CASE STUDY

Using e-assessment to support flipped-style teaching

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Abstract

We show how weekly formative e-assessments are used to support flipped-style teaching of a module delivered to all first year Mathematics students at the University of the West of England, Bristol (UWE). The flip lecture approach places students at the centre of the learning process. For the module described here, a highly scaffolded approach was employed. A workbook containing gapped lecture notes was created as well as a handbook containing exercise sheets and extra reading material. 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. During the following two hour class, TurningPoint questions and group activities were used to encourage active learning. Student feedback of this new teaching approach has been very positive.

Keywords: flipped-style teaching, e-assessment, gap notes, active learning.

1. Introduction

Flipped-style teaching or the flipped classroom has seen a surge in interest recently (Brame, 2013; Maciejewski, 2016). This style of teaching, pioneered by Mazur (1997), 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 material and pace at which this is delivered. 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 material takes place in their own time, so students work through material independently at their own pace before the formal class. Class time may then be 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 case study we describe the process and results of flipping part of a level 1 (first year undergraduate) calculus module, focussing on how we have used e-assessment to support this.

2. Background

The module considered in this case study is called Calculus and Numerical Methods (CNM). This is a level 1 module delivered to all first year students on the BSc (Hons) Mathematics and BSc (Hons) Mathematics & Statistics courses at the University of the West of England, Bristol (UWE). CNM is taught over the whole academic year; the first semester is delivered in a traditional way whereas the second semester has been delivered using a flipped approach since January 2015. The material covered in the second semester includes the topics of differential equations, numerical methods, series and report writing.

The module is assessed through a written examination (worth 75% of the module mark) and coursework which comprises four e-assessments (7.5%) and a group case study (17.5%). E-Assessment has been used on this module for many years and our assessment strategy has evolved from being merely summative to also include formative assessments that give high quality feedback from which students actively learn (Gill and Greenhow, 2008). Using online tests to support learning

has become standard practice in many institutions (Sangwin, 2013). We use Dewis (2012) to deliver the e-assessments on this module.

Dewis is a fully algorithmic open-source web-based e-assessment system which was designed and developed at UWE. It was primarily designed for the assessment of mathematics and statistics and supports a range of inputs, such as numeric entry, algebraic entry, matrix entry, multiple choice and drop-down selection. An example of several e-assessment questions used for CNM is illustrated in figure 1 together with the full feedback received for one of the questions. Using an algorithmic approach enables the separate solution, marking and feedback algorithms to respond dynamically to a student's input and as such can perform intelligent marking. In addition, the Dewis system is data-lossless; that is, all data relating to every assessment attempt is recorded on the server. This enables the academic to efficiently track how a student or cohort of students has performed on a particular e-assessment (Walker, Gwynllyw and Henderson, 2015). Recent developments include using embedded R code to facilitate the assessment of students' ability to perform in-depth statistical analyses (Gwynllyw, Weir & Henderson, 2016) and using Dewis to automatically mark computer code (Gwynllyw, 2016). Implemented for the first time in 2007 the system is now well-established and in 2015/16 within UWE and partner institutions, Dewis was used for formative and summative tests to support over 3,500 students involving more than 50,000 assessment attempts.

