The Development of a Blended Learning Model to Deliver Construction Science Teaching

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This paper presents the outcome of a module curriculum review informed by constructivist theory, constructive alignment and student-centred learning. The review led to the development of a new blended learning approach to teaching a mathematics-heavy Construction Science module. The new model allowed the intellectual challenge posed to the students to be significantly increased whilst improving both the attainment and satisfaction on the module. Driven by student demand the approach has begun to embed further in the other units in the module and more widely in the School.

Keywords: Blended learning, construction science, e-resources

Introduction

Well-designed teaching and assessment can encourage and enable students to learn more deeply. Prosser and Trigwell (1999) argue that well-designed teaching and assessment is student focussed. The design of teaching should start from a consideration of what students need to learn and not, as can be the temptation, what the subject matter or lecturer's expertise dictates. In addition to being student focussed, well-designed teaching should, according to Biggs (1996), be constructively aligned. Biggs argues that students learn in a system in which the component parts relate to each other. If these different but interconnected parts are poorly aligned this makes it difficult for students, particularly those who are less able, to succeed. The key aspects of the teaching that should be aligned are what the students should learn (most likely now codified in learning outcomes), what teaching methods will be employed and what assessment tasks and criteria will be used.

There is a real challenge in teaching diverse subjects such as those found in Built Environment disciplines. Built Environment curricula typically have significant breadth, taking in subjects from management, sociology and law to engineering, technology and science. This range of subject material means that students are unlikely to have a natural affinity or flair for all the subjects they encounter. The purpose of this paper is to explore if it possible to develop a model of delivery and assessment that allows teaching to be constructively aligned, student focussed and practically deliverable in a mathematics heavy, construction science module. Two important measures will be used to establish this, first student attainment and second student satisfaction.

How do Learners Learn?

Most modern approaches to understanding students' learning flow from a constructivist theory of one flavour or another. Constructivism, broadly speaking, involves the move away from learning being seen as the acquisition of discreet, well-defined packets of knowledge into a more open approach that recognises that the learner plays a significant role in giving meaning to the knowledge they acquire. "*Constructivism is the philosophical and scientific position that knowledge arises through a process of active construction.*" (Mascolo and Fischer, 2005, p.49)

There are two main schools of constructivist thought. The difference between these stems from how distinctly they treat learning as separate from the social context in which it takes place. The first school of thought developed

chiefly by Piaget (1950) and Bruner (1960, 1966, 1996) has at its core the belief that individuals make sense of new knowledge by relating it to existing understanding. They form the cognitive constructivists. In contrast to this, Vygotsky (1962; 1978) developed the concept of social constructivism. In this strand of constructivism more emphasis is placed on the social context in which the learning takes please. What is important for this work is the recognition that the learner plays a very active role, either individually or socially or perhaps both, in constructing the meaning to the knowledge they acquire. Effective teaching, which promotes deeper learning, should encourage the student to make sense of any knowledge they acquired and provide a variety of learning materials to allow learners to create their own path to knowledge.

The Purpose of Assessment

The Quality Assurance Agency (QAA) is the quality assurance body that monitors and advises on UK higher education standards and quality. They produce a range of guidance to approaches to higher education including on developing assessment (QAA, 2012). They identify two core principles relating to assessment. Assessment should be "*valid and reliable*" and should be conducted with "*rigour, probity and fairness*". They then expand upon these for four key stakeholder groups; students, lecturers, institutions and finally professional, statutory and regulatory bodies.

For the student, individual pieces of assessment provide a source of motivation for study; they promote learning by providing feedback on performance and help students to identify their strengths and weaknesses. (QAA, 2012, p.6)

From this we can draw that assessment is not simply about establishing performance but is a source of motivation for students and of corrective intervention. Assessment has an important part to play in creating effective feedback.

For the lecturer, assessment provides an opportunity to evaluate the knowledge, understanding, ability and skills attained by different students. The overall profile of student performance offers useful information for assessing the effectiveness of course content and teaching methods, thereby facilitating improvement.

Assessment then provides an important feedback mechanism for the lecturer as to how well the delivery is working. Are the students following the content and are they able to mobilise it in the way intended? Are they learning what the lecturer has established they need to learn?

A Framework for Evaluation

The preceding sections have discussed a number of areas of pedagogy relevant to this study. This section will attempt to draw these together into a framework that can be used to appraise the teaching considered in this project. The framework will be articulated as a series of questions relating to the delivery and assessment of the teaching.

