Flipped teaching: finding room for interdisciplinary content and peer learning

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Abstract: Three years ago we introduced flipped teaching strategies to large cohorts of first-year university students learning about construction. Paradoxically, our aim in providing online content was to improve and expand the on-campus experience. By transferring lecture content online we were able to extend our two-hour face-to-face tutorials to three hours and also increase the interdisciplinary content in keeping with the spirit of our new undergraduate degree. The transition has not been without hurdles. Each semester we have refined content and adopted strategies aimed at consolidating and accelerating learning but we continue to be surprised by what students excel at and what they struggle with. As we begin our sixth experience of the flipped classroom, we are exploring the potential of learning analytics to promote a deeper understanding of core issues while concurrently struggling with the issue of students who come unprepared to classes. At the heart of this teaching and learning approach is the ambition for students to work collaboratively, bringing together knowledge across discipline domains and across learning styles and strengths. We see benefit in Eric Mazur’s iterative approaches to peer instruction to encourage deeper understanding of how structures, construction and materials interconnect into a knowledge system.

Keywords: Flipped teaching, learning analytics, peer learning, just-in-time teaching

1. Background to flipped teaching

We adopted flipped teaching in 2013 for our classes of between 230 and 360 first-year students who were learning about construction. It was an opportunistic decision made possible by a $50,000 teaching and learning grant. We had just three months to transform the way we taught. We anticipated difficulties but, surprisingly, our anticipated problems were easily solved. We found unexpected hurdles and each semester we continue to make changes as we gradually learn what works.

Flipped teaching is not a new idea. The physicist and educator, Eric Mazur, back in the early nineties saw benefit in moving the lower-order teaching activities involved in content delivery out of the classroom in order to free contact time for higher-order tasks such as the application and integration of learning (Mazur, 2012).
The change from conventional lecture and tutorial structure to a flipped approach is summarised in Figure 1: In-class and out-of-class delivery. (source: Author based on Steed) Flipped teaching, which is also referred to as flipped instruction, the backwards classroom and the reverse classroom, turns teaching on its head. Content that is normally delivered face-to-face is delivered online. Online delivery has advantages; students can learn at their own pace and time replaying segments that are complex or confusing as required. This can be useful for students whose first language is not English, particularly because the content includes the introduction of construction terminology, which may be unfamiliar. Flipped teaching is more than introducing a blended learning environment for students where online resources complement physical and face-to-face resources (Garrison and Kanuka, 2004). Flipped teaching is a strategy that enables students to be more active in class.

![Flowchart comparing traditional and flipped approaches to teaching](image)

Figure 1: In-class and out-of-class delivery. (source: Author based on Steed (2012).)

The idea of students as sponges or blank slates ready to receive the necessary knowledge of their discipline is outmoded and yet the lecture format has remained intact for the past 600 years. Mazur (2012) suggests we are in the twilight of the lecture. The University of Adelaide is the first Australian university to propose the entire university transition to flip teaching beginning with first year students; their plan is to shift away from lectures to online learning integrated with small group work. The Vice-Chancellor, Warren Bebbington describes the lecture format as obsolete, ‘my view is they’re gone; they’re never coming back’ (Dodd, 2015). His view is supported by a recent study which tested the hypothesis that lecturing maximised learning and student performance (Freeman et al., 2014). Based on a meta-analysis of over 200 studies it was found that active learning in undergraduate science, technology, engineering and mathematics (STEM) courses improved student performance when compared with traditional lecturing. Results of the meta-analysis suggested that traditional lecturing correlated with students being 1.5 times more likely to fail than were students in classes with active learning.

Active learning requires students to undertake higher-order learning activities. Taxonomies of higher-order and lower-order learning tasks have been compiled with the most famous known as Bloom’s taxonomy (Krathwohl et al., 1964). Rote learning through memory of content alone is considered as lower-order learning whereas integration, application and creation of new knowledge is recognised as higher-order learning.

