Experiences with flipped learning in a postgraduate subject in civil engineering

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INTRODUCTION

The design of a flipped learning environment typically blends online and face-to-face activities. A major affordance of this type of learning environment is the opportunity to use class time for students and the instructor/s to participate in collaborative learning activities [1].

The consensus in the literature is that lecturing is not the most effective instructional method and that active learning activities are more effective [2–4]. Flipped instruction makes time for active learning activities in face-to-face class sessions by introducing subject content before the face-to-face session, typically through online resources such as readings, videos, simulations and/or quizzes. Previous research [5] showed that postgraduate students preferred the flexibility of flipped learning over traditional transmission-based subject design.

This paper describes how the postgraduate subject Concrete Technology and Practice at the University of Technology Sydney was redesigned to create a flipped learning environment. The focus of the flipped design was to develop students' contextual critical thinking skills and apply these skills to issues encountered in professional practice. This paper will focus on three key aspects of this

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transformation namely feedback, collaborative ways of working for students, and the time involved for the instructor.

1 BACKROUND

A variety of theoretical foundations and frameworks are used for justifying the flipped classroom. Typically, these foundations draw on one of several student-centred theories of learning. Such theories include constructivism and collaborative learning based around Piaget's theory of cognitive conflict [6], which give rise to problem-based and active learning literatures [7]. Co-operative learning is another example of a student-centred framework used in such learning theories, which draws from Vygotsky's [8] zone of proximal development.

In contrast, other researchers such as Zainuddin and Halili [9] have framed their study of flipped classrooms on Bloom's taxonomy in relation to the types of activities students engage in during class time: "*the learners focused on higher forms of cognitive work, including applying, analyzing, evaluating, and creating*." This suggests the potential for providing opportunities for the development of critical thinking skills during class time, which was one of the stated motivations for the change in subject design discussed in this paper.

The overall indications from previously reported studies [2-5,9-11] strongly suggest a predominantly positive response to flipped learning in relation to achievement, motivation, engagement and interaction. Researchers have also reported that the flipped model allowed for significant class time for problem-solving exercises [12]. Sickle [13] and Kim et al [14] highlighted the increased opportunities for feedback while students worked collaboratively to solve problems during class time.

The study reported in this paper is an example of practitioner-led planning, design and implementation of a learning innovation that contributes to the growth of literature evaluating the use of flipped instruction in higher education.

2 DESIGN & IMPLEMENTATION

The subject Concrete Technology and Practice was redesigned in line with the collaborative learning framework [15] as shown in Figure 1, and delivered in this format for the first time in the Autumn 2015 semester.

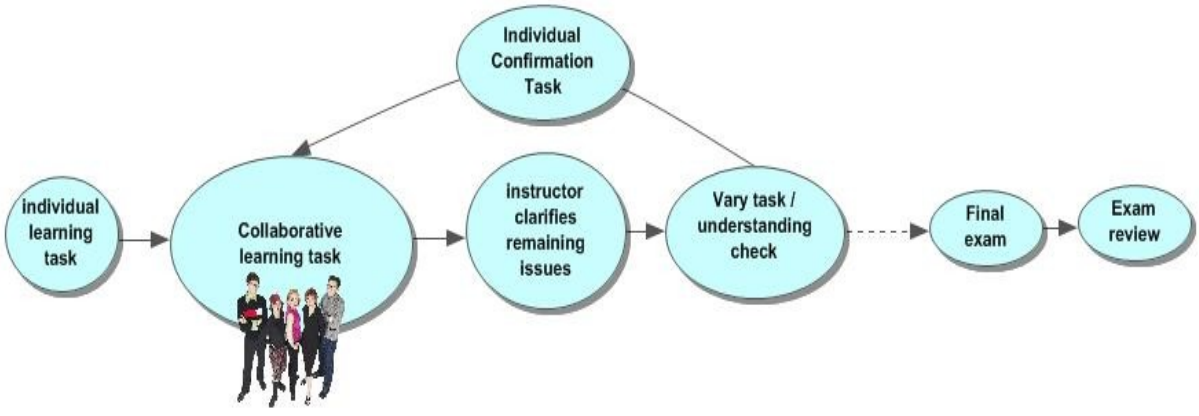

Fig. 1. Collaborative Learning Activity Framework [15]

In the framework in Figure 1 individual learning activities precede the face-to-face time which is used for collaborative problem-solving exercises. To allow students to meaningfully participate in the in-class learning activities, resources were created

and made available on the institutional learning management system (LMS). These resources included information in the form of slide-packs and videos as well as online quizzes, and constituted the individual learning tasks of the collaborative learning framework. Writing suitable questions for these online quizzes was both intellectually challenging and time consuming for the instructor as was creating the quizzes in the LMS. Students were instructed to access the information and attempt these online questions before the face-to-face sessions.