Teaching delivery

- Does the approach to teaching align with the intended learning?
- Does the teaching maximise the opportunity for the students to construct their own meaning?
- Does the teaching allow students to come together to test their individual understandings against each other?
- Is there variety in the approach to teaching?

Assessment

- Is the assessment valid and reliable?
- Is it conducted with rigor, probity and fairness?

- Does the assessment encourage the students to engage with learning?
- Does the assessment provide an opportunity for feedback to both the student and lecturer?

Overview of the Situation in 2011-12

The Construction Science module (CE1CCS) module "introduces the fundamental concepts of Construction Science through an examination of the physical properties and mechanics of construction materials and the physics of heat, fluids, light, sound and electricity". (MDF, 2013) It is a Part 1, compulsory module that carries 20 credits and typically has large classes (70 - 170 students). It is well known in the department as a module the students either "love or hate" and often has issues relating to attainment (attainment is the performance of students as measured through assessment).

In 2011-12 the module was delivered in a classic lecture and tutorial approach. In the rest of this work this approach is described as the 2011-12 approach (i.e. before changes were implemented). Students attended 20 hours of lectures on materials and mechanics along with 3 hours each of tutorials, in classes of around 30. The tutorial questions were answered in class individually and were summative in nature contributing 20% towards the module mark. Students were only asked to answer three questions each tutorial class.

Students answered only nine questions in total across the all of the tutorial classes. Each question carried equal weight. The consequence of this was that each question carried significant jeopardy for the student. One "silly mistake" and the student would lose a significant percentage of their tutorial mark.

Teaching Delivery

This section applies the framework developed above to appraise the current approach.

Does the approach to teaching align with the intended learning? To a great extent the approach is appropriate for the intended learning outcomes. The underpinning theory of scientific subjects is traditionally taught in this style. However, if the understanding of "intended learning" is broadened to include programme level learning outcomes some opportunities have been missed. The programme specification (PS, 2013) includes the following:

"...students will have had the opportunity to develop such skills, in particular relating to ... numeracy, problemsolving, team working and information technology, and will have been encouraged to further develop and enhance the full set of skills through a variety of opportunities" (PS,2013)

There was a clear opportunity to enhance how this module contributed to the wider programme level learning outcomes and the mission of creating independent learners and developing skills such as problem-solving and team working. To do this some element of the working in groups needed to be introduced. If possible the approach should encourage independent learning, and to take into account the way in which different learners might learn. To achieve this the project intended to introduce a range of teaching material.

Does the teaching maximise the opportunity for the students to construct their own meaning? Not to any great extent. The significant weakness of the traditional science/engineering approach to teaching of theory is that it is very much predicated on the student listening to the lecturer explain their understanding and then being tested on the recall/application of this. There was a large potential to introduce a different, complementary approach to encourage deeper learning.

Does the teaching allow students to come together to test their individual understandings against each other? The learning as it was designed did nothing to facilitate the students working together to challenge each others' understanding and collectively move to a shared understanding. There was significant opportunity here to create a different type of learning environment.

Is there variety in the approach to teaching? There was little variety in the teaching and in the learning resources available to students. As students are actively constructing their own learning, and each student is different, it is reasonable to suggest that an increase in diversification of teaching approach would help a broader range of students master the subject.

Is the approach practical for the students and staff? Yes. The delivery of this teaching was relatively low maintenance once the slides were prepared with little additional marking load. For the students there was little work outside of the lectures.

Assessment

Is the assessment valid and reliable? Employing the QAA definitions previously referenced an evaluation of the tutorial assessment leads to the conclusion that there could be significant improvement in the validity and reliability of this assessment. Firstly, the level of challenge was significantly below where you might expect Level 4 education to be. This undermined both the validity (appropriate level) and the reliability (no way to really distinguish which students had a mastery). Further, given that there were so few marks available one or two "silly mistakes" could disproportionately affect a student's overall grade.

Is assessment conducted with rigor, probity and fairness? Again, there was the potential for significant improvement here. It is unfair if an assignment is set at such a level that it does not reflect the challenge of the material that is being delivered. This would serve to undermine the learning set out in the MDF. Students were also likely to take a cue on what is important to recall from the tutorial which was significantly less challenging than the examination questions. The lack of challenge prevented the students with a real mastery from distinguishing themselves.

Does the assessment encourage the students to engage with learning? Again, for the reasons identified above, the students were likely to be dissuaded from engaging in the more challenging lecture material as the tutorials content was pitched significantly below the level of the lecture material (and learning outcomes). This could have created a false sense of security around student's performance and therefore the assessment was missing the opportunity to give useful feedback.

