**Evaluation of flipped teaching**

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Abstract

We report on our evaluation of flipping the classroom for two modules: a compulsory first year calculus module and an optional second year coding theory module taken by Mathematics students at the University of the West of England, Bristol (UWE). Flipped teaching is a change to the traditional lecture model used in universities for hundreds of years. In the traditional model the lecturer is in charge of the class and largely dictates the content and pace at which this is delivered. The idea behind the flipped classroom is that the students’ initial exposure to material takes place in their own time allowing the class time to be used to deepen their understanding of the material through active learning. The flipped approach has been used very successfully for the modules described above for several years, measured in terms of student engagement, attainment and satisfaction. The impact of flipping the classroom was evaluated through pre-module and post-module questionnaires and in-depth focus groups, and the overall feedback was positive. With the trend in HE to move away from traditional didactic approaches to teaching, it is important and useful to teachers of mathematics to provide evidenced-based recommendations of alternative approaches for comparison.

1. Introduction

Flipped-style teaching or the flipped classroom has seen a surge in interest recently (Brame, 2013; Maciejewski, 2015). This style of teaching, pioneered by Mazur (1997), is a change to the traditional didactic model. In the traditional model the ”sage on the stage” largely dictates the content and delivery pace. Typically students are then required to work through more challenging material on their own before attending tutorials/problem classes for support. The idea behind the flipped classroom is that students’ initial exposure to a topic takes place in their own time, so students work through material independently at their own pace before the formal class. Class time is then used for active learning, where students are able to deepen their understanding of the material, through for example problem-solving, peer instruction and discussion.

In this paper we give the context in which we deployed the flipped approach, our methodology for evaluating the student experience and the results of this evaluation, together with a discussion of our experience as lecturers and plans for further work to use Technology-Enhanced Active Learning spaces to enhance class sessions.

2. Context

2.1. Calculus and Numerical Methods module

Calculus and Numerical Methods (CNM) is a 30 credit compulsory first year module taken by all mathematics students at UWE. It runs year-long and the second semester has been taught using a flipped approach since the 2014/15 academic year. For this module, a highly scaffolded approach was employed using technology to create pre-class materials (Hooper, Henderson and Gwynllyw, 2014). A workbook containing gapped lecture notes was created as well as a handbook containing exercise sheets and extra reading material. Typically there were four screencasts to watch each week lasting on average 10 minutes each. A total of 35 screencasts were produced using Camtasia Studio software on a tablet PC. These were made available through SCORM packages on the University’s Virtual Learning Environment (VLE). Each week students were expected to independently: watch screencasts and fill in the relevant gaps in their workbooks; take a formative e-Assessment; try some basic questions from the exercise sheet and optionally do some extra reading and/or work through a Maple file. The formative e-Assessments were run using Dewis (2012) and further details of how e-Assessment was used to support the delivery of this module can be found in Henderson (2017). During the two hour class, TurningPoint (TP) questions and group activities were used to encourage active learning. Worked solutions as well as the filled in workbook were made available via the module’s VLE after the class.

2.2. Coding Theory and its Applications module

Coding Theory and its Applications (CTA) is a 15 credit optional module run in the first semester of students’ second year of the Mathematics award at UWE. It has been taught using the flipped approach very successfully since the 2013/14 academic year. For the last two academic years, students coming into the second year have had experience of the flipped approach through taking the CNM module in their first year. The CTA module is based on a set textbook (Biggs, 2008). Students are expected to undertake directed reading each week in advance of the class; this is typically a chapter of Biggs (2008), and to attempt particular exercises from this book. Some videos, recorded via a data visualiser, covering particular algorithms/problems are available. During the 3 hour classes, students work together on problems designed to check their understanding of the material. This takes the form of TP questions, further exercises from Biggs (2008) as well as supplementary problems. The style of the module is to develop active rather than passive learning. Students are expected to contribute to sessions, by reporting on a particular topic they have researched, or by presenting their solutions to problems to the rest of the class. After each class, the TP questions (with solutions) and worked solutions to exercises are posted on the module’s VLE.

3. Evaluation Methodology

The evaluation methods took the form of focus groups and questionnaires. The focus groups, carried out separately for each module, enabled us to gain greater depth of understanding of how the students responded to and felt about the flipped classroom style of teaching. These focus groups were carried out at the half-way point of the semester and run by an experienced practitioner (Last) external to the students’ department. Running the focus groups in this way and at that time meant that students were used to the change of style and the pace of the teaching but no assessment had yet been undertaken. Numbers attending were small (3 students for CTA, 5 for CNM) but we also used qualitative questionnaires for both modules to provide validity for the focus group data that was missing from such small groups. In addition, for CTA, a Likert Scale questionnaire was used, applied before the module was undertaken and repeated on completion of the module, in order to determine whether there had been any change in the student’s attitudes towards learning.

