REAP Completion Report Engineering Mechanics, Department of Mechanical Engineering

Project Sign-off

1. Project achievements

*Have all **project activities or deliverables** been completed? What, if any, work remains outstanding from your plans for this academic year?*

The main objective (deliverable) of this Project has been to reduce the (significant) amount of marking required in a large and important 1st Year class which is delivered to over half the incoming students in the Faculty of Engineering from four departments. A typical cohort is 250 students, split between two sections and delivered by four academic staff; the subject matter is fundamental engineering mechanics, which requires a significant amount of problem solving as well as conceptual understanding. Both of these basic skills have not been well developed during secondary school physics, even with well qualified students, and both need considerable practice (and indeed a re-focussing) during the students' initial year at university. Over the past ten years the issue of conceptual understanding has been well addressed through the use of in-class discussion facilitated by Electronic Voting Systems (EVS). This has improved not only their fundamental understanding, but also examination performance, attendance at class and retention. However the problem solving aspect remained problematic and required a significant amount of staff time marking and annotating (for formative feedback) fortnightly written homework. To reduce this, at most two written problems were required to be completed using a highly structured (multi-representational) problem solving framework and strategy. At problem-solving sessions (tutorials) the students tended to focus on these homework first, and left investigations of other problems until last, even though a structured problem set was specified. In addition they remained very much focussed on what type of problem would appear in the class tests, and tended to concentrate on those. (The class is assessed by the written homework (25%) and two 2-hr written class tests (75%) at the end of each semester). It was decided as the main objective of this Project to try to reduce the marking 'burden' using a combination of in-class tests and the next generation EVS systems (which allowed more diverse question types other than multiple choice, MCQ) and intelligent on-line homework systems.

The introduction of the online homework and testing systems has been very successful, but has led to some 'apparent' unexpected consequences. It also became apparent that in-class testing, using different question styles, would need to be developed further since the 'concept' seemed to prove strange to most students. It had been hoped that these issues would have been resolved during this academic year, which will need to be investigated further in the next academic year (as described further below).

At the end of the project, do you feel you achieved the aims and objectives identified at the start? What is missing? What have you done that wasn't in your original plans?

Overall the Project aims and objectives have been achieved – in particular staff marking time (of homework and class tests) has been reduced considerably, with no disadvantage to the students' learning experience (as indicated by an evaluation carried out by the University of Glasgow partners). However, as indicated in the preceding, some 'unintended consequences' arose from the use of the online homework system, and the in-class testing component needs to be re-designed (although it is important to point out that this is not a reflection on the tests themselves, which proved successful and highly useful with significant potential, but rather the students' reaction to them – we suspect we need to 'front-load' these and give these 1st Year students more preparation, probably due to their previous assessment experiences and expectations from school).

2. Impact on students

What has the impact of the project been on students? Have marks, attendance, retention, progression or other key indicators changed or improved (please give details)? Do students demonstrate differences in their satisfaction with the class or course? What evidence can you draw on (please give details)?

Over the past ten years, this class has introduced group work, re-designed learning spaces, teaching-by-questioning using EVS and structured problem solving strategies. Overall the impact on the students has been profound, with high levels of attendance (even at early morning 2hr sessions on Mondays and Fridays), improved grades and an impact on retention. The unresolved issue with this class has been the style of assessment (fairly traditional written homework and tests) and the student focus on exam preparation (what is required to pass the test?!). At the beginning of this Project, the highest risk was identified as possible negative reaction to online homework for 'formative' assessment (although the homework is graded), since the students are wholly unfamiliar with this, and shorter written tests (with less choice). During the first year of the project it became apparent that this was not a problem. Further, an evaluation undertaken towards the end of the second year of the project by the University of Glasgow partners resulted in a very positive response from the students, including those who were under-performing and struggling with the work-load. More detail on this can be found in the *University of Strathclyde Mechanical Engineering Student Focus Group Report*, March 2007, by Mel McKendrick & Pippa Markham.

3. Impact on staff

What impact has the project had on staff? Has workload changed significantly? Do staff members involved in the project feel differently about the class or course now that changes have been made? How?