2. An interdisciplinary approach to construction teaching

Our construction subject introduces structural principles, material properties and construction strategies. Previously these three strands had been taught largely in parallel, with engineers taking a
predominantly mathematical approach to teaching structures, while architects focussed on construction learning using detailing strategies. We found students did not translate the learning across the different domains once they went into later subjects. Flipped teaching has enabled a more interdisciplinary approach. Using flipped teaching we have developed a hands-on experimental and case-study approach within the longer studio times.

As well, all students come together as a group for six-weekly sessions in the theatre. These sessions lie at the heart of our interdisciplinary approach. Because we are no longer focussed on delivering content within the lectures, we are able to run panel discussions with designers, project managers, construction managers and engineers taking students through the process of transforming a design idea into a built reality. Students begin to understand how professionals collaborate across disciplines.

This interdisciplinary approach is challenging for students as it requires them to apply many disparate learning skills and strategies but it also opens opportunities for students to excel in a range of ways. Howard Gardner challenged the idea of intelligence being a single entity by identifying seven types of intelligences. Arguably our subject now includes learning across all of Howard Gardner’s (1999) multiple intelligences with the exception of musical intelligence. Structural understanding involves bodily-kinesthetic, logical-mathematical and learning from nature. Construction and material learning involves visual-spatial understanding and learning through verbal linguistic strategies. Inter and intrapersonal learning underpin the studio learning using group work and peer learning (including group quizzes) and the out-of-studio self-directed learning.

Learning occurs through reading, research, analysis, experimentation, testing and review. Increasingly we are getting students back onto construction sites as a rich learning environment even though there are increased logistical hurdles with large student numbers and increased health and safety constraints within the construction industry. Through exercises, site visits, model-making and research, students learn about forces and support systems, the key material groupings of metals, masonry, ceramics, polymers and timber and basic construction strategies.

The learning outcomes for students are an introductory understanding of how structural principles, material properties and construction systems underpin the form and fabric of the built environment. Students are expected to develop an appreciation of construction processes and detailing and begin to understand how these are communicated within working drawings. More broadly, students begin to appreciate the environmental implications of construction decisions and how construction links to the local circumstances of available materials and labour.

We understand that even though many of our students may not have attended a construction site or laid a brick, they still bring a deep knowledge of structural and material principles developed through their day-to-day living. Likewise it is no longer possible or necessary for students to grasp the complete knowledge set needed to be effective within the construction-related professions. Techniques and terms learnt within the first-year of a university course might be out-dated by the time they graduate as the industry shifts towards more off-site construction and new materials and processes. Online resources means that information is readily accessible and so rote learning seems to be no longer useful. Instead, students need to have the skills to search, analyse, understand and critique construction; this requires first-principle knowledge about structures and materials. Our aim in the course is effectively to develop their intuitive understanding of construction based on the principles of structures, material groups and qualities, as well as building performance in terms of heat, light, moisture, air flow, longevity, ease of construction, ease of use, safety etc. Students tell us that they
particularly value the hands-on learning of model building and testing as well as the learning from visiting live construction sites.

3. We made mistakes and encountered unexpected hurdles

Previously we had been giving two hours of lectures per week and these were always recorded and made available for students online. We found that many students were choosing not to attend the lecture classes, and preferred to listen online. By around the fifth week of the semester, the lecture theatre would only be one third full. For us this was a clear message that students could cope with flipped teaching approaches that would enable us to provide a richer on-campus experience using small-group strategies alongside a new kind of theatre experience. Instead of lecturing on content we were choosing to run six theatre sessions with demonstrations and panel discussions.

Things we thought would be hard were often easy but we sometimes found ourselves stumbling across unexpected hurdles. In the process of trying to resolve these difficulties we were forced to reflect on our own learning about teaching and the need to keep adjusting strategies particularly for those students who do not yet have the independent learning skills expected of university students.

