Collaborative Problem-Solving In First Year Physics

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OVERVIEW

This case study describes an assessment design for collaborative group working of first year students in Physics, implemented in teaching activities we call 'workshops', that were originally introduced 5 years ago as a replacement for the standard tutorial-plus-laboratory format. These workshops comprise a variety of different group activities, but here I focus on collaborative problem-solving and the way that the workshop activities feed into the assessments for the course. The case study addresses themes 1 and 2 of this conference (1st year experience and assessment designs). I also describe the spread of this activity throughout first and second year teaching in Physics and how it has led to a reconsideration of the importance of variety in teaching accommodation at an institutional level.

INFORMATION ABOUT THE CLASS, MODULE OR PROGRAMME

This case study documents an assessment design within a first-year undergraduate Physics class, taught at the University of Edinburgh ("Physics 1A: Foundations"). It is, as the name suggests, a foundation course in the classical Physics of space and time. The specifics detailed here pertain to this class, however it is an assessment design that we currently use widely across pre-Honours (years 1 and 2) Physics teaching in Edinburgh. Equally, the subject focus is on Physics, but this design is transferable across many science disciplines.

The particular Physics class described here contains approximately 250 students each year, with a wide variety of background study of the subject (approximately 30% have Scottish Highers, 40% Advanced Highers and 30% A-levels). Each year, around 40% of the class are students who are taking this course as an elective option and are studying towards a degree other than Physics.

Teaching on the course comprises interactive lectures and *workshops*, implemented five years ago as an alternative to the standard tutorial-plus-laboratory format. They are three hour sessions that students attend weekly and undertake a variety of different activities with a strong focus on working together in groups of four to six. The class size is such that students attend one of four possible afternoon sessions, as best fits their other timetable commitments. The design and rationale behind the introduction of these workshops, together with a more detailed description of the different types of activities undertaken has been described elsewhere (Bates 2005). A description of the underlying teaching ethos used throughout all aspects of the course, in particular the role of technology and online learning materials to support student study, which play a key role within the workshops, has also been published (Bates *et al*, 2005) This case study focuses on one particular activity that features prominently within every workshop, occupying approximately one third of the time

each week; that of collaborative problem-solving and the subsequent assessment that follows from this.

DESCRIPTION OF THE CASE

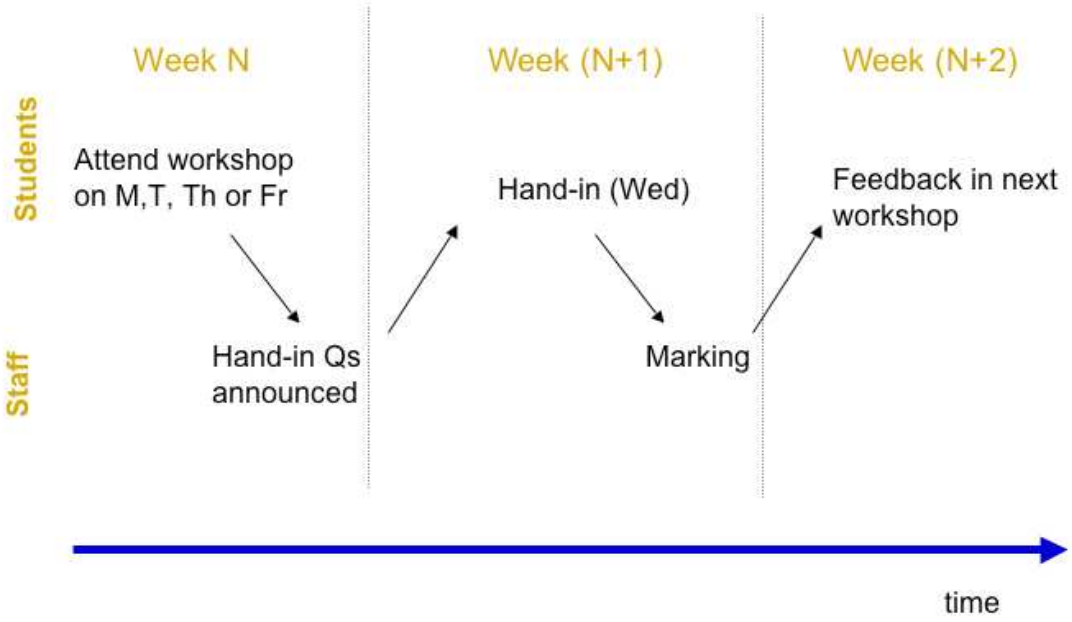
Workshops comprise a variety of different activities each week, but a major component is time that students spend collaboratively working on a number of problems relevant to the material of the course for this particular week. This set numbers anywhere between 6 and 15 problems, and students are advised to plan within their groups which problems they are going to tackle within the allocated time (with the expectation being that other problems are done out of class!) Typically, the questions are such that a group can reasonably expect to be able to tackle approximately 6 within an hour. None of the activities within the workshop are explicitly assessed (but the problem solving ones do feed into assessment – see below) and students are encouraged to make as much use of the postgraduate tutors and staff members who facilitate these sessions. Students are advised not to spend workshop time generating perfect solutions to problems, but to "work through" them, focussing on the process of how to solve them, rather than the final product (often, but not always a numerical answer).