Staff reaction to the changes in assessment has been two-fold. Firstly, assessment workload has reduced considerably. Before the changes each of the (four) members of academic staff involved in the class would typically spend 4hrs each fortnight marking and providing (written) feedback on written homework together with approximately 32hrs marking each end of semester written class tests (both of 2hrs duration) – in total about 102hrs. This may seem to the layman not to be a significant burden over the whole academic year. However this has to be put in context – class contact is 96hrs over the year (24 2hr teaching and tutorial sessions each semester). In other words, for large classes, assessment exceeds student contact, and has never been seen as an efficient use of academic staff time – most would prefer more student contact time (if feasible, but this usually is not). In other parts of education assessment usually does not exceed about 30% of contact time. Following the changes, staff involvement in assessment has reduced considerably: one written homework is submitted each semester – requiring about 6hrs marking each, together with a reduced 1hr written test at the end of each semester – each requiring 16hrs marking. The total has now changed to 44hrs spent on assessment (that is, 50% of contact time) – a reduction of 50%. It is expected that if the two written homework can be completely removed by in-class testing, the assessment total could be reduced t0 32hrs – a more efficient 30% of contact time. In conclusion, it is fair to say that all the staff involved in marking were always alarmed at the amount of marking required – this has now been removed and time can be more effectively spent elsewhere.

However, there has also been a second impact on staff. Student attendance at the problem solving (tutorial) sessions reduced considerably (before, almost all the class would attend – now less than 10%). The main resulting concern of all staff involved has been a feeling of a loss of personal interaction with the students (although this has been replaced to a limited extent by online discussions in WebCT). A few of the students in the Glasgow Focus Group Study also commented on this, but otherwise the students did not see this as a particular problem. However there are significant implications for class scheduling (more of which later).

4. Impact on costs

How do you think that the changes you have made will affect the efficiency of class or course delivery in the future? Have costs been reduced? Or has quality improved significantly with no additional long-term costs?

As indicated in the above, significant efficient gains have been made, with no apparent damage to student learning (or class attendance and retention). It is also fair to say that quality has improved. An important component of the changes made by the project has been the introduction of a custom published text, with associated online access and very high quality learning materials (quizzes, problems, real-life applications and various other supplementary materials). This has allowed the use of Just-In-Time-Teaching. In addition the two homework systems which have been investigated over the duration of the Project – *Mastering Physics* and *WebAssign* – are directly linked to the custom text and make good use of randomised numerical problems, as well as concept questions and ranking tasks. However this high quality material, coupled with intelligent homework systems, does come at a cost. While major gains have been made in staff efficiency, use of the homework systems does have to be paid for - £12.95 per student (if shrink-wrapped with the custom text) for *Mastering Physics* (which proved an excellent online formative assessment system, now coupled directly with the textbook) and £7 per student for *WebAssign* (better as a graded homework testing system). In the first year of the project, where *Mastering Physics* was used, we were provided free access, while *WebAssign* was trialled during the second year (at full cost). For a large class of 250 students *Mastering Physics* would cost £3250 while *WebAssign* would cost £1750. While these costs are not large (in the context of a large engineering department, where significant sums are devoted to laboratory work and the licensing of modelling and simulation software), they do need to be justified. There is also the issue as to whether the students should pay for access to these systems (as is the typical model in the US).

5. Sustainability

Explain how current project activities will continue in the department. What measures are in place to ensure that activities are embedded? Who is responsible for ensuring sustainability?

The success of the use of online homework systems, directly linked to high quality (custom published) textbooks and supplementary material, has been very evident. The Department has three streams of engineering science subjects progressing through the first three years of a 5 Year Course (the 4th and 5th year being more specialist) and has already started investigating the exclusive use of available textbooks (rather than printed notes), with online assessment being introduced as this type of content becomes available. Two other classes have also started to use WebCT for formative assessment (quizzes) and summative assessment (end of semester class tests). All staff are responsible for ensuring sustainability – although it should be emphasised that our Department has a history of investing in educational initiatives and innovations, so the culture for positive change is implicit.

6. Plans for further development

Are other courses or classes in the department planning to change their assessment practices as a result of your work (please give details)? What do you think would need to change in your department if your REAP-supported ideas were fully adopted across all courses and years?

In the context of the culture of our Department (and its reputation for educational innovation), sustainability and further development are essentially the same. The comments given in the preceding section are valid here. Our experience is that the active hands-on support of departmental management is essential for success in this area (including the Head of Department), if such initiatives are to succeed beyond enthusiasts.