The fundamental mistake we made in the first iteration of flipping the classroom was to simply record and upload the lectures that had previously been provided face-to-face. We were missing the opportunity to refine and focus content into themes and shorter blocks of delivery. By the second iteration we completely transformed the content and delivery into multiple short blocks, usually between seven to fifteen minutes each. We compressed content to the essential elements we believed students would need for the later studio class and we built stronger links between the online learning and the studio activities. This strategy of shorter videos not only helped us to better structure the content but also enabled students to more easily fit the videos into their lives.

The second problem, to do with WiFi connections in the theatre, was harder to anticipate as even the university information technology experts took some weeks to determine the cause. To encourage students to complete the weekly online learning we decided to do weekly quizzes when we came together as a group in the theatre. These quizzes contributed to a small component of the final mark. We researched audience-response devices and decided on phone-based licences rather than physical clickers, as students carry their phones whereas clickers would need to be handed out each week or remembered by students. We were in a new theatre and were told that the theatre was equipped with WiFi. We paid for licences and students logged on but when questions were asked only ten to fifteen per cent of the students were able to successfully upload their answers. It turned out that our new theatre was not sufficiently equipped for every student to be online concurrently. Our solution in the second iteration of the flipped classroom was to swap the quizzes to the studio time slot and to make them paper based. This solution has had benefits as tutors get immediate feedback on how their group of students is performing and they can quickly respond to gaps in knowledge.

There has been an unanticipated sense of loss for us as lecturers as we flip the classroom. Even though we present within the online content we had not anticipated the loss of the weekly lecture ‘performances’ in front of students. Lectures have always been a core teaching role for academics so it can be confronting to no longer experience that the same level of face-to-face contact time. Instead the tutors take on a larger role and the time we spend as a group in the theatre is used primarily for panel discussions with some Q+A and almost no traditional lecture content. One challenge from this is the requirement for greater instruction and coordination of the tutors than normal in order to ensure the content and activities are delivered in tune with the weekly learning objectives.
4. But some things went better than expected

One of our main concerns going into the flipped teaching mode of delivery was how to provide a professional online presence without access to affordable green-screen technologies and editing support. This has turned out not to be a significant problem. We did use some of our grant funding to do some introductory videos using green-screen strategies so students could see the lecturer in the first weeks. We then did the bulk of the presentations using simple screen-capture software. The benefit of this basic and accessible technology is that we can easily redo and refine online learning each semester once we see what works. This means that the presentations are not as sophisticated or as entertaining as the online TED (Technology, Entertainment and Design) talks which have set a high benchmark in podcasts but they are kept succinct and focussed on content if not entertainment. Another successful decision was to translate podcasts into ‘You Tube’ formatting which has enabled students to access the content on a range of devices.

A decision bringing benefits beyond our expectations has been the shift from a two-hour tutorial to a three-hour studio format where students are doing hands-on exercises or site visits each week. The flexibility provided by shifting from two hours to three hours has been substantial. We try to largely complete exercises and feedback within the tutorial time, which frees up the students’ external time commitments to focus on the online learning and research for the main assignment. One of the great benefits of the three-hour studio has been that we can use the city and the campus as learning laboratories, taking students out to look at construction sites helping them to ‘see’ the construction, structural and materials decisions being made. The three-hour studio has meant that students can work their way through a complex set of working drawings, interpreting parts of the orthographic scaled drawings into full-scale diagrams as well as three-dimensional models.

5. Our evolving understanding of the potential of weekly quizzes

Students who attend to weekly online learning prior to the studio session will benefit more from the in-class small-group teaching and yet we are aware that not all students manage to keep up. Our initial strategy for the weekly quizzes was for every weekly quiz to contribute a small percentage to the final mark. While this made sense it caused more stress for students than we anticipated. In later iterations we therefore changed the quiz assessment so only three quizzes contributed to the final assessment mark. The non-assessed quizzes gave formative feedback to students who could see how they were doing in relation to others. In this sense, students perceived them as part of their learning rather than part of our ‘policing’ of learning. The performance metrics of the students undertaking the quizzes was invaluable for tutors to give on-the-spot instruction whenever it became apparent that students were confused.