At the end of the workshop week on a Friday, once all students on the course have attended for that particular week, three of the group of questions are designated "hand-in" questions, and students are expected to write up full solutions to these individually for hand-in the following Wednesday. The scripts are collected prior to the lecture, distributed to staff and postgraduate student markers, and handed back to students at the beginning of the following week's workshop. The marked assessments contribute (along with pre- and post-course diagnostic testing) to a coursework mark, worth 33% of the final mark for the course.

The start of a workshop will typically start with return of scripts to students and staff will spend 10-15 minutes going over general feedback on the previous week's assignment (common "banana skins" etc), give students an opportunity to compare their scripts with full solutions online, and give time to enable them to digest the feedback on the scripts. At certain points in the course, student scripts are returned to them with one question unmarked. They then spend the first part of a workshop peer-assessing someone else's script with the aid of the online solutions.

The "cycle" of attempting, writing up, submitting and receiving feedback on question takes two weeks and a timeline of student and staff activity is shown schematically below. There are a total of 9 such cycles over the Semester-long course.

Figure 1: Cycle of attempting, writing up, submitting and receiving feedback on questions



RATIONALE IN TERMS OF EDUCATIONAL IDEAS

The key educational aim of the workshops is to foster not just the "hard" skills needed by the professional Physicist, but also the more qualitative (or "thinking") skills that will be valuable to all students, whatever their chosen career. Implemented within a group-working environment, the workshops give students low-stakes opportunities to acquire and refine such skills as stating and defending a point of view and presenting or explaining material to peers (students are given flipcharts for their group problem-solving). Allied to this is the aim that our students be actively engaged with the material (despite much of it being rather familiar in this course) and be on a pathway towards more autonomous and independent learning, and the overall design of the workshops and the assessment that results from them is geared to support this.

The workshops are not assessed, yet active participation in the activities within them feeds into the summative assessments on the course. The Friday evening announcement of the hand-in questions forms a useful line in the sand. Prior to this, collaboration and group working is entirely acceptable and strongly encouraged (both within and outwith formal workshop slots). After the announcement, it is made clear to students that what follows should be entirely their own work and submitted as such.

A strong emphasis is placed on feedback at all points in the cycle. In the group-working phase, students get feedback from peers, tutors and staff both on the specific problem at hand, but in the wider context of the course as well. Following marking, general assignment feedback is provided to the whole class online, together with a histogram of class marks for that assignments, so students can easily identify the relative value of their particular mark. Finally, time is made for students to digest individual feedback on scripts and have it clarified or expanded upon. Many of the principles of good assessment practice identified as part of the REAP project (adapted from Nicol and MacFarlane-Dick (2006) and Gibbs and Simpson (2004)) can be distilled from this design.

EVALUATION

Workshops were originally introduced into second year teaching as part of a raft of measures to arrest an increasing failure rate. They were soon adapted and adopted into the first year course described here. In both years, they have turned out to be an overwhelming success story from all points of view. Student satisfaction, as evidenced from staff-student meetings and course questionnaires, is extremely positive, more so since problems with the physical room layout have been addressed (see below). Attendance is consistently good at these sessions, which energises (and in some cases, rejuvenates) staff involved in a positive feedback loop. A tea-break midway through the three hour sessions provides the opportunity for social interactions between staff, Pgs and students as well. The workshops have also given us a specific activity to focus on when providing training and support to postgraduate student demonstrators. I am cautious in trying to draw firm conclusions from exam results, as year-on-year there are many variables which can affect performance in either direction.

Having been through several years of workshops, we can confidently say this is not just a 'halo' effect where a new practice is initially met with great enthusiasm from both staff and students, but which proves harder to sustain in subsequent years. In fact, the opposite is probably true, that this is a practice that is gathering momentum both within and outwith the School of Physics. Within the School workshops have been *requested* by students in other courses, to the point now where it is deployed as a teaching method in nearly all Physics courses in years 1 and 2. (Interestingly, students have also requested this style of teaching and learning in other *disciplines*).

A particularly striking (apparent) turnaround is in a mathematically-demanding course that was becoming our Achilles Heel in recent years, with a disastrous failure rate. These students are about to sit exams on this course which has employed workshop teaching for the first time this year. The attitudinal shifts (of staff and students involved with the course) have been remarkable and we await the end-of-year results with considerable expectation.

Outwith the School, the introduction of workshops in Physics has been used to lever changes in the way the teaching estate is designed and used. A refurbishment project allowed us to campaign for the refitting of four traditional face-the-front tutorial rooms as a single 100-seat workshop studio. This is now a centrally-bookable teaching space, located in the central area of the University. Subsequent refurbishment on the science campus (King's Buildings) this summer looks likely to provide one or more similar-sized facilities of this type.

REFERENCES

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Re-Engineering Assessment Practices in Scottish Higher Education (REAP) is funded by the Scottish Funding Council under its e-Learning Transformation initiative. Further information about REAP can be found at http://www.reap.ac.uk