Experiences with flipped learning in subjects in consecutive stages of a Civil Engineering programme

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CONTEXT
Flipped learning is an instructional approach which allows instructors the opportunity to use a blending of online and face to face learning activities. The main affordance of flipped learning is the opportunity to free up class time to allow students and instructors to engage in collaborative learning activities designed to consolidate and deepen conceptual understanding of the subject material. Research has shown that participating in flipped instruction can change the way students approach their studies and improve motivation.

PURPOSE OR GOAL
We are interested in students' experience of the flipped environment, particularly their expectations of a learning environment, and the level of responsibility they take for their own learning. The purpose of this analysis is to create a baseline against which future instances of flipped learning can be compared.

APPROACH
Student perceptions of flipped instruction were investigated through survey responses and observations of students in a first year subject (Engineering Mechanics) a second year subject (Engineering Computations) and a third year subject (Construction Materials) in a Civil Engineering degree programme. In particular, students were asked to explain the impact of the flipped activities on their learning experience including any changes in how they approach their studies or managed their time.

OUTCOMES
Most students in each of the three subjects agreed that they 'liked' flipped instruction compared to the traditional lecture format. The majority of students in each subject also agreed that it is reasonable to expect students to prepare before attending a face to face session. However, some students made strong negative comments demonstrating how the flipped environment did not meet their expectations of how learning should be organised. This study suggests that students in the second and third year subjects were not necessarily showing signs of better self-regulation and time management skills or being more comfortable with taking more responsibility for their own learning.

CONCLUSIONS
Flipped learning challenges students to develop metacognitive skills such as time management, self-regulation and self-evaluation, while providing opportunities to deepen conceptual understanding of the subject material. Given the different experience of students, both within a particular subject and between subjects at different stages of their degree, we need to provide scaffolding to assist students to understand how to make the most of these learning opportunities, including how to approach them, evaluate their learning, develop their judgement and the required learning skills.

KEYWORDS
Flipped instruction, curriculum development, student experience, civil engineering

Introduction

Flipped learning is an instructional approach which allows instructors the opportunity to use a blending of online and face to face learning activities. The main affordance of flipped learning is the opportunity to free up class time to allow students and instructors to engage in collaborative learning activities designed to consolidate and deepen conceptual understanding of the subject material. Research has shown that participating in flipped instruction can change the way students approach their studies and improve motivation.

We are interested in students' experience of the flipped environment, particularly their expectations of a learning environment, and the level of responsibility they take for their own learning. The purpose of the analysis presented in this paper is to create a baseline of student response to flipped learning against which future instances of flipped learning can be compared.

Background

While flipped instruction has been used in school classrooms and humanities subjects in higher education for many years, it has more recently come to the attention of science, engineering and technology instructors.

There is consensus in the literature that lecturing is not the most effective instructional method and that active learning activities are more effective (Lord 1994, Prince 2004 and Mazzolini & Daniel 2014). Flipped instruction makes time for active learning activities in face to face class sessions by moving much of the content transmission to before the face to face session typically through online resources such as readings, videos, simulations and/or quizzes. Everett et al (2014) report that continuing to lecture in class when online resources are provided for preparation resulted in minimal preparation by the students i.e. this practice reinforced negative preparation behaviours. They tried to compensate for poor engagement with pre-class resources by allocating marks to online quizzes. They report that students then did the pre-work only to the extent they needed to to accumulate the marks for these quizzes rather than learn the material. In other words the marks encouraged an attitude of compliance and mark acquisition rather than learning, as students skimmed the resources for the quiz answers.

Azemi (2013) observed increased exam grades and student engagement in face to face sessions which now involve much more problem-solving and solving of more complex problems than in previous versions of the subject on electic circuits. Amresh et al (2013) are continuing to investigate how best to increase student engagement with their pre-lecture material having drawn attention to the potential for student learning culture to be an obstacle to successful implementation of flipped learning. They report improved assessment results and increased self-efficacy in their introductory computing subject.

Self-efficacy is an important factor in determining how a student engages with the learning opportunities provided in the context of being enrolled in a subject at university. Unless a student believes they have the capacity, including understanding, judgement and/or skills, to learn from flipped activities they are unlikely to have the incentive to engage or persevere when difficulties are encountered (Bandura, 2001). Self-efficacy becomes more important since typically the design of flipped instruction gives students more responsibility for and independence in their learning.