In the most recent iteration we continue this structure but have inserted a group quiz based on peer learning strategies (Boud et al., 1999). After attempting the questions individually, students are randomly allocated to groups of three to negotiate an agreed response. In the process of negotiating an agreed response students need to either convince others or be convinced through explanation and clarification. Generally the wisdom of the group prevails and a higher percentage of answers are correct.
6. Learning analytics and the bell curve

The shift to quizzes has highlighted our access to what students know and how we can fill knowledge gaps. We record responses to every quiz and exam questions and get overall figures for the class. The quizzes were an indirect component of the flipped teaching environment but we are finding them a powerful feedback loop for us to provide ‘just-in-time’ teaching and feedback (Novak et al., 1998). It has only been in the most recent semester that we have started to understand the potential of learning analytics not just to track students’ use of the eLearning environment and their marks for the subject but to provide studio content or extra eLearning in response to gaps in student knowledge. Learning analytics is defined as ‘the measurement, collection, analysis and reporting of data about learning and their context, for the purposes of understanding and optimizing learning and the environments in which it occurs’ (Ferguson, 2012).

Tracking activity of students accessing the eLearning was not originally possible within our earlier LMS environment. For the most recent semester we developed a two-part linking into the You Tube based content which has enabled us to see who is viewing what and when. Figure 2 shows how students access eLearning immediately prior to an assessed quiz and prior to the exam. Further work can now be undertaken to see whether there is the expected correlation between accessing eLearning and assessment marks.

Along with the eLearning tracking we are now tracking more carefully individual components of assessment with the aim of developing stronger mastery of learning strategies. Even the summative assessment within the exam is in an accessible format that will help refine the teaching of learning for future cohorts. For example in this most recent iteration ‘load path’ understanding was a focus in studios and quizzes and we found students generally did well on these questions in the final exam but struggled with the simpler concept of a ‘beam span’. This detailed feedback will guide future teaching.

Our construction subject was a case study for a small research project exploring how students might also make use of learning analytics to gain insight into their learning using the subject assessment dashboard within the LMS environment. This work indicated that students were well equipped to reflect on and respond to the assessment although they tended to be primarily focused on whether they were achieving higher than the average score rather than whether they were on track to achieve their preferred assessment outcome. For many students, the comparison of their data to that of their peers was obscuring their view of progress towards their overall goal in the subject. For example, although
several students indicated that they were aiming for the highest grade possible, they were satisfied when they saw that they were performing slightly above class average' (Corrin and de Barba, 2014).

Since implementing flipped teaching strategies we are not yet able to confidently state that we are seeing an improvement in learning outcomes overall but we do see a wider division of students as results shift towards a double bell curve rather than single bell curve with a cluster of students excelling and another cluster of students struggling. This is not entirely unexpected, as flipped teaching strategies require students to be more self-organised in order to benefit from the studio format.

We see potential to develop the area of learning analytics particularly to provide us with just-in-time feedback to adjust teaching to improve learning but also to provide students with immediate feedback on how they are progressing relative to our expectations and relative to other students.

7. The textbook controversy

Our first-year students mainly come from secondary schools where subjects normally have a textbook comprehensively covering the content required for passing and excelling in the subject assessment. Prior to flipping the classroom, we provided students with a workbook which covered the core content and prepared students for the exam. Students appreciated this approach and have stated in feedback that they found the workbook approach reassuring, giving them a clear program of knowledge content. Given the student preference for a textbook or workbook approach, it is worth explaining why we have chosen to no longer provide the comprehensive handbook or workbook for the subject.