Students were then expected to collaboratively work on problems in class, which was facilitated in a number of different ways such as:

- All student groups worked on the same problem. Students completed questions individually, discussed their answers with the other students in their group and then explained their answer to the rest of the class;
- Groups worked on different problems or different aspects of the same problem, then students from one group would come out to the front of the room and the rest of the class would listen to the answers and explain why they either agreed or disagreed with the presented solution.

Additionally, the types of questions asked in quizzes and the final examination were changed to complement the new subject design by asking students to apply critical thinking skills rather than using purely descriptive questions.

The instructor and evaluator considered it an important aspect of the implementation that the instructor took time in class to explain to students why the subject was designed the way it was and how the instructor expected the students to benefit from the various learning opportunities provided.

3 EVALUATION

Student perceptions of flipped instruction were investigated through observation, questionnaire responses and focus group discussion with students and the evaluator. The questionnaire gave the evaluator some quantitative data but because of the small number of students in this subject its main purpose was to identify aspects of the subject design to explore in the focus group. The standard institutional student feedback survey also provided the instructor and evaluator with comments on the transformed subject. Examination scripts were studied for evidence of critical thinking and paired with each student's questionnaire responses to begin to see what the relationships were between the ways these students responded to flipped learning and the learning they could demonstrate. Reflections of the instructor and evaluator involved in this subject redesign are also included.

In line with ethical practice, the questionnaire and focus group was conducted by the evaluator who was not involved in marking the examinations and all data from the questionnaire and focus group was not available to the instructor until after the subject results had been published.

3.1 Student perceptions

Seventeen (17) students were present for the paper-based questionnaire, which was administered in class by the evaluator. Most of the students answered most of the questions, but some students did not answer some questions – respondent numbers are indicated where relevant. With a total enrolment of 23 students this represents a high response rate of 74%. However, the main purpose of the questionnaire was to seed questions for the focus group. Comments from the focus group are

incorporated into discussion of the questionnaire responses where this elaborates or clarifies the situation.

Table 1: Proportion of postgraduate students compared to undergraduate students

Students	Class enrolment (n=23)	Questionnaire responses (n=17)
Postgraduate	65%	59%
Undergraduate	35%	41%

From Table 1 it can be seen that there are slightly more undergraduate students represented in the questionnaire responses compared to postgraduate students. Table 2 shows that of the respondents to the questionnaire, most (90%) of the postgraduate students were international students and most (71%) of the undergraduate students were local students.

Table 2: Proportion of local and international students

Students	Postgraduate (n=10)	Undergraduate (n=7)
International	90%	29%
Local	10%	71%

As with most postgraduate subjects at the University of Technology Sydney the classes in this subject were held in the evening. This means that most students in this subject (both postgraduate and undergraduate students) were attending class after their work day. After the demographic questions, the questionnaire consisted of a series of questions aimed at assessing the student's engagement with various aspects of the subject and their attitude to engaging with these aspects.

Figure 2 shows the distribution of responses to the question of how often the students used the online resources provided. While 90% of the postgraduate students indicated that they always used the online resources, 57% of undergraduate students did so, and 29% of these students also indicated that they only used the online resources sometimes. This agrees with previous research [5] which suggested that the postgraduate students appreciated the flexibility of being able to use the online resources provided.

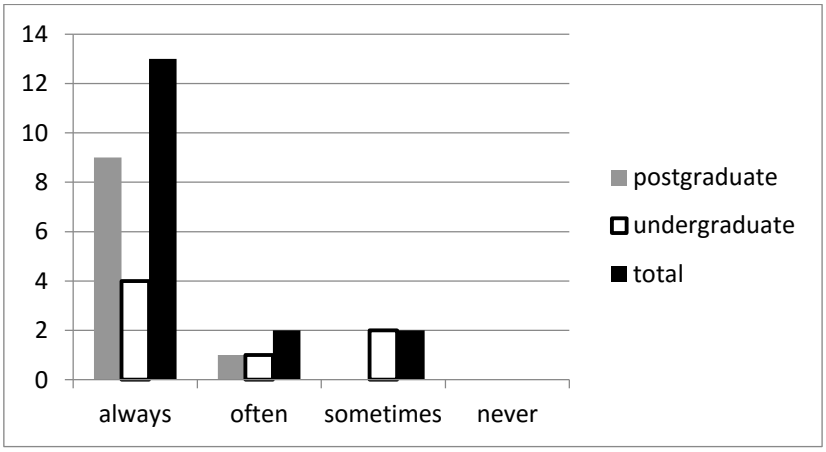

Fig. 2: Responses to the statement "I used the online resources provided in this subject..." (n=17)

