions were generated randomly from a question bank so each student got a different set of questions. The quizzes were set to adaptive mode so students were able to make repeated attempts at answering the question until they got it correct. Each incorrect answer drew a penalty. Each quiz was worth 0.5 to 1.0% of the final course mark and closed 30 minutes before the class time. The objective of these online quizzes was to encourage the students to review the course content before the class time.

There were two 1.5 hour sessions of class contact time allocated each week. A variety of activities were undertaken during this time including class discussions, solving actual engineering problems, reviews of engineering documents and other activities designed to orientate student learning to the application of the course content.Some classes started with snap quiz which was marked in class by the students and which together were worth an additional 5% of the final course mark. The students did not know when the snap quizzes would be held and therefore had to review the online content before all classes. The snap quizzes also provided a good way to set the scene for the class with the answers being discussed as they were presented and the following activities linking to some of the snap quiz questions.

Methodology

This study aimed to determine how useful the flipped learning approach was to the course. The question was addressed in two ways. Firstly, the performance of the students in controlled assessments was analysed and compared with the performance of previous cohorts taught the course using traditional methods. Secondly the student attitudes to the course were examined using a questionnaire that the student were asked to complete at the end of the semester.

The performance of the students was measured from the mid-semester test and the end of course exam. The test comprised 15% of the total course mark while the exam comprised 40%. The remaining 45% was comprised of uncontrolled assessments which were not considered as a reliable indicator of student competency in the subject.

The questionnaire sought to provide an initial view on whether flipped learning could be useful by measuring a few parameters that could influence student engagement. It was composed of three parts. The first part was a series of demographic questions to determine the respondents' age, course, gender, achievement to date, proficiency in English and time spent studying. The second part was designed to determine the students' views and preferences in regard to flipped and traditional learning approaches. It consisted of sets of two or three statementswith the respondents being asked to select which one they agreed with most. These statements are presented in Table 1 later in this paper. The statements were mixed so that statements favouring the flipped learning approach and those favouring the traditional approach were mixed between sets to minimise any favouritism that might have been conferred by statement order. The last part of the questionnaire contained open-

ended questions to allow students to provide comments on flipped learning and the course in general.

The questionnaire was anonymous so information that could have been used to identify individual students was not sought. This was necessary in order to encourage students to provide frank responses to the questions rather than saying what they thought the tutor wanted to hear. However the demographic questions in the first part allowed the responses of the second and third parts to be cross referenced to general subgroups within the class to determine whether there were any trends in the wide variety of students that made up the class.

Results and discussion

Test and Exam

Figures 1 and 2 show box plots for the Mid-Semester Test and End of Semester Exam marks respectively. The study cohort (BET 2013) is compared to the cohorts in 2012 (BET 2012) and 2011 (BET 2011) who did the same course using traditional methods. The top vertical line for each plot shows the range of marks for the top quartile. Likewise the bottom vertical line shows the range for the lowest quartile. The box between the lines shows the range of the middle half of the cohort with the middle horizontal line showing the median mark and splitting the second and third quartiles.
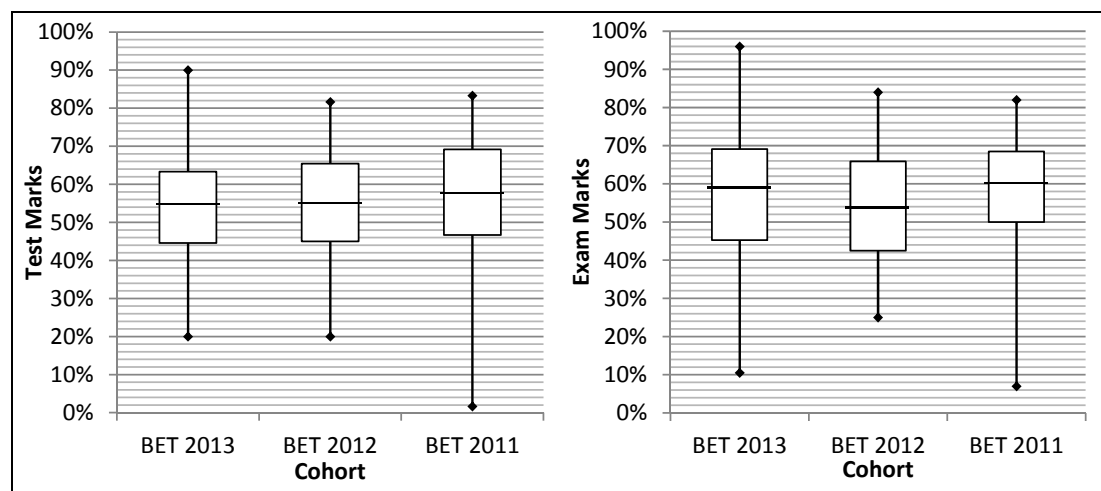

