FLIPPED TEACHING AS A METHOD FOR ENGAGING LARGE GROUPS

DR SAM MARSH AND DR NICK GURSKI

Abstract. In a large-scale trial at the University of Sheffield ($n = 236$), we implemented a flipped approach to teaching mathematics to first-year engineers. Lectures were discontinued and replaced with an integrated format of specially filmed short videos, online quizzes and twice as much small-group learning. We found strong evidence that engagement and exam performance were boosted by the new method by comparing with students on an identical syllabus taking the same exam but taught traditionally.

1. Introduction

1.1. **Background.** The School of Mathematics and Statistics provides mathematics teaching for undergraduate students in the Faculty of Engineering at the University of Sheffield. Predominantly, these modules have been taught in a traditional format of two large-group lectures (200 students or more) and one smaller-group problem class (approximately 40 students) per week. Attendance records are kept for problem classes but not lectures. We find that attendance usually starts high, but drops off as time progresses (see Figure 1).

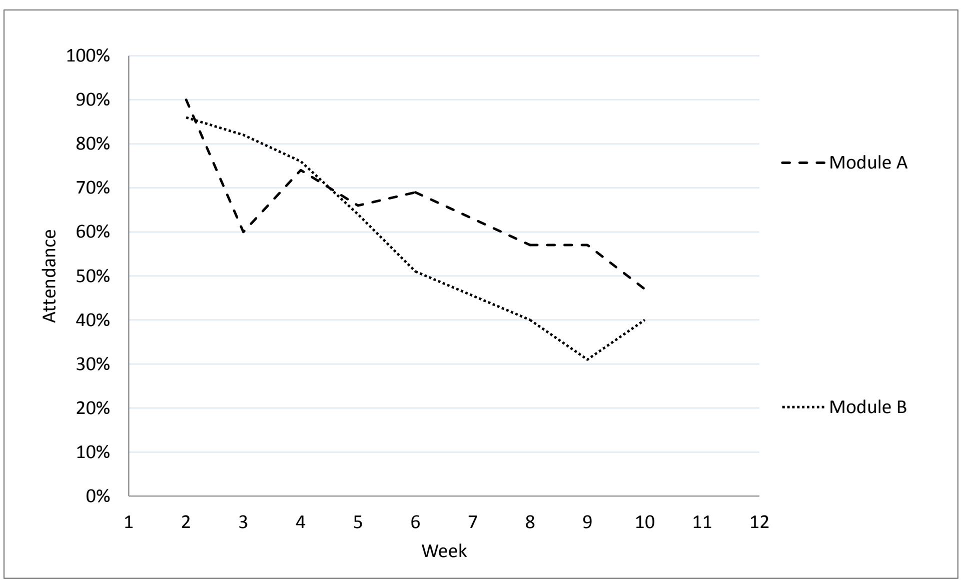

Figure 1. Problem class attendance on two traditionally taught engineering mathematics modules, Semester 1 2013–14

A working group was established to look into the effectiveness of these modules, with a particular focus on whether a flipped approach, based around videos, online tests and small-group classes, could provide a more engaging course for students.

The working group established a key proposal: that large-group lectures would be discontinued, and their content split into theory (to be included in the videos) and examples (to be done in classes). Further, the amount of contact time allocated to small-group learning would be doubled. This approach was to be piloted on a first-year module of 236 students, with two other modules totalling 298 students which cover an identical syllabus but taught traditionally used as a comparison.

1.2. **Literature.**

2. Comparison of teaching methods

2.1. **Summary.** The difference in structure of the flipped approach as compared with the traditional course format is summarised in Table 1. Both formats are for year-long, 20-credit modules for first year engineers from varying departments studying the same syllabus. Note that timetabled sessions are 50-minutes in duration, and these are the units used for counting lectures and problem classes.

	Traditional	Flipped
Lectures per week	2	0
Problem classes per week	1	2
Problem class format	Exercise booklet, reactive teaching	Worksheets, proactive teaching
Continuous assessment	End of semester homework	Online tests
Additional resources	Typed notes, office hour, webpage/VLE	Video lectures, typed notes, additional exercise booklet, discussion board, office hour, webpage/VLE

Table 1. Comparison of teaching formats

The main differences in approach are that two or three short (10–15 minute) video lectures replace each face-to-face lecture, quick online tests follow each video, and problem classes are doubled in frequency and given more structure.