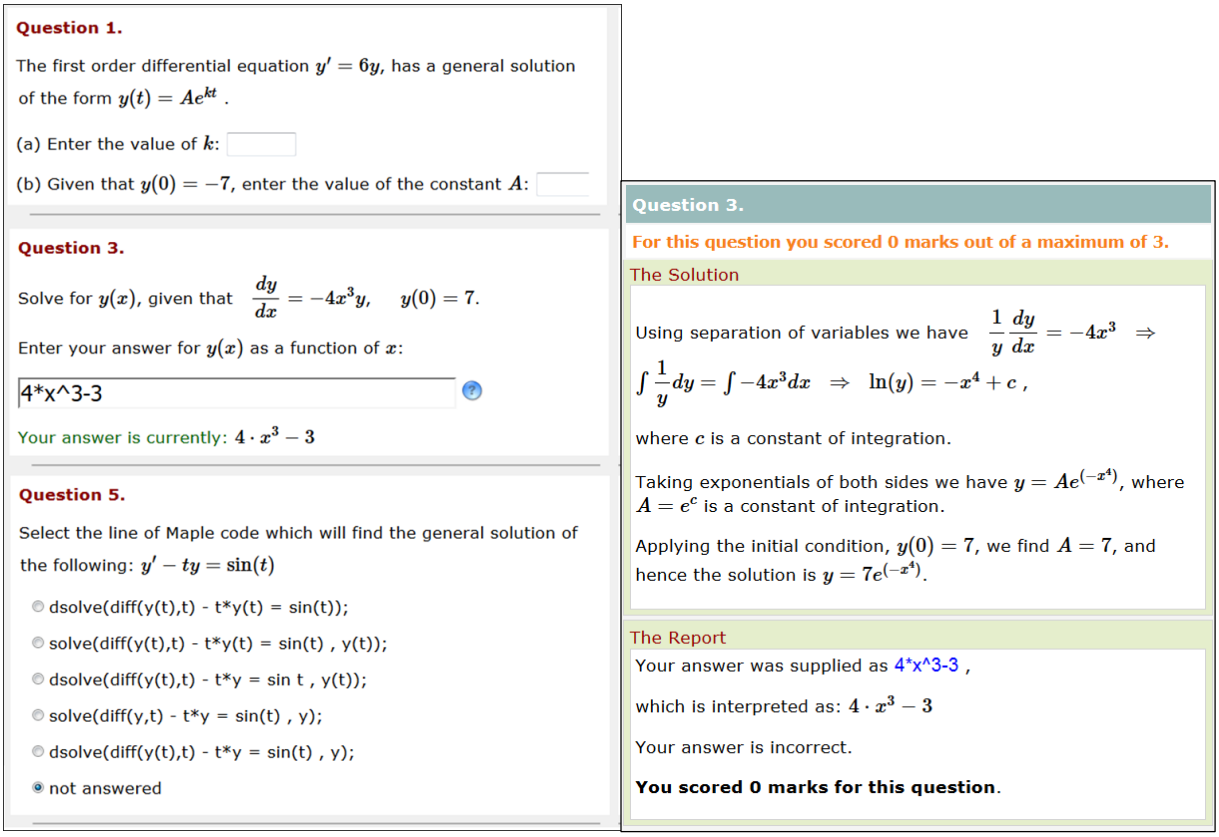

Figure 1. Example Dewis questions, together with feedback and marking bespoke to the random parameters used for one of these questions.

3. Methodology

3.1. Motivation

There were several motivations for deciding to adopt the flipped approach on this module. Despite always having good student feedback and results I was concerned as to how much my students were learning and in particular whether they could still remember techniques and methods when

they came to their final year. I also wanted students to have a deeper learning experience and to take control of their learning. In order to investigate how the flip lecture could best be incorporated into my teaching, I attended an HEA STEM workshop on `Lectures without lecturing' in February 2013 and participated in classes run by fellow practitioners. Mathematics has been slower than other subjects to embrace this approach and I felt for it to work effectively, especially at level 1, students needed scaffolding. Building on my experience of using technology (Hooper, Henderson and Gwynllyw, 2014) I created materials to use pre-class and in-class and these are described in the following two sections.

3.2. Pre-class material

Prior to the start of the second semester, all students were issued with a workbook of gapped notes. This contained background material, key mathematical theorems and examples, all of which contained gaps in selected places. Each week, prior to the scheduled class, students were expected to:

- watch a series of screencasts and fill in the relevant gaps in their workbooks;
- take a formative Dewis e-assessment test;
- try some basic questions from the exercise sheet;
- optionally do some extra reading and/or work through a Maple file.

Typically there were four screencasts to watch each week lasting on average 10 minutes each. A total of 35 screencasts were produced with a tablet PC using Camtasia Studio software. These were made available through SCORM packages on the University's VLE (Blackboard) and students were deemed to have completed that task if they watched 95% of the screencasts, with their progress monitored through the VLE. Additionally, at the end of each screencast students were asked to provide feedback as to whether they "thought that the video was (a) Good (b) OK (c) Poor: Please re-record for next year". This gave me timely feedback on the quality and relevance of the screencasts. There was no limit on the number of attempts allowed at each weekly formative Dewis e-assessment which typically contained five questions. Only three attempts were allowed for each summative e-assessment, which comprised a selection of questions already seen in these weekly tests, so students had an additional incentive to attempt the practice tests prior to the summative e-assessments becoming live.