Does the assessment provide an opportunity for feedback to both the student and lecturer? There was an opportunity to further develop the potential for the teaching material to provide feedback to the students (again at a more challenging level) and to the lecturer.

In applying the framework it has become clear that whilst the lecture approach was typical of the subject area, the tutorial work was pitched significantly under the challenge of the material in the lectures. This is likely to have caused the students to disconnect from this learning and is an example of a lack of constructive alignment. Students worked individually to make sense of information provided by the lecturer and were assessed on their ability to recall and apply these concepts. There was potential to provide a greater array of teaching materials and to increase the contribution that the module made to the programme level learning outcomes.

Developing the New Model (from 2012-13 onwards)

'Blending' traditional and electronic approaches gives the potential to provide a student-centred experience that does not require a significant degree of extra resource. (Tucker, 2013) The technology-rich approach can include podcasting (Ruffini, 2012), flipped classroom (Tucker, 2012) and pre/post-lecture quizzes (Brink, 2013) some of which are covered above. However, the driving concept considered in this project was to focus on the blending of a modified, traditional tutorial approach and supporting e-resources. Second was to make the Blackboard space a 'hub of activity' through the inclusion of other e-resources supporting the lectures. The anticipated benefits were to be able to bring the students together to facilitate social learning and to support this with e-resources that promote ownership of the learning in a time-efficient manner.

The tutorials were significantly redesigned. They were made formative but their link to the new, summative "end of term tutorial test" was made explicit. This created a safe space for the students to gain feedback from their learning and to give an indication to the lecturer if the material was being understood. This was important because the challenge was significantly raised. The format of the tutorial was changed. Students were asked to complete a tutorial question sheet at home and bring it with them to the tutorial. Their task in the tutorial was then to work in groups (4-5 students in a class of 30) to produce a model answer under time pressure. This was designed to facilitate the social aspect of constructing the meaning of knowledge. Until the Q&A session at the end of the tutorial, students were encouraged to help each other rather than seek answers from the lecturer. Retaining the requirement for the students to attend a tutorial class was important to mitigate the risk of a decrease in engagement. In some of the more 'virtual' deliveries outlines in the approaches considered section there is the risk that students can see the work as optional or less important.

The model answers were collected from the students and marked for the following week's tutorial class. At the start of each lecture the top five tutorial groups marks were given in a league table. The goal here was to harness some of the latent competitiveness of the students. To augment the newly created tutorial format a series of podcasts were created to provide feedback to the students and embedded in Blackboard. They were made available as soon as the students had completed, and handed in, the tutorial work and remained available for the rest of the term. Each question had a podcast providing a full model answer written with each step in the mathematics explained with a voice over. An example of one of the podcasts is shown in Figure 1.



Figure 1: Podcasted model answer.

To provide instant feedback to the students and to encourage them to independently engage with the material outside of the lecture a series of formative post-lecture quizzes were created and hosted in Blackboard. Each lecture had a series of multiple choice quizzes capturing the key points.

Summary

The new model linked together, in a blended learning style, a lecture with a set of more demanding tutorial questions. The students completed these at home and brought the work with them to the tutorial. They worked in groups to produce a model answer. This was assessed formatively to produce feedback and a new summative end of term test was created. Podcasts of the model answers were released as soon as the students had submitted their tutorial work. To engage the students more instantly in the lecture material a series of post-lecture quizzes were created and embedded in Blackboard.

Appraisal of the New Model

The framework used to appraise the 2011-12 approach will also serve as a useful structure to evaluate the new 2012-13 approach.

Teaching Delivery

Does the approach to teaching align with the intended learning? As with the 2011-12 approach the 2012-13 approach was aligned to the intended learning outcomes of the module. So in this sense there was no significant improvement in this space. However, adopting the broader programme level interpretation there was an improvement. The new emphasis on group work, and on independence in learning, was more constructively aligned than before with the programme level learning outcomes.

Does the teaching maximise the opportunity for the students to construct their own meaning? The 2011-12 approach presented students with a single pedagogy. The new 2012-13 approach presented students with a more diverse range of approaches. This appears to have worked very successfully indeed as evidence by the excellent attainment, in the context of an increased challenge, and the high levels of satisfaction (see below).

Does the teaching allow students to come together to test their individual understandings against each other? The 2011-12 approach did nothing to facilitate the students working together to challenge each others' understanding and collectively move to a shared understanding. The 2012-13 approach represented a significant improvement in an unexpected way.