The role of university educators has shifted substantially over the last two decades as information becomes readily available to students. Academics no longer attempt to focus on content delivery and can instead start to help students develop a framework for knowledge and critical thinking and research skills. In teaching first-year students, we see advantage in providing a bigger framework of knowledge that maps out a pathway into professional practice rather than simply the foundation blocks needed for first-year students. We use a well-known text, which continues to be useful for graduates entering practice. We help students to manoeuvre through the text, highlighting differences in language and approaches across cultural and national boundaries.

This controversy around the role of the textbook highlights a particular difficulty we face as educators of first-year students who arrive at the university with expectations regarding the learning experience. Part of what we do as coordinators and tutors is to manage student expectations and introduce them to university learning. We have changed to flipped teaching but this is just one of the eight subjects they take in their first year which means that students are likely to be somewhat confused by the multiple expectations of university teaching and learning.

8. What the students told us

In addition to the university’s regular feedback loops (subject evaluation surveys), we have implemented further feedback mechanisms. The most recent was a focus group over lunch on the final day of semester attended by 23 students (of the 230 strong student cohort). We offered lunch and brought together both international and local students of mixed abilities (based on assessment results at that time). These particular students attended because they were either invited or volunteered to take part in the session. We achieved representation across the studios but recognise that we were unable to guarantee balanced representation in terms of gender, SEO standing, local and overseas students, age,
construction experience, learning styles etc. and that the composition of the group may distort the results obtained. The focus group was led by our faculty’s teaching and learning expert and no staff from the subject attended.

The focus group was structured into three parts. Students initially responded to a one-page SWOT Analysis (Strength, Weakness, Opportunity, Threat) with a request for one sentence on each. In addition, we prepared the list of adjectives shown in Figure 3: Survey instrument within focus group discussion and asked students to circle any they felt relevant and add more if they wished. We attempted to include oppositional adjectives but did not use the standard ‘likert’ style of questionnaire, which asks students to scale responses according to their degree of agreement. Our simplified method has advantages in being quick to answer and meant that students highlighted only those that were most important. The main part of the focus group was a ‘conversation with a purpose’ (Burgess, 1988) led by the faculty’s teaching and learning academic. The feedback from the three survey instruments of the SWOT, the descriptors and the focus group discussion is summarised below.

In the open-ended SWOT analysis, ten of the 23 students highlighted the eLearning as a strength and five suggested that uploading the lecture slides would improve the subject. Given the SWOT analysis was open-ended, we were not expecting this amount of repetition from students. However we were surprised that no students highlighted the site visits as a strength; indeed four felt the ‘site visits were not sufficiently organised’ and another two felt they ‘took a long time’. Given our large student numbers (up to 360 per semester) we consider it to be a logistical achievement to manage to negotiate access to 30-50 sites needed each semester. As we write, we are still pondering what adjustments we should make for future student cohorts and are somewhat reassured by the recently released Student Evaluation Surveys (SES) where one-third of the 90 students who responded with comments highlighted the site visits as a strength with none commenting negatively. Perhaps a structural difficulty of the SWOT method was limiting students to one positive comment only and almost fifty per cent choosing to highlight the eLearning. In the SWOT, five students felt there was too much information and not sufficient time for learning to ‘sink in’ and another felt the ‘eLearning took too long’. Five students found the three-hour studios to be long if there was not an activity, which is also a curious comment as we perceive each studio to contain an activity. Perhaps some activities with smaller bodily movements such as drawing were not perceived as activities. Interestingly, five students highlighted the difficulty of the new terminology being introduced as a threat particularly for students with language difficulties.