Engagement with the online resources was also explored by asking students how the online quizzes influenced their use of these resources. Figure 3 shows that the most popular answer was that they studied the online lecture material closely and completed the online quizzes, referring back to the lecture material until they could answer all the questions – 60% of all students gave this response (56% of these were postgraduate students and 44% were undergraduate students). The reasons students gave for options 1 and 2 (see Figure 3) were:

"online resources help understand the content in detail and the students can get added knowledge from the prof. [sic] about the subject which adds as a bonus. Also it helps in self analysing and adds to more excitement in attending lectures";

"it is much better to understand what the lecture point is and to answer the quiz questions";

"the way I used the resources depended on my schedule. Mostly I went through online lecture material and then went through quizzes";

"to improve understanding and to analyse my knowledge by the marks I was getting";

"so I learnt the content, but also got good mark in the quiz. It let me realise the content that I wasn't confident about and improve my knowledge";

"by referring back to the lecture notes to get better understanding";

"this was a way to introduce myself to the topic and have an understanding of content and the information provided";

"get feedback from online quizzes to point out areas I need to work on", and,

"...I am being pushed to learn independently which actually helps. Was sceptical of the new process at first, but liking it more and more as I learn".

The above comments suggest that students were looking to understand the material and recognised the usefulness of the quizzes in providing feedback to their own understanding of specific topic areas. Feedback also featured strongly in the focus group. Students valued the multiple sources of feedback in this subject, one student commented that feedback in this subject comes from: "*everywhere*", i.e. from the online quizzes, from peers and from the instructor, before the class, during the class and after assessment submission. Other comments described sources of feedback in more detail:

"Well from here and sitting at the table and suggesting something and someone was saying oh yeah I agree or no, not really. The quizzes, speaking, like when you give that summary and someone had to get up at the end and present the answer to the question. "; and,

"Feedback on the specialty assignments is great. Very helpful."

Not all students demonstrated high levels of agency for their own learning. Comments such as the following from a postgraduate student: *I wanted to study the lecture material closely only after the lecturer would explain all my doubts,* suggest either a lack of confidence in their own judgement or an expectation of how formal learning should be organised. Beetham and White [16] also report some student dissatisfaction with flipped learning and attribute this to the students' expectations of what constitutes "*legitimate learning practice*".