3.3. In-class activity

Each week students were timetabled for a two hour class in a flat teaching room, with a one hour optional support session available every fortnight. The two hour class started with listing the learning outcomes for the week followed by a suite of TurningPoint (TP) questions, which typically took an hour to complete (Hooper, Henderson and Gwynllyw, 2014). An example of a typical TP question is shown in figure 2.

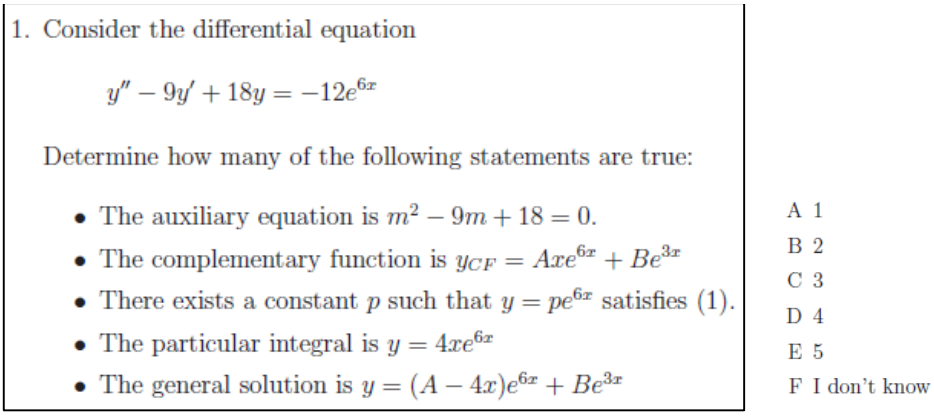

Figure 2. An example of a typical TurningPoint question used in the class (left), together with the voting options for this question (right).

Depending on the success of the cohort with a particular question I would re-poll (if the vote was significantly split), go through the answer in detail (if several did not know the answer – this was always one of the response options, or answer correctly) or move onto the next question (if everyone answered correctly). Question sheets were handed out at the start of each class, so that students didn't have to waste time writing out the question and could move onto the next question if they finished early. Students who attended the class but who had not done the pre-class work were able to view a PDF of the completed workbook from the University's VLE. This became available at the start of the class.

4. Results

4.1. Monitoring engagement

Three measures were used to monitor engagement with the module. These were whether the student had that week: attended the class; watched the screencasts; attempted the practice e-assessment. The semester 2 attendance for both years that the flipped teaching has been employed stayed fairly constant throughout the first ten weeks and was at a similar level to that experienced in semester 1 (approximately 75%) in which a more traditional lecture/tutorial delivery was employed. The remaining two weeks of semester 2 was used for revision purposes. Table 1 gives an indication of how many students did the pre-class work in 2015-16. The second column gives the number of students who watched at least three-quarters of the screencasts for that particular week at some stage prior to the final exam. In the next two columns we show details of the number of students and total number of attempts at each weekly practice e-assessment prior to the class. These numbers are disappointingly low, particularly for the practice tests from week four onwards. We note that practice tests 1-3 contributed to summative e-assessment 3 and practice tests 4-7 contributed to summative e-assessment 4, whilst the questions in practice tests 9 and 10 did not contribute to a summative e-assessment. Columns five and six show the number of students and total number of attempts made at the weekly practice tests prior to the written exam in May. We can see that, particularly for weeks 1-7, although not all students tried the tests, those that did made multiple attempts at each test.

Table 1. Details of the number of students (out of a total of 36) who did the pre-class work in 2015-16.

Week no.	No. students who watched 75% of weekly screen-casts	No. of students attempting test before class	No. of attempts at test before class	Total no. of students attempting test	Total no. of attempts at test	Comments
1	29	14	19	25	78	Practice tests 1-3 contributed to assessment test 3
2	31	11	19	22	90	
3	27	15	23	26	69	
4	24	1	1	15	45	Practice tests 4-7 contributed to assessment test 4
5	25	0	0	17	47	
6	21	8	10	17	47	
7	19	6	8	17	43	
8	19	Report writing and group work - no Dewis test				
9	23	0	0	4	8	Practice tests 9-10 not used in a summative assessment
10	17	4	5	7	9	

4.2. Student performance

In table 2 we display the exam marks and exam pass rates for the last four years. We can see that there has been a marked increase in performance since we started flipping in 2014-15. However, this was not the only change brought in at that time. We also increased the e-assessment coverage across the whole syllabus (semester 1 and semester 2), introduced fortnightly Dewis practice tests in semester 1 and actively monitored engagement with all practice tests.