Having to take responsibility for their own learning can be problematic for recent school leavers. Studies in transition pedagogy (Kift et al. 2010, Scutter et al. 2011, Brinkworth et al. 2013) illustrate the gap in expectations between first year students and instructors in relation to the amount of study (outside of class time) students should be undertaking when enrolled at university. Recent school leavers entering university also felt that school had not adequately prepared them for university study (Brinkworth et al. 2013).

Hence given the different experience of students, both within a particular subject and between subjects at different stages of their degree, we need to assist students to understand how to make the most of these learning opportunities. In establishing a baseline for student perceptions of flipped instruction, this study points to aspects of the flipped learning environment that need our particular attention when deciding how to scaffold these learning opportunities.

Our approach

We will first briefly describe each subject before we describe the survey which was deployed in each subject towards the end of Autumn semester 2014. The three subjects that are the focus of this paper are all compulsory subjects for students studying the Civil Engineering or Civil and Environmental Engineering programs at the University of Technology, Sydney. Engineering Computations is also compulsory for students in the Mechanical Engineering program. For Autumn semester 2014 most of the students in these subjects had not previously experienced a flipped learning environment.

Engineering Mechanics (1st year) addresses the concepts typically included in a first year mechanics course. The first author has been teaching this subject for many (more than 10) years. Autumn 2014 semester was the second time that substantial sections of this subject were flipped and there were 110 students enrolled. Students were expected to engage with the content each week by reading the relevant sections of the specified textbook, watching short videos and answering a set of online questions before the nominal lecture session. After the lecture session they were expected to attempt tutorial questions before attending a face to face tutorial session. Each week two types of videos were posted. The first type explained that week's content and the second type showed the instructor's process in solving example questions in a 'think aloud' way (Litzinger et al, 2010). During the nominal lecture session students worked collaboratively with each other and the instructor to explore and solve problems chosen to illustrate particular aspects of the week's concept, or completed formative assessment tasks aimed at allowing them to determine what they didn't yet know at the required standard.

Engineering Computations (2nd year) addresses fundamental concepts/theory and applications for computations and aims at building engineering computational skills and ability in solving disciplinary related problems for mechanical/civil/environmental engineering students. The subject content covers numerical methods, programming fundamentals, Excel spreadsheet and Visual Basic programming as well as applications of these tools for problem solving. The fourth author has been teaching this subject for many years. On average the subject has 200 students enrolled per semester. The recent development of the subject provides students with a series of learning activities including pre- and post- lecture as well as in-class activities throughout the semester. The activities are monitored by an 'activity gauge' which produces an individual weekly report for each student with his/her ranking, a track of learning activity attempts to date and class statistics. Subject resources include study guides, instructional videos, online resources and online quizzes.

Construction Materials (3rd year) covers common materials used in construction and aims to provide students with a basic and fundamental understanding of these materials in relation to their engineering properties and behaviour in a range of applications. In Autumn semester 2014 there were 175 students enrolled in the subject and, for the first time, the four tutorials were converted to flipped interactive sessions. Students were requested to attempt a set of worksheet questions prior to attending each tutorial session. During the tutorials, a collaborative learning environment allowed students to discuss in small groups the probable answers to the questions asked by the instructor. A learning dialogue then took place between the students and instructor in which the responses from students were further developed and interrogated. The importance of using a problem-solving approach to unfold the intricacies of challenging questions was emphasised. As a supplement, the instructor asked students to consider a change in parameters to practice sample questions outside of

the classroom. At the conclusion of each tutorial session, students were asked to complete a formative online quiz. The online quizzes were designed to allow students to engage in the different styles of questions to expand and enhance their problem-solving skills. The objective was to foster self-learning whereby students could evaluate their performance against examination content.