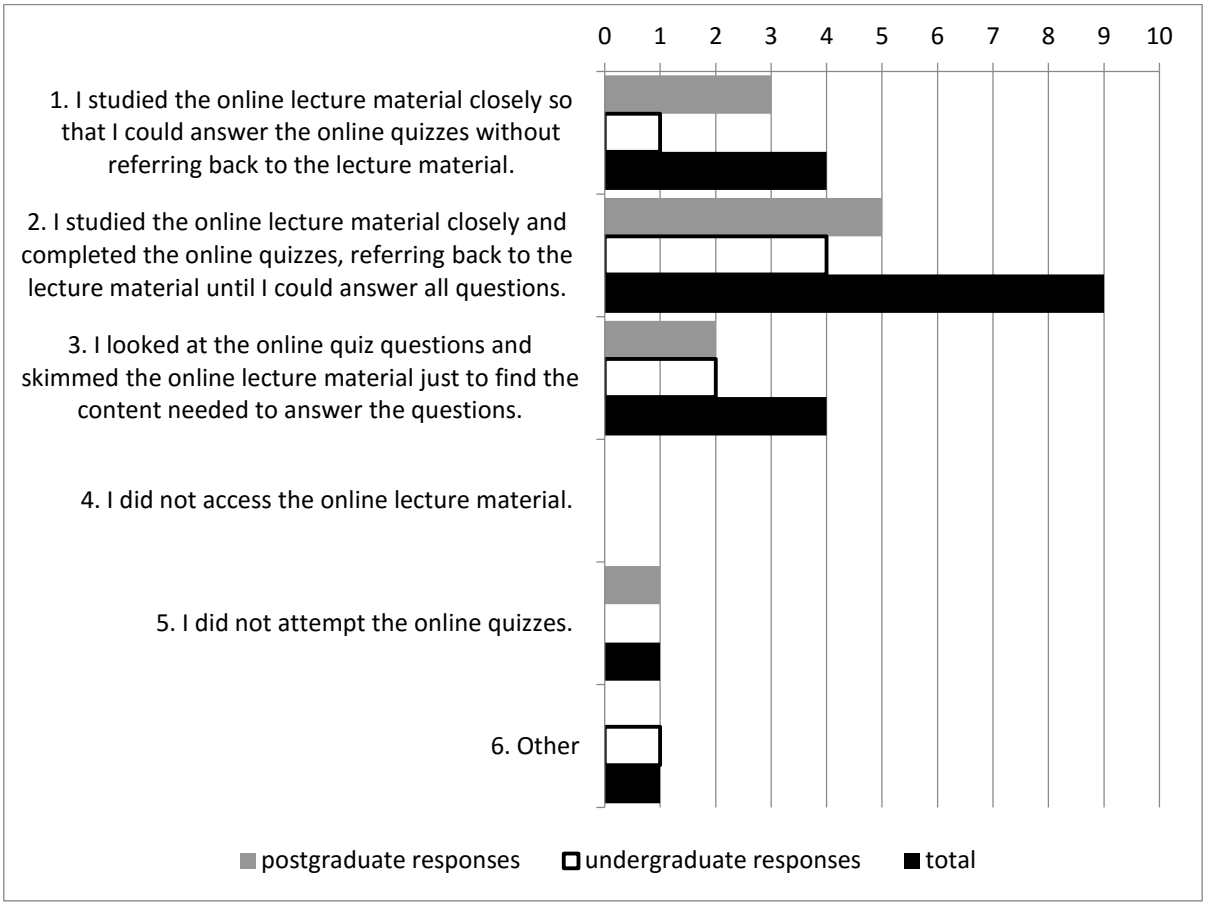

Fig. 3: Responses to the question "How did the online quizzes affect how you used the online resources?" (n=15, NB students could indicate more than one option)

There is a continuing argument amongst some instructors that students will only engage with an activity if there are marks attached to it. With this in mind, the evaluator asked students if they would have worked as much to get the quiz questions correct if there were no marks allocated to them. Figure 4 shows that most students (53%) indicated that that they would have worked at the same level to answer the quiz questions even if there were no marks attached. Student responses to the previous question showed that they valued the online quizzes for the learning and feedback opportunities provided. Most students who answered 'Yes' to this question were postgraduate students (78%) while most of the students who answered 'No' were undergraduate students (75%). This raises an interesting question of what makes our undergraduate students more 'marks' focussed rather than 'learning' focussed.

There was also discussion on the value of the pre-lecture preparation, including the use of the online quizzes, in the focus group. Students commented that having now experienced a flipped learning environment they could see the benefits, but they needed the personal experience to appreciate the value of the pre-lecture activities, for example:*"... like I did this and now I know the advantages then maybe next time when there are no marks I will do it. In the beginning I didn't know its benefits. I would rather do something else.*"

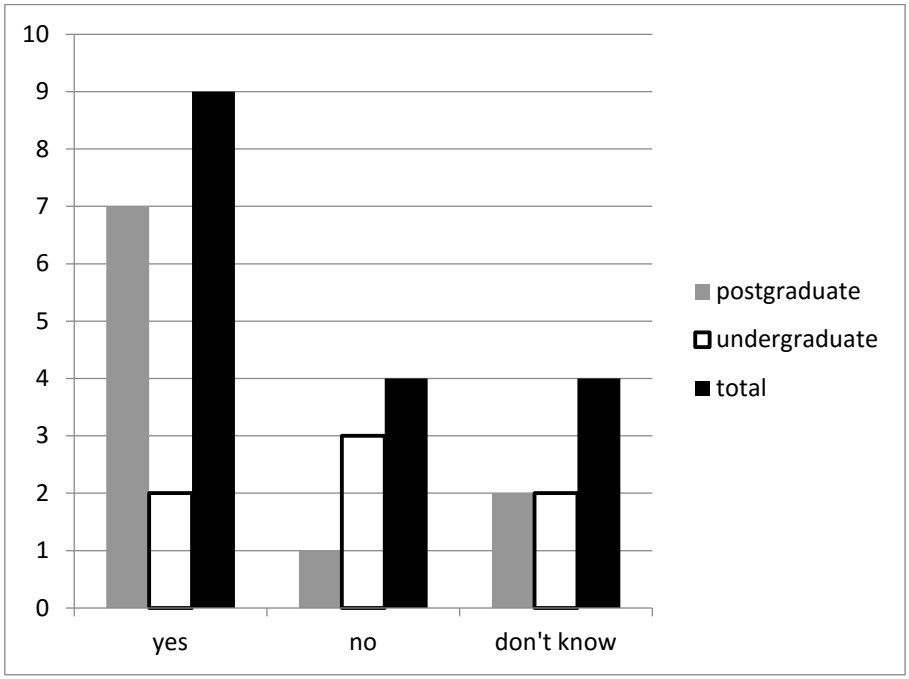

Fig. 4: Response to the question "Would you have worked as much to get the quiz questions correct if there were no marks allocated to them?" (n=17)