Figure 1 - Mid-semester Test Results   Figure 2 - End of Semester Exam Marks

The comparisons of the test and exam results showed no improvement in student performance in controlled assessments across the cohorts. Both the ranges and median marks of all cohorts only vary by a few percent which is not significant given the coarseness of the comparison methodology. The upper and lower quartiles appear to vary more but this is due to exceptionally good or exceptionally bad results extending the range rather than any consistent trend. Further analysis of the results did not indicate any improvement in the performance of ESL (English as a Second Language) students as indicated by Pinder-Grover et al (2011). There were also no significant changes in the performance of other demographic groups.

The comparisons in Figures 1 and 2 would indicate that the study cohort had achieved about the same level of understanding and ability as the previous cohorts had using traditional learning methods. The flipped learning approach did not appear to achieve improved performance. It is noted that it also did not cause any reduction in performance so the use of flipped learning did not disadvantage the students.

There are several possible reasons for this lack of improvement. The most obvious is that flipped learning does not provide improved performance. This would indicate that there is

essentially no difference in how well students understand and apply the course content whichever approach is used. However a more likely explanation is that the course was not delivered in a way that would allow the claimed advantages of the flipped learning approach to yield better performance. In particular the tutor was not experienced in implementing active learning and the students were not used to having a more active role in class. Many class activities did not really work with many students just sitting and waiting for the answers to be presented in discussion rather than engaging in the problem solving and discussion required to improve their understanding of the content. Future classes will require more intensive and informed management of the class activities by the tutor to try to get more students engaged.

The presentation of the content may also have been an issue. The content was presented in a series of narrated slidecasts. This format is not interactive and requires the student to passively sit and watch 30 to 60 minutes of video. Many students may well have found that a chore rather than an exciting learning experience that they wanted to do. This was indicated by the Moodle activity logs that showed a significant decrease in the viewing of the slidecasts for topics that did not have quizzes. Students had to download and view the slidecasts to be able to answer the quiz. When no quiz was set, many did not download the slidecast and presumably did not view it. They turned up to class with no knowledge of the content.

The comparison method is also rather coarse in than it assumes the students sitting the test and exam were of the same level of ability and motivation between years. Further examination of this assumption indicated that the 2011 BET cohort seemed to have generally been more academically gifted and motivated than later cohorts as evidenced by superior grades in other subjects and by discussions with other tutors. This may explain why that cohort scored well despite being taught using the traditional method.

Another assumption was that the tests and exams used to assess the cohorts were of the same level of difficulty between years. The exam papers were examined and appeared to be of similar difficulty. In addition, a series of common questions were identified between exams. These were questions that examined specific concepts with just the wording changing slightly. The performance of students in these common questions reflected the differences shown in the analysis of the whole test and exam mark. That is the 2011 cohort scored highest followed by the 2013 cohort and then by the 2012 cohort. This would indicate that the exams and tests were of simular difficulty.

Questionnaire
The questionnaire was administered in one of the last classes of the semester. It consisted of three parts designed to elicit data about the respondents' demographics, views on flipped learning and allowed students to make their own comments on flipped learning. Thirty one students (70% of the total class) filled in the questionnaire with some respondents choosing not to answer all questions. Table 1 sets out the statements and responses for the second part of the questionnaire. The responses that favour the flipped learning approach are highlighted.

The results shown in Table 1 were cross referenced to the demographic responses from the first part of the questionnaire. Preference or aversion to the flipped learning approach was evenly distributed across all demographic groupings. However it is considered that the coarseness of some of the demographic groupings and the relatively small size of the sample may hide some correlations. For example, the "English as a second language" grouping included students from a wide variety of cultures each represented by just a few students. It may be that some cultural groups actually do have strong collective views on the flipped learning approach that were not picked up by the research.