After securing institutional ethics approval, student perceptions of flipped instruction were investigated through an online survey which was made available to all students in these subjects from week 12 to week 14 of a fourteen week long semester. The survey consisted of a series of four point Likert scale and free response questions very similar to those described in Willey & Gardner (2014a) and a companion paper at this conference (Willey & Gardner 2014b). In particular, students were asked to explain the impact of the flipped activities on their learning experience including any changes in how they approach their studies or managed their time. From Engineering Mechanics 13% of students (14 of 110) responded to the survey, 12% of students (27 of 219) from Engineering Computations responded and 17% of students (29 of 175) in Construction Materials responded. For comparison between Likert scale questions the Strongly Disagree and Disagree responses have been combined to give a general 'disagree' response and the Strongly Agree and Agree responses were combined for a general 'agree' response. Comments from students are used to illustrate the findings and indicate the subject in which that student was enrolled: Construction Materials = CM; Engineering Computations = EC and Engineering Mechanics = EM.

Results and discussion

Most students in each of the three subjects 'agreed' that they liked flipped instruction compared to the traditional lecture format – 64% in Engineering Mechanics, and 67% in both Engineering Computations and Construction Materials. Most also 'agreed' that flipped instruction had a positive impact on their learning experience – 71% in Engineering Mechanics, 78% in Engineering Computations and 63% in Construction Materials. The results for Engineering Mechanics and Engineering Computations suggest that some students who didn't necessarily like flipped instruction admitted that it had a positive impact on their learning.

Students who responded favourably to flipped instruction appreciated being able to access resources when at their convenience and thought it was an effective use of their time:

The flipped learning approach is better in a way that it allows us to look at the materials available in our own time so to gain more time in clarifying our queries with the lecturer during contact hours.[CM]

It provided more opportunity for me to spend more time with the subject regardless of other commitment with other subject. [EC]

...liked it because more time was spend on questions during lecture time [EM]

However, one student felt the face to face time was insufficient:

... the provided time for class is not enough particularly for this subject, there is huge amount of information included in this subject but only 1.5 hrs class in 2 weeks. its just not enough. [CM]

Instructors have felt this pressure too. Since students are able to engage in problem-solving in class they start to question concepts at a deeper level than typically happens in a traditional lecture and these deeper questions often need more time to explore.

Other students' complained about the extra time they now needed to spend on their studies. Flipped instruction does not impose extra time commitments on students; it is just more obvious when students don't put in the time they should be spending on their studies during the semester anyway:

...the good thing about the old system was all your learning happened in the allocated times on your time table, now we are being asked to get a weak grasp of knowledge in class and then develop that at home. this not only takes significantly more time for the same results but wastes time searching for the material online through various "flipped learning" websites eg uts online, spark notes, uts libary. [EC]

...the problem with flipped learning is, studying full time uni is supposed to equal full time work, but as a student we also need to work jobs to pay rent, food etc. This equates to hypothetically 7 days a week full time work, plus every human being need a social life on top of that. [EC]

Students liked flipped instruction because the process helped them learn the subject material:

I like I a lot because it got me more involved and the more I got involved the more the material seems to stick with me. [CM]

the online quizzes it a good platform for me to studied some key concepts and also learn new ideas. [EC]

I like the fact that we could first get an idea of what we were going to learn with worked examples through the video and then the lecture could be dedicated to more in depth questions we would have trouble with in exams. [EM]

However, there were several strong objections to not having traditional lectures where the instructor presented the material and provided worked solutions to many example problems:

I strongly dislike the flipped learning approach. I believe the content of Construction Materials is very comprehensive and requires a more face to face approach to ensure that concepts are grasped. Also while there are some resources online I believe that there should be more stuff like for instance Detailed Tutorial Answers with working out.[CM]

I still believe that face-to-face contact is critical and that lectures are best presented and understood in the lecture theatre rather than online. [EC]

If I'm learning new content, I prefer when its taught to me instead of me having to teach myself. [EM]

This inability of some students to learn on their own and/or their attitude that it is not a skill they need to develop is a recurring theme and discussed further later in the paper.

Students also liked the motivating effect of the flipped learning environment:

It was good because it mixed up the learning and allowed for more engagement as opposed to the same monotonous lectures. [EC]

... it encourages students to be organised and pro-active with learning, plus provides an opportunity to have questions answered during the learning process, as opposed to it happening at a later stage...[EM]

Students commented that the online resources were useful for students who could not attend every face to face session, or for whom English is not their native language:

It was helpful since I was not able to attend every single lecture or class due to various reasons. This approach helped me catch up on work without relying on notes taken by fellow students. [EC]

It's quite good for the students whose English is not good like me. I can rewind the video when I don't understand something, but I can't rewind the class time. [EM]

The numerical results for the survey questions relevant to this study are shown in Table 1: Student Expectations and Table 2: Self-management and Self-efficacy perceptions.