2.2. **Video delivery.** The videos are best described as for-purpose 'chalk-and-talk' short films, made using minimal equipment (camcorder, lapel-mic, umbrella lights and blackboard in a standard office). In a few places cutaways to narrated slides also feature. The videos are hosted, unlisted, on Youtube and students access them as embedded into a page within the Assessment in Mathematics (AiM) learning-environment, itself mostly developed at our department. AiM allows for each video to be followed by mathematical questions, randomly varied by student, and the underlying software is able to manipulate algebra so as to accept any valid rearrangement of a correct answer. It also gives instant feedback on student responses and records all activity, allowing us to track engagement and performance.

2.3. **Problem classes.** In a standard week students complete two iterations of the cycle: log in to AiM > watch 3 videos > rewatch if necessary > complete the online tests > attend a problem class. Additionally, students are encouraged to work on a booklet of practice exercises independently, supported by the course notes and staff or peers on an online discussion board.

Students are assigned to a problem class group of size 40. These groups meet twice a week. The class is run by a tutor who recaps and reinforces the theory seen in the videos (5–10 minutes), encourages input on an example demonstrated at the board (5–10 minutes), then sets problems for students to work on, encouraging peer-discussion. Each problem class has a lesson plan which is made available subsequently to students via the course webpage.

The format for the new problem classes differs from our previous approach, where the ratio of teachers to students was better — 40 students were catered for by one staff member and one postgraduate student assistant — but the class was reactive, with students working on exercises and teaching staff responding to demand for assistance.

3. Methodology

The pilot implementation of our scheme was restricted to a module for one of the engineering departments (Module C, $n = 236$), with modules for two further departments directly comparable (Module A, $n = 137$, and Module B, $n = 161$). The latter two modules were lectured in a single group. All students had attendance recorded at problem classes and received feedback questionnaires at the end of each semester. Data on the use of the video-system (AiM) was recorded for students on Module C. The exam was identical for all students and sat concurrently.

Raw exam data for the preceding two years was also available, where all three modules were taught in the traditional format with a common exam, allowing for an analysis of exam performance that could control for variations in the relative abilities of students on different courses.

4. Analysis

Engagement. Attendance at problem classes was considerably better across the year for the new format, Module C (see Figures 2 and 3, and Table 2). Students attended approximately three times as many problem classes across the year, due to a higher attendance rate (77% compared to 50–60%) over twice as many scheduled classes.