A key feature of the redesign of this subject was the introduction of in-class collaborative problem-solving activities. **All** students either agreed or strongly agreed that the collaborative problem-solving activities in class helped them learn the subject content because students were expected to apply this content to practical situations. Students commented that these activities helped them understand the content especially because of the opportunity to hear about different students' perspectives:

all people in class having different knowledge related to subject;

this activity is good, it helps in conveying your knowledge to others in a friendly way, and also we learn from others' point of view and experience it is good activity;

specifically understand the information;

discussion is better way to understand and remember;

practice always helps to remember learning material. Works the same way as laboratory tests;

get me to understand the content;

there is a lot of emphasis on justification which has broadened my understanding;

added in understanding the scope of the subject;

it provided an opportunity to interact and see different perspectives/way of thinking; and,

I had the opportunity to explain concepts I understood to my peers, and to have concepts explained to me by others.

Even those students who primarily focussed on marks could see the benefits of the collaborative exercises:

collaborating allowed answers to be discussed and made sure answers were correct; and,

group discussions to solve exam questions helped prepare for final exam.

Comments from the focus group elaborated further on student perceptions of the usefulness of the collaborative learning activities with benefits coming from their own personal involvement including learning from their own mistakes*:*

"You retain more information if you're doing it yourself...";

You get a chance to learn from your own mistakes : you know the right way when he teaches, but you also know the wrong ways in which you did it. So it's helpful.";

"Your thinking changes.";

"You start thinking...- it's always interesting to come to concrete. I'd rather not go to some engineering management lectures because I feel sleepy... but I make it a point, I don't miss concrete because I find it interesting."; and,

"...because you're actually every time involved in the class and you get something extra from the professor. Everywhere else you already know what you're going to get. It's the same module and everything is written, but here you get something else so it's good."

Some students commented that collaborative learning was **the** aspect of the subject that had the **greatest impact** on their learning.

Finally, as well as impacting on how students learnt in this subject, the potential of the flipped learning environment to impact on the way students learn in other subjects is demonstrated in the student comment that: *My approach towards other subjects has changed*.

3.2 Instructor perceptions and analysis

Questions on the final examination paper that particularly required critical thinking to create an answer were identified by the subject instructor. Student responses to these examination questions were studied. Those students who demonstrated critical thinking skills generally aligned with those who had engaged with the pre-class online quizzes suggesting that the quizzes had helped these students develop the skills necessary for the high stakes assessment activity:

...there is some relationship there that students are engaging more and more in the online quizzes as you go on from week to week but they also have an understanding of more of that style of questioning and being able to tackle that style of questioning.

The instructor also observed the benefits of collaborative learning activities for the students:

"I found it to be valuable for students because the interaction between themselves was very good particularly when they were put into groups and then they had to come up in front of the class and share that information with other groups. Then other groups were asked to actually give their feedback. So as an instructor, I could come in and sort of give students some direction where I could see they needed that direction but most of it was actually controlled by the students. That interaction I think really got them to see the differences in opinions between themselves. They had a clearer understanding like how another student would see this question."

From the instructor's perspective, it took a lot of time to create learning resources such as the learning material and assessment tasks. McGivney-Burelle and Xue [10] also comment on the significant time and effort required from academics to create resources and implement a flipped class, compared to a traditional class. The subject instructor, who had not flipped a class before, reflected that preparation took them

"*five times as long as what I thought it would take*". However, there is a potential for a return on this time investment the next time the subject is delivered.

4 SUMMARY

The redesign of the postgraduate subject Concrete Technology and Practice changed all aspects associated with the subject delivery as well as the skills required of both students and the instructor. Students could see the benefits to their learning from participating in a flipped learning environment.

Students made strong assertions about feedback in both the focus group and student feedback survey questions and comments. Student comments included that feedback in this subject comes from "*everywhere*", i.e., from the online quizzes, from peers and from the instructor, before the class, during the class and after assessment submission. Comments from the questionnaire and the focus group reinforced the learning benefits of the individual work followed by collaborative activities.

However, the subject instructor needed the time to make these changes and to reflect on and learn from each session as well as the overall experience.

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