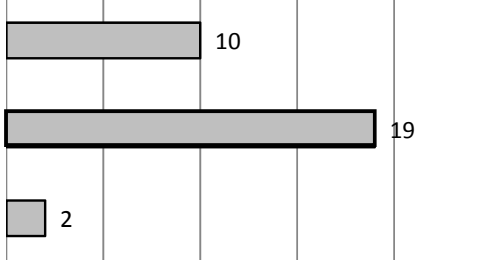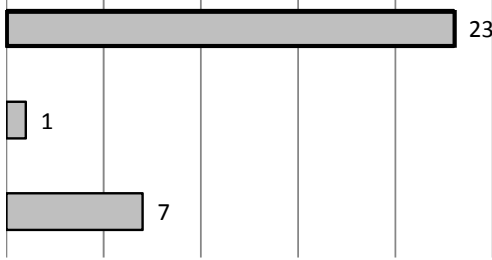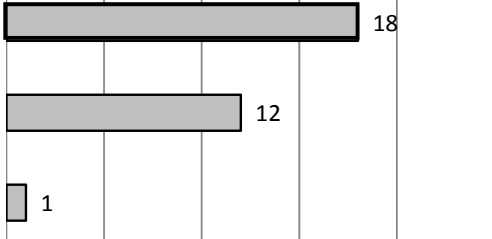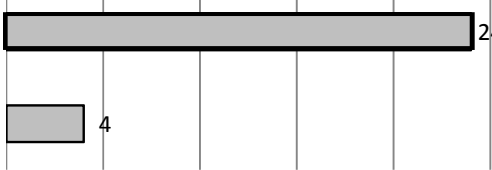**Table 1 - Questionnaire results**
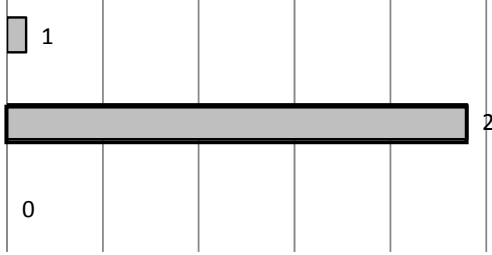
Statement	Responses
I prefer having a topic presented in class.	10
I prefer learning about a topic before I go to class and then doing related activities in class	19
I have no preference for either approach.	2
I better understand engineering management because of the flipped classroom approach	23
I think I would have better understanding of engineering management if it had been presented using the traditional approach.	1
I think I would have about the same level of understanding about engineering management whatever approach was used.	7
The flipped learning approach made the course more interesting.	18
The flipped learning approach did not make any difference to how interesting the course was.	12
The flipped learning approach made the course less interesting.	1
I feel more confident about passing the course because we used a flipped learning approach.	24
I would feel more confident about passing the course if we had used the traditional approach.	4
Unitec should only deliver classes using the traditional approach.	1
Unitec should deliver more classes using the flipped learning approach.	24
Unitec should deliver all classes using the flipped learning approach	0

Table 1 indicates a consistent preference by the majority of students for the flipped learning approach over the traditional approach. The majority of students considered that the flipped learning approach helped them understand the course content better and made the course more interesting. They also felt more confident about passing the course and preferred to have the content presented before the class sessions.

In the last set of statements the majority of students considered that Unitec should deliver more courses using the flipped learning approach. However it is interesting that no students selected the last option which was that Unitec should deliver all courses using the flipped learning approach. In the third part of the questionnaire, some students commented that

they considered some courses were better presented with the traditional approach with one student naming maths and structures papers as requiring a traditional approach. While he did not elaborate, it is possible that he was referring to the fact that a significant part of the teaching in these courses involves the tutor working through maths based answers on the board with students following. However it is noted that other institutions are successfully teaching these maths based subjects using the flipped learning approach. It may be that the Unitec   students view that some courses cannot be taught using the flipped learning approach may be simply because they have never experienced such a course.

The questionnaire also invited comments from the students about what they liked and did not like about Flipped Learning and how they felt the course could be improved. Many of the positive comments revolved around being able to review a topic before class making class time more productive, being able to repeat parts of the slidecast that they did not understand, having the slidecasts available for exam preparation, being able to study when they wanted and being able to learn the content at their own pace. A few students mentioned that they like the online quizzes as they helped them test their knowledge and asked for more.