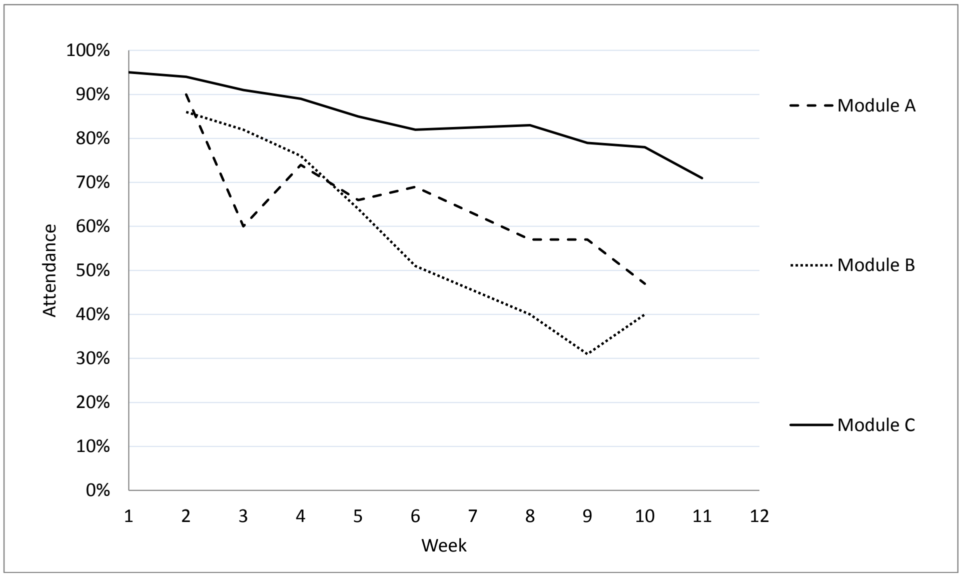

Figure 2. Problem class attendance, Semester 1

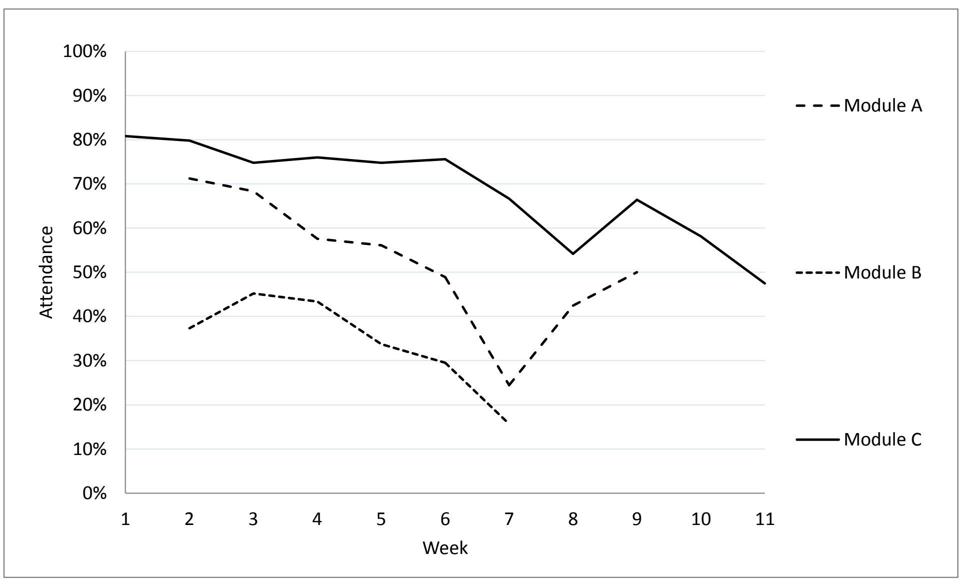

Figure 3. Problem class attendance, Semester 2

Additionally, as students were unable to access the online tests until they had watched the relevant video in full, without fast-forwarding, we were able to determine the number of students who had watched each video on time (see Figure 4). The data from indicates that the vast majority of students (86%) watched at least 80% of the videos on time, and half of students watched at least 97% of the videos on time. It is possible, and indeed likely, that students who had not watched the

	Average attendance	Average no. classes attended
Module A	59%	10–12*
Module B	50%	7.5–11.5*
Module C	77%	31.5

Table 2. Summary of attendance data

videos on time watched them at a later date, but we didn't have a method for tracking such engagement.

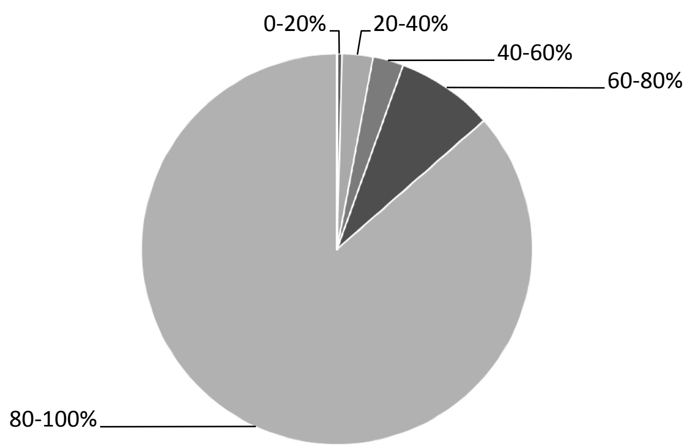

Figure 4. Proportions of videos watched on time

5. Conclusions

Here we sum up.

6. References

References

[KWSC] C. Karr, B. Weck, D. Sunal, and T. Cook, *Analysis of the Effectiveness of Online Learning in a Graduate Engineering Math Course*, Journal of Interactive Online Learning, **1** (3), 2003.

[JT] M. Jiang and E. Ting, *A study of factors influencing students' perceived learning in a web-based course environment*, Journal of Educational Telecommunications, **6** (4), 2000, 317–338.

[RA] E. Rowe and J. Asbell-Clarke, *Learning Science Online: What Matters for Science Teachers?*, Journal of Interactive Online Learning, **7** (2), 2008.

[GA] D. R. Garrison and T. Anderson, *E-learning in the 21st century: A framework for research and practice*, New York: Routledge Falmer, 2003.

[NK] D. Nguyen and G. Kulm, *Using Web-based Practice to Enhance Mathematics Learning and Achievement*, Journal of Interactive Online Learning, **3** (3), 2005.

[GS] K. Golden and C. Stripp, *Blending on-line and traditional classroom-based teaching*, available at

`http://www.mei.org.uk/files/pdf/LOUGHBOROUGH_PAPER_D3CS.pdf.`

[W] J. Williams, *The place of the closed book, invigilated final examination in a knowledge economy*, Educational Media International **43**, Number 2, June 2006, 107–119.