Please circle any words that you would use to describe this subject:
- hard
- valuable
- confusing
- challenging
- necessary
- disorganised
- good learning
- theoretical
- practical
- informative
- boring
- comprehensive
- hands-on
- random
- hands-on
- good teaching
- bad teaching
- practical
- theoretical
- clear
- diverse
- current
- dull
- worthwhile
- too easy

Please add any other words you can think of to describe constructing environments

Please circle any words that you would use to describe yourself in this subject:
- confused
- interested
- lazy
- fee paying
- older student
- hard worker
- CSP student
- self motivated
- bored
- focused
- committed
- last-minute
- male

Figure 3: Survey instrument within focus group discussion (Source: Author)
The adjectives most commonly selected and least commonly selected are noted above. Given the limited number of participants, we were unable to link the subject descriptors to the student descriptors but we aim to run the survey in future semesters to complement the standardised Subject Experience Survey undertaken by the university.

It was perhaps in the final conversation with students that some of the more subtle strengths and weaknesses were described. No student had been a part of a flipped classroom previously and they were interested in the experience and intrigued by the concept. There was consensus on the value of the new model, although different students appreciated the different strategies differently. For example, the video recordings were particularly welcomed by the international students present. In the focus group discussion there seemed to be agreement on the value the industry panel discussions and the more ‘hands on’ elements of the subject. A concerning consensus amongst the students that the weekly content delivered through the online platform was not related to the activities undertaken in the studio session. This feedback is both bewildering and alarming for us as we had focused on tailoring the weekly activities to apply and test the concepts and contents delivered online. It seems we need to further refine the communication and the weekly activities to ensure students are able to link the weekly iterative learning taking place rather than perceiving the online work to be unrelated to the studio content. A more thorough briefing with the tutors will also be needed to ensure they help students conceptualise the content in more holistic ways rather than seeing a disconnection between the hands-on learning and the online learning.

Students were asked to give feedback on the quiz format particularly as we had refined the quiz format in the most recent semester to include a group as well as individual response. In the focus discussion, students said the quizzes seemed to work well as accents and boosters in the subject’s progression even though four students highlighted the quizzes as a weakness in the SWOT analysis. Students said that they tended to catch up with online delivery when the quizzes have marks associated to them if they had dropped behind. The online statistics described in the section on learning analytics supports this statement. In terms of the group quizzing, the impressions were mixed. While some thought the group quiz was a good idea, others thought the outcome was too dependent on the particular group.

Students told us that the Discussion Board within the Learning Management System (LMS) was not a helpful tool for organization because it had no notifications, as opposed to Facebook which is what most of them ended up using instead. This may be an area for future improvement although we also see advantage in student initiated Facebook environments complementing the Learning Management System. Students did appreciate the Announcements we made within LMS because they did help with managing time and tasks.

9. Bringing it all together

The recently released university-wide Subject Experience Survey for the most recent semester included room for students to make multiple comments on the subjects. As well as the positive comments on the site visits there were many comments related to the restructuring of the subject.

Getting so much time with the tutor was good, as we were always able to ask questions. I liked that we did a lot of hands on activities in class, such as the model building, sketching, and walking around campus to observe the elements we were discussing. (Anon student)
Online learning is excellent and provides each individual student time to complete the study as they see fit—easily allows for revision through the week or at the end of semester and breaks down information into accessible sections. More subjects could take a leaf from the online information provided through this subject. (Anon student)

The entire structure of the course was brilliant. There was a clear educational progression over the course of the semester and the assignments and each weekly quiz complemented the learning process without being too much of a burden. The site visits were also great, but it would have been easier if they were coordinated and integrated into the schedule of the subject. (Anon student)

We are still refining our flipped teaching approach and learning (as teachers) with each iteration of the subject. Our next step will be to focus more on just-in-time feedback for students as they complete each set of eLearning and implementing Mastery Learning strategies into the quizzes. We would not consider returning to the traditional lecture format. We argue it is time for even the most engaging university lecturers to consider whether part of their content might be more efficiently and effectively delivered online. This online delivery can paradoxically enhance the on-campus experience for students and open up possibilities for more higher-order, hands-on, integrative and interdisciplinary learning.

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