**4. Evaluation Results**

**4.2 Calculus and Numerical Methods module**

For most of the students taking this module it was their first experience of a flipped classroom and initially several students had reservations about this approach. This including students who prior to coming to University, had already experienced flipped style teaching whilst at sixth form college. However, once the students had taken the classes, of the 27 students surveyed in 2017 66.7% agreed that they liked the flipped style of teaching and would like to experience this style of teaching in their level two modules whilst just 7% disagreed. It appears that having access to videos and questions to do each week, instead of just reading had a positive impact on their experience.

Students liked the fact that they knew what would be covered in the lecture in advance and that having gap notes, where they had to fill in the blanks, meant that they were more likely to watch the videos. The In-class questionnaires indicated that on average students spent just over an hour per week on the pre-class work each week and that finding the time/remembering to do the pre-work was the most common response to the question "the worst thing about being taught in this way". Some of the responses to the question "the best thing about being taught this way was" are reproduced below:

* Having the information consolidated in the lecture
* Made the most of our time with the expert ... Best value for money
* Encouraged more independent learning and extra reading
* Already knowing something before the lecture
* A chance to work though problems at our own pace

Most students felt they would like this teaching style to be used for other level one modules but thought that it could be too much if all modules were run this way. Some students pointed out that they were not able to ask questions while they were watching the videos but felt that they were given time in the class to ask questions and check their understanding of the material.

**4.1 Coding Theory and its Applications module**

There were 35 pre-module completion questionnaires completed from a class of 42 and 17 post-module completion questionnaires that comparisons could be drawn from. Overall the responses were more positive following the completion of the module.

Following completion of the module the students were more likely to agree with the statements:

* I feel comfortable raising questions with staff about what I am learning
* I am responsible for my learning
* I use feedback on my work to improve in the future
* I feel confident contributing to seminars

They were more likely to disagree with the statements:

* When I find learning too challenging I give up
* I prefer to follow other people’s ideas than develop my own
* I do not like it when I find learning challenging

The focus groups and qualitative questionnaire indicated that, having had previous experience of the approach during CNM, the students were positive about the experience and were looking forward to having a module taught in a similar way. Some reported that they had felt anxious or unsure about this style of teaching at the start of the module but were now pleased with the delivery style.

The students were very happy with the overall teaching and structure of the module. They said that they preferred this teaching style to the more traditional method of university lecturing. A number commented that it suited their style of learning as the approach allowed them to work at their own pace.

The flipped style was talked about as being a ‘positive teaching style’ using the example that if they missed a lecture they weren’t ‘playing catch up’ because they had already done the reading.

The students felt that the sessions allowed them to clarify which concepts they understood and which they did not, allowing them to focus their independent learning time. They felt this was the opposite of other modules, where they came away from the lecture with no understanding of whether they had any misconceptions.

The only negative was that they would have liked to see more variety in the material provided and for the pre-reading to include some video input rather than just purely reading, which has since been implemented.

5. Discussion

Student feedback has been positive to the flipped-style approach. Emphasising the benefits and value of the approach at the start of each module has been key to engaging students.

From the lecturer’s point of view we have found it important to convey our expectation that students will have done the work in advance and to conduct each session with the assumption they have indeed done so. Using TP quizzes at the start of each session emphasises this expectation. Students quickly realise that they will get more from the sessions if they do the pre-work.

As usual, module performance is strongly correlated to engagement and attendance. Anecdotally, we have observed that attendance on modules using the flipped approach is better than at other lectures, despite some initial worries that students who had not found the time to do pre-reading would be put off attending. Students discover that active learning is more enjoyable than passive learning.

Both modules described here have relatively small cohorts (between 25 and 50 students) and so as lecturers we have been able to get round the group relatively easily during class-time and build a personal relationship with our students. Flipped teaching has been shown to also be beneficial for larger classes (Drew, 2017), but a slightly different approach may need to be implemented than described here.

Research has found that students who work in groups perform better academically, particularly in regard to reasoning and critical thinking skills (Lord, 2001). Enabling students to work with each other is an effective methodology and for the 2016/17 academic year we held our classes in a Technology-Enhanced Active Learning (TEAL) space (MIT iCampus, 2016) to facilitate this. This space contains collaborative working pods which each seat up to six students and includes a PC. Students within each pod can work independently on their PC and the lecturer can choose to project the pod’s or the podium’s screen to the whole class if desired. Using a TEAL space encouraged better small group discussion and peer instruction in class and our evaluation on how collaborative teaching rooms support the flipping process is ongoing.

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