Students attended the class with their work. Rather than look to the lecturer to establish if their solutions were correct they were asked to look to each other. In almost every group in each class this created controversy. Students had differing answers and were looking to each other to explain, and justify, how this answer was arrived at. This created a more dynamic and vibrant learning environment.

In the evaluation of the different approaches the diverse range of abilities in the class was not really given much thought. This range of abilities introduced a new dynamic into the classroom in a very positive, but unexpected, manner. Those with a greater flair for mathematics very quickly began to occupy a role in the classroom that could be described as a "student teacher". Typically each tutorial group had someone who occupied this role. The student

teacher often spent time explaining the solutions to the problems to their classmates. In turn, increasing their confidence and allowing them to challenge the "lecturer teacher" in second half of the session.

Although predominantly positive, careful observation was needed to ensure that a group who lacked a member who was confident in mathematics did not find themselves at a disadvantage.

Is there variety in the approach to teaching? There was an increased in the variety of learning materials and approaches employed within the module.

Is the approach practical for the students and staff? Yes. The delivery of this teaching was relatively low maintenance once the e-resources had been created. This is evaluated in more detail in a separate section below.

Assessment

Is the assessment valid and reliable? The new end of term tutorial test developed in the 2012-13 approach significantly raised the challenge of the assessment to a standard fitting with Level 4 study. This was a key objective. The number of questions was also increased, although at the cost of marking workload, to reduce the jeopardy that the student faced in the 2011-12 approach from a single "silly mistakes".

Is assessment conducted with rigor, probity and fairness? The standard in the tutorial is now more reflective of the standard in the examination. However, the support system put in place has allowed most student to excel. The question remains if it is fair to increase the challenge further to allow the very top students to distinguish themselves. Currently the standard has not been raised further as the risk is that the challenge then becomes more appropriate for Level 5 study.

Does the assessment encourage the students to engage with learning? The new approach is popular with the students and seems to encourage them to learn. The section below contains a series of quotes from student feedback evidencing the enthusiasm with which they have greeted the new approach.

Does the assessment provide an opportunity for feedback to both the student and lecturer? The approach has been successful in providing an increased range of feedback to the students for a small outlay of resource (when taking a long term perspective).

The 2012-13 approach presented an increased challenge to the students in the form of a new tutorial approach. This approach was coupled with a series of podcasted solutions to the tutorial questions. Table 1 shows the attainment of the class in the end of term tutorial test over the first three years of implementation of the new model. Table 1 excludes non-submissions of which there were five. The observation drawn from Table 1 is how well the students have performed given the significant increase in difficultly of the problems posed.

Table 1

	Number of students			
Grade range	2012-13	2013-14	2014-15 (n=118)	Total
	(n=68)	(n=72)		
90 - 100%	26	43	47	126
80 - 89%	22	21	23	66
70 - 79%	14	5	17	36
60 - 69%	2	0	6	8
50 - 59%	3	2	4	9
40 - 49%	1	1	0	2
Below 40%	0	0	0	0

Attainment in the end of term test

The premise underpinning the new approach was to use the principles of constructive alignment together with the concept of students as constructors of their own learning. The data in Table 1 supports the conclusion that this rational has been successful.

The principal goal of this project was to raise the challenge of the material and to support the students in addressing this. However, the increase in performance shown in Table 1 has also been coupled with a high degree of satisfaction. For the three years evaluated to date no student indicated that they were dissatisfied with the materials and mechanics element of the CE1CCS module.

The new blended learning approach received many comments in the qualitative feedback on the module evaluation forms. Some examples of these are presented below:

- "Takes the time to breakdown information to make it substantially easier to digest. Also produces a lot of online help and support for the module (podcasts, quizzes etc)"
- "I like the video aided tutorial on Blackboard, they help my understanding"
- "Video tutorials and tutorial work has helped me a lot"

These comments help to illuminate how the students identified the increased variety of teaching resource as a positive feature of the module. It is reasonable to infer that this variety enhanced the students' learning experience which in turn supported the performance demonstrated in Table 1.

Summary

Drawing upon a number of strands of the pedagogic literature (including constructivist theory, constructive alignment and student-centred learning) the approach taken in the teaching of the materials and mechanics unit of the CE1CES module was undertaken. This literature and review informed the development of a new blended learning deliver model at the same time as the challenge posed to the students was significantly increased. The new model delivered remarkable results in terms of student achievement and satisfaction and has begun to embed more widely across the School in response to student demand.

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