Table 2. Comparison of exam marks and pass rates over the last four academic years.

Exam and year	Number of attempts	Pass rate	Average Mark
2012-13	37	75.6%	55.5
2013-14	65	66.1%	45.8
2014-15	64	92.0%	72.6
2015-16	36	88.9%	71.0

We found a strong correlation between engagement and exam performance. Further, the three students who failed the exam in 2015/16 did not attempt any of the practice e-assessments, engaging through watching the screencasts and attending only.

4.3. Student feedback

Student feedback has been overwhelmingly positive to the flipped-style approach. At the end of the first year (April 2015) I ran an in-class questionnaire to gauge student feedback. Answers to selected questions have been collated in table 3.

Table 3. Outcomes of some of the questions used in an in-class questionnaire (April 2015).

Qn 1: *On average I spent the following amount of time on the pre-class work*				
30 mins	1 hour	1.5 hours	≥ 2 hours	Did not do
5.5	12.5	14	2	1
Qn 2: *Doing the weekly Dewis tests was helpful to my learning*				
Strongly agree	Agree	Neutral	Disagree	Strongly disagree
14	15	6	0	0
Qn 3: *I liked the new style of teaching*				
Strongly agree	Agree	Neutral	Disagree	Strongly disagree
20	10	4	1	0

It was encouraging to see that the majority found the weekly e-assessments helpful to their learning. A similar response to Qn 3 in table 3 was received from the second group of students via the university formal online module evaluation in May 2016. Specific comments from students were collected via module evaluations and some are shown below:

"I thought that the Flipped Learning technique … was very effective, it meant that we could get the majority of the knowledge in our own time and at our own speed (we could pause the videos if we wanted), then in the lecture we could go over any problems that we may have had with harder questions."

"… the flipped class teaching worked very well, as often the easy, basic stuff is taught in lectures and then the harder stuff is left to questions out of class. Whereas instead the videos online before the lecture were all encompassing of the information we needed and then in lectures everything was made clearer by group questions and further demonstrations."

"The flipped learning approach helped me to learn the semester two work well. The weekly tests were good as they helped with learning content and the online coursework tests."

"the pre work was amazing, I got so much more out of the lectures because of it."

"The flipped classroom approach was something I wasn't expecting to get on with, but instead was a far better style of teaching than I had anticipated and would like this to be continued next year."

"The flipped approach worked really well for me as it allowed me to get a basic understanding of the work first for myself, and it actually made me do the work before the lecture so that I knew what was going on."

All comments received were positive of the flipped-style teaching.

5. Discussion

The flipped-style teaching worked much better than I had hoped and students responded very positively to it. Having a highly-scaffolded approach worked well, in that students were very clear

what they needed to do each week and had a range of different learning activities to work from. It also meant that students who were not able to attend the class, for whatever reason were still able to keep up with the work to a certain extent. However the drawback was that it was quite time-consuming to set up which could potentially be a barrier to adoption on other modules.

During the class itself, not everyone in the room voted using the TP clickers. This did not appear to be due to technological problems; instead it seemed that some students preferred not to partake, despite responses being anonymous. The drawback to this was that I may not always have had an accurate picture of the class' understanding of different topics. It was slightly disappointing that more students didn't attempt the Dewis practice tests prior to class. Anecdotally students said to me that they didn't want me to see if they achieved a low mark, so preferred to try them after the class when they were sure of the material. To address this for future years I may amend the wording of these practice tests from "engagement will be monitored" to "non-engagement will be monitored".

From January 2016 the class will be delivered in a Technology-Enhanced Active Learning (TEAL) space (MIT iCampus, 2016). This space contains collaborative working pods which each seat up to six students and include 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 this TEAL space may encourage better small group discussion and peer instruction in class. In addition, this different learning environment will enable students to use relevant software, e.g. Maple during class.

6. References

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