Table 1: Student Expectations

	Engineering Mechanics n=14 out of 110		Engineering Computations n=27 out of 219		Construction Materials n=29 out of 175	
	Disagree	Agree	Disagree	Agree	Disagree	Agree
I think it's reasonable to expect students to engage with material out of class that has not yet been discussed in class if resources such as online videos are provided.	36%	64%	52%	48%	31%	69%
I think it's reasonable to expect students to find their own resources in addition to those provided by the instructor to support their learning.	50%	50%	33%	67%	50%	50%
I think it's reasonable to expect students to prepare before class for in-class learning activities.	14%	86%	22%	78%	23%	77%

The low number of responses prevent us from making definitive statements, however, the results are indicative, providing us some initial issues to address and in line with results from other undergraduate engineering classes (Willey & Gardner 2013).

From Table 1 we can see that the majority of students in each subject agreed that it is reasonable to expect students to prepare before attending a face to face session. However, there is much less agreement that this is reasonable if the material has not been discussed in class beforehand, and there is significant resistance to the idea that students should be finding supplementary resources themselves.

Most students think it is reasonable to expect them to prepare before class because it helps them learn the material, even material that has not yet been discussed in class:

I think we should prepare before class to participate with them. if not, we are getting only the answers not the ideas [CM]

Most students will appreciate the availability of resources online since it gives them a chance to understand the topic which will be discussed in class beforehand. This is essential in helping me improve in areas of the course in which I had difficulty with. [EC]

I used those videos to prepare, and that worked.[EM]

Not having enough time was a common reason that students thought it was unreasonable to expect them to prepare for lectures:

The students have to organize their times for many things, not only this subject [CM]

This depends on the student, some students may have enough time to prepare for the class and others may not due to work commitments. [EC]

This is unreasonable because when I sit down to teach myself a new topic, it takes a lot of time whereas if I'm doing homework or something like that I can do it in shorter time periods. Out of class I have limited free time and never a long enough time to teach myself entire new topics. That's what the three hour lectures are meant to be for. [EM]

Some students thought it unreasonable to expect students to prepare for class because such a process was not how they thought subjects should be organised:

The in-class learning is for learning and being introduced to new material and shown how to use that material correctly. Post-class reinforcement should be done. Expecting students to have knowledge of the material before it is properly introduced is a little unreasonable. [EC]

Other students agreed that it is reasonable to expect students to prepare but such an expectation is contrary to common student 'culture', or what they are paying for:

i think it's reasonable to expect it, but don't be surprised when very few actually do. To change this approach to learning would involve a complete overhaul of the current student culture and attitude. I am a firm believer in the more times you are exposed to material, the more likely you are to understand it. So I do think pre-class preparation is important but to

make it effective, you must attach some sort of mark to it for the majority of the student body to engage in it. [EC]

I don't think it's reasonable. We pay go to University to be taught and to learn from the lecturer, not to told that the material we need to learn is to be taught by ourselves online. I believe student will be put off by this and not be bothered to learn that material. Also i believe the student may have difficulties trying to understand the content. If the material is gone through class, but also put up online with addition/extra material then I'd find that more beneficial. [EC]

Online resources should be supplementary to class material. It is very difficult to understand brand new concepts in an environment where there is no opportunity for interaction. I also feel that this approach will result in a larger number of students failing as only disciplined students will make the effort to look online. Classroom first, then online after for students to deepen understanding. [EC]

Students are lazy in general and won't do things unless in dire straits or unless its compulsory or marked. Also the fact that it is "there" means that for some students, they can always look at it "later". i.e We need to be force or tricked into using the out of class material. [EC]

The issues of 'not enough time' and student culture were again apparent in their responses to the idea of finding their own resources, unless it's in relation to a summative task. As with comments on the previous question it is the second and third year students who provide a more negative reaction:

It is partially reasonable but I believe that sometimes it can get really hard and time consuming to find resources on our own. The time that the students utilises when finding resources can be used in understanding the concepts more. [CM]

Unless it is for an assignment, a teacher/lecturer should have the responsibility of providing all the necessary information for a student to study. Unless they choose to provide external reading data. We pay hefty uni fees, we expect to receive what we are paying for. Teachers should encourage individual study, but not force it upon us. [CM]

With computers, no, because it can take hours and hours and hours trying to find something online that can be learnt in 5 minutes. We are paying for this tuition, so why not provide resources in a more compact form, rather than make us search high and wide for them? [EC]

We are paying a lot for the uni to give us the education so they should provide the resources. [EC].