One advantage noted by several students was that having regular slidecasts and quizzes forced them to keep up with the course work which they considered to be an advantage. Interestingly other students considered that the forced pace of the course was a disadvantage as they wanted the freedom to set their own pace and concentrate on other subjects at times. The issue of work overload dominated the negative comments with some students saying that they found it hard to find the time to work through the slidecasts and do the quizzes. While many students did not like being forced to work at a set pace it does seem to have contributed to the fact that no students dropped out of the course after the second week. Usually the course has several students dropping behind and eventually pulling out before the end of the semester. The forced pace seemed to have a positive effect on retention however further work is required to check this.

It is also noted that this improved retention rate meant that some of the struggling students stayed on to the end of the course and sat the exam which they may not have done in previous years when the traditional approach was used. This may be one reason why there is no discernible improvement in student performance when measured by exam marks. In the comparison cohorts the less able students did not sit the exam and did not drag the class median down as may have been the case with the study cohort. Once again this observation requires further investigation.

Another issue raised by several students was that the slidecasts could be boring at times and the suggestions section was dominated by pleas for shorter, more interesting slidecasts. Many of the slidecasts were indeed too long and boring because they tried to cover all of the content in one go - essentially the slidecasts were just online versions of "long boring lectures"... It is proposed to redo the slidecasts to make them shorter, to use graphics instead of text as much as possible, to get more movement using PowerPoint animations and to incorporate short videos of engineering work in action to make the content easier to understand and to make the slidecasts more interesting. The content of the slidecast will also be reduced so that the slidecasts present the important concepts rather than trying to present everything. The detailed content will be supplied in multimedia notes that will accompany the slidecasts.

Other comments focused on how the class groups operated with some students feeling they were left out of the discussions and one student even feeling the group discussions just made him more confused about the subject. This is another reflection of the failure of the in-class active learning processes to engage all students.

Conclusion

Unitec delivers NZDE and BEng Tech courses to approximately 400 students. Increasing student numbers, reducing resourcing and increased industry requirements have provided

challenges that need to be addressed in order to continue providing a high quality education. One approach that is being considered is the use of flipped learning to allow the advantages of the internet as an information dissemination and communication medium to be fully utilised. Flipped learning allows the content of the course to be presented online before classes leaving time for active learning approaches in class to allow students to explore the content in more detail gaining a better understanding of the content and its application to real world engineering practice. However, conversion to the flipped learning approach requires a significant amount of time and resources to implement. This expenditure needs to be justified by improvements in student outcomes.

An existing engineering management course was converted to the flipped learning approach over the period of two years. Student outcomes such as performance in tests and exams, perceived improvements in understanding and interest and student preference for the flipped learning approach were measured by the comparison of test and exam results with previous year's cohorts and with a questionnaire. The comparison of test and exam results indicates that there was no change in performance. However, this is not an unequivocal indication that flipped learning does not improve performance as the course did not fully utilise the full benefits of flipped learning especially in the application of active learning in the class sessions.

Students' views on flipped learning were sought in a questionnaire given to the study cohort at the end of the semester. This questionnaire showed that the majority of students preferred the flipped learning approach for the course. They felt it helped them to understand the course content better and made the course more interesting. They liked the flexibility in being able to learn when and where they liked, knowing about the content before they attended class and the ability to replay a lecture.

The study demonstrated an enthusiasm for the flipped learning approach in the student population. There were no performance changes but this could be because of deficiencies in the course delivery rather than any issue with the flipped learning approach. The conclusion from this study is that the flipped learning approach is worth developing but the course delivery needs to be improved.

References

Frederickson, N., Reed, P., & Clifford, V. (2005). Evaluating Web-supported learning versus lecture-based teaching: Quantitative and qualitative perspectives. Higher Education, 50(4), 645-664.

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. The Journal of Economic Education, 31(1), 30-43.

Pinder-Grover, T., Green, K. R., & Millunchick, J. M. (2011). The efficacy of sceencasts to address the diverse academic needs of students in a large lecture course. Advances in Engineering Education, 2(3), 28.

Strayer, J. F. (2007). The effects of the classroom flip on the learning environment: a comparison of learning activity in a traditional classroom and a flip classroom that used an intelligent tutoring system) The Ohio State University

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