7. Lessons learned

What changes contributed most to improving the quality of student learning?

An ***integrated*** approach to class re-design – in our case group work, EVS and teaching-by-questioning in a group setting – now supplemented by high quality support material and intelligent online homework systems. Just changing one aspect we suspect would not be sufficient for a major change. For example, some institutions have reported poor responses to the use of online homework systems – which we suspect were due to being seen as an 'add-on' to a traditional class rather than the basis for a radical re-design.

What changes contributed most to reducing costs?

The use of high quality online homework systems, used appropriately. Of course these are not available in all subjects and for all classes in a typical degree program – however they are available, or are being actively developed, for many fundamental science and technology subjects, especially in the early years.

What implementation issues were most important?

Apart from the comments on an integrated approach given above, the only real issue identified at the outset would be student reaction to the online systems. This did not arise in practice – engineering students seemed to adapt to the online system very well, with no training.

If you could start again, what would you have done differently? What lessons would you pass on to other departments undertaking similar projects?

See comments above on essential lessons which we should pass on – but in addition, general advice would be to talk to practising academics who have made the change, and visit their classes (in person and online).

The only thing we would have done differently would have been giving more thought to the in-class testing component using the new EVS systems and the use of different question types. We thought that this would be fairly straightforward, but the student reaction was mixed – we think because this was so alien to them. This is discussed further below:

8. Future Research

Have any issues emerged from the project which merit further investigation or future development work by your department, by CAPLE or by other organisations?

Three main issues have emerged – these will be investigated further in the next academic year (hopefully with input from CAPLE):

For many years in some classes, short 1hr written tests, often marked by other students and checked by tutors, have been used mid-term and end-of-term, to reduce the time required for a formal written test at the end of each semester. These have been quite successful over the years and appreciated by the students in terms of a reduced load at examination time. As part of this project it was proposed to use such short in-class tests using the EVS and a variety of question types. (The in-class written tests have never been used in this class, due to the frequency of written, assessed homework). Three different question types were used: standard MCQ, MCQ supplemented by *Certainty-Base Marking* (CBM) and *Ranking Tasks*. In the first year of the Project, a few practice tests were run in the 2nd Semester, followed by one graded tests. In the second year of the Project, three in-class tests were used (one practice). In fact the students did not respond well to the Ranking Tasks (although these are widely used in physics education) – after various discussions, we came to the conclusion that the written component of the Ranking Task (explanation of student reasoning) was key. Further, student reaction to CBM was very mixed – we have come to the conclusion that students need more practice in this, probably through formative online assessment, and this should be introduced very early on. How this will be handled in the next academic year will be discussed by the teaching team after the summer break. This style of in-class assessment has considerable potential in numerous ways, but

we expect needs more care in implementation, especially for new incoming students who are wholly unfamiliar with this type of grading and assessment.

As highlighted in the preceding discussions, attendance at tutorials (problem solving sessions) has been sparse – although the students have not reported any perceived loss to their learning (from the Glasgow University Focus Group Study). If indeed this is an (unexpected?) outcome of the Project, there are major implications for how this time could be used (or not used) – tutorials account for about one-quarter of contact time. There are various options: remove tutorials but maintain contact time and use the time in other ways (many options here), have staffed computer labs while students use Mastering Physics or WebAssign, reduce class contact and so on. This will again be discussed by the teaching team in the Autumn in preparation for next year.

There has always been feedback from students – anecdotal, in-class and online in Discussion Forums – that they forget some of the logic and arguments behind the resolution of in-class ConcepTests using EVS. This has been a common problem with the use of this technology with class discussion, and systems have appeared (and apparently been successfully used) which can capture the whole classroom experience (PowerPoint talk-through, video of in-class discussion and so on) and at relatively low cost. This possibility will also be examined for next academic year (using remaining funds form the Project) since it could be a key component of student self-study and formative assessment.

9. Dissemination

List the dissemination that has been done (or is being done) since January 2007 about project findings and outcomes, e.g. journal articles, conference presentations. Please give details.

Presentations (on the use of EVS) have been made at seminars at the University of Edinburgh, the University of Bristol and Dublin Institute of Technology.