These attitudes are reflected in the responses and student comments to the questions shown in Table 2. They point to student resistance to accepting responsibility for their own learning. Even students who agreed that they did take more responsibility for their learning were unhappy that they had to do so:

I strongly agree because there are more resources published online and students are expected to do more self study before and after contact hours. [CM]

Yes, I agree with this. I feel I need to keep on top of my work more than usual than other subjects that did not do this style of learning. However, I did not like this because I found it more difficult to learn and teach myself the content. Like I stated before, I pay to go to university to be taught and to learn from the material presented, not to go to university to do the work and to learn and teach all the content to myself. [EC]

makes me feel that university should pay me to work for them, understand everything myself, keep track of my own performance and when i will pass out with good marks then university will say.... wohooooo... we made a really good engineer and our teaching methods are really great. [EC]

Since this model has made it easier to fall behind, yes, a much greater responsibility exists for individual learning. [EM]

Table 2: Self-management and self-efficacy perceptions

	Engineering Mechanics n=14 out of 110		Engineering Computations n=27 out of 219		Construction Materials n=29 out of 175	
	Disagree	Agree	Disagree	Agree	Disagree	Agree
Compared to the more traditional lecture/tutorial approach flipped learning has made me feel I am more responsible for my own learning.	21%	79%	7%	93%	33%	67%
Flipped learning has required me to better manage my study time compared to previous traditional style subjects I have undertaken	43%	57%	30%	70%	43%	57%
Having to undertake flipped learning has made me more confident that I can learn on my own.	50%	50%	33%	67%	53%	47%

The results in Table 2 suggest that students in the second and third year subjects were not necessarily showing signs of better self-regulation and time management skills or being more comfortable with taking more responsibility for their own learning. This could be because the third year subject, Construction Materials, was only partially 'flipped', while for the other two subjects flipping applied to the whole subject.

Although our survey indicates a positive response to flipped learning, some students made strong negative comments demonstrating how the flipped environment did not meet their expectations of how learning should be organised. These attitudes are in line with findings from other researchers in engineering education such as Bishop and Verleger (2013) who reviewed twenty-four studies of flipped learning and found that: "*Opinions tended to be positive, but there were invariably a few students who strongly disliked the change*" (p.9). These comments have recurring references to 'paying' to being 'taught' in lectures despite the literature finding that lectures are not effective for learning (Lord 1994, Prince 2004, Mazzolini and Daniel, 2014). Effectively dealing with student expectations about what we should be doing and what they should be doing is one of the potential obstacles to successful implementations of a flipped learning environment.

Increasing student engagement with the pre-class resources is a problem we are still wrestling with, as are other researchers (Amresh, Carberry and Femiani, 2013). Some of our students suggest we "*attach some sort of mark to it*". Bishop and Verleger (2013) report that many instructors have a marked quiz on the pre-class material which "*was touted as a highly successful practice*" (p.9). Everett et al (2014) report that in their study the main motivation for students to engage with the provided resources was to accumulate these quiz marks and that student preparation was often limited "*to the amount necessary to complete the online quiz*" (p.5), i.e. students may have been complying with the requirements to get marks, but they weren't necessarily learning the material in any depth.

We will be watching in future semesters to see if there are any changes to student perceptions of the flipped learning environment as they and we become more used to it.

Conclusions

Given the different experience of students, both within a particular subject and between subjects at different stages of their degree, we need to provide scaffolding to assist students to understand how to make the most of these learning opportunities, including how to approach them, evaluate their learning, develop their judgement and the required learning skills. The results of this study have highlighted to us specific aspects of flipping that we need to scaffold for undergraduates such as the time involved in learning for university level subjects, that active learning in class is more effective than passively sitting in lectures, but that this requires some preparation on their part for which they are responsible because we

are trying to facilitate the development of the skills they will need to keep learning as they enter professional practice.

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