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USE OF COMPUTER MODERATED QUIZZES TO DEVELOP A 'REAL-TIME ENGAGEMENT' CULTURE

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ABSTRACT
Recruitment and retention is a major problem within Electrical Engineering at undergraduate level. Experience at the University of Brighton has shown that the majority of students recruited to these programmes struggle to cope with modelling and analysis of electrical circuits, which is critical to their design capability. Hence it is necessary to offer a study package of remedial input to bring them up to the standard required for progression to subsequent years.
It has become progressively more difficult to achieve the required level of engagement with this study package. The problem came to a head in 2006/7 when most students failed to achieve a pass mark in the phase test used to gauge the success of its assimilation.
Hence a programme of action was initiated to improve engagement with the study package as it was delivered, in near real-time, and to reduce the reliance of assessment upon examinations only. Computer moderated quizzes were introduced to stimulate engagement with guided reading materials very soon after those materials were delivered to the students.
This new strategy gave pleasing results. The performance of the cohort on the phase test at the end of the material was very much improved. The addition of a 'Coursework Element' from the quizzes gave all students a significant lift on their overall marks, and this improved their confidence and gave them encouragement throughout the remainder of the year with their application-oriented studies, which built on this material.

Keywords: Engineering recruitment, online assessment, computer moderated quizzes, CAL, real-time engagement

1 INTRODUCTION

In the UK there is a critical problem in the recruitment to, and retention within, the formation of Electrical and Electronic Engineering designers at undergraduate level. The reasons for this problem could be the subject of several PhD-level research programmes, and are beyond the scope of this paper. However, they are certainly linked to a general decline in enthusiasm for mathematics in recent generations and the perception that Engineering is a 'hard' subject, heavily dependent on mathematical analysis and with low-key career prospects. Thus it does not compete well with other disciplines that appear to offer lighter undergraduate workloads and more glamorous career opportunities.

1.1 Poor image and status

Engineering has a particular image problem in the UK, where a person who mends a washing machine is all too frequently known colloquially as an 'Engineer'. Furthermore, our government lacks representation of members of the Engineering professions, and hence exhibits a severe lack of understanding of the critical role played by Engineering. Contrast this with the situation in China, where, until very recently, all nine members of the Politburo were trained engineers [1]. So it is no surprise to find that Engineering is a high status profession in China, which is currently the world's fastest growing major economy.
These combined factors have led to significant drop in recruitment to electrical and electronic engineering undergraduate programmes nationally, as monitored by a forum for academic leaders in electrical and allied technologies called 'Professors & Heads of Electrical Engineering (PHEE)'. At their 2008 annual conference, Prof. Morling noted that the total number of acceptances of undergraduate places on electronic engineering courses had fallen by 35% from 2002 to 2007 [2]. At the 2009 conference Prof. Ramsden observed that the number of full-time enrolments to electrical and

electronic engineering undergraduate courses in 2006/7 had fallen from their 1997/8 level by 2%, which contrast badly with an aggregate growth of 24% for all courses over the same period [3].

1.2 The end of the decline?

Recently the Engineering and Technology magazine of the IET (The Institution of Engineering and Technology; - the professional body that represents Electrical and Electronic engineering in the UK) went as far as publishing an article with the provocative title *"Engineering has ceased to be… it is a dead career!"* [4]. Despite this gloomy title, the article carried the strap-line *"Has engineering finally reached the bottom of its long decline?"*. It posited that the need to meet the UK's predicted gap in power generation capacity in the next decade would urgently require a new generation of skilled and motivated electrical engineers to design and deliver power generation capability that is affordable, effective and environmentally acceptable.

Evidence from South Africa, which now regularly experiences power cuts because its power production and distribution system cannot meet existing demand [5], supports the notion that the looming power generation gap in the UK is likely to be one of the first issues to raise the profile of the lack of skilled engineers in the public eye. However, more and more products are coming to rely intrinsically on embedded electronic systems to supply their functionality and desirability; - slickly designed exteriors are nothing without the 'works' inside. So the teams that design complex interactive products increasingly rely on engineering expertise.

So, this underlines the reality of engineering (rather than the common perception), which is that it is a career that invariably involves the incredibly creative and satisfying business of designing elegant, practicable and affordable solutions to real-world problems.

1.3 The challenge for academia

Hence it seems imperative that academics find ways to fully motivate and engage our current cohorts of electrical and electronic engineering undergraduates, sparsely populated as they are, to develop their design skills to a level that will allow them to fully participate in their burgeoning careers.

Recent experience at the University of Brighton has been that the majority of students recruited to electrical and electronic engineering programmes are finding it progressively harder to cope with the modelling and analysis of electrical circuits. It is an integral part of their training that they can develop pragmatic (simplified) models of real systems and analyse them so that they can predict the behaviour of the systems under a variety of conditions. Clearly students recruited to such courses exhibit a fascination for electrical and electronic engineering design, but increasingly that is not matched by their enthusiasm for or ability in the necessary modelling and mathematical analysis techniques.

2 THE CONTEXT OF THE PROBLEM

This situation came to a head at Brighton in 2006/7, and the mismatch manifested itself as a severe lack of engagement with a first year study package that was concerned with laying the foundations of modelling and analysis for the design of electrical and electronic circuits.

2.1 The "new portfolio" and the critical study package

This study package was part of a module called "Electronics and Power" which constituted 25% of the first year of study for these students. The module was first developed for the academic year 2005/6 and was typical of the philosophy of the "new portfolio" introduced in that year, which was intended to restore cohesive study of engineering, after a long period of modular compartmentalisation. The idea was to develop modules with sufficient breadth and coverage to allow students to understand and benefit from the commonality and interdependence of related topics. Hence "Electronics and Power" replaced modules related to "Electronic Engineering" and "Electrical Engineering" and integrated a treatment of the fundamental modelling and analysis principles that underpin both of these application-oriented study themes. The aim of the new portfolio was to maximise the benefit of the enthusiasm of the students for their chosen discipline.

The study package of fundamental skills in modelling and circuit analysis necessary to underpin both the "electronics" and "power" application themes was developed to be delivered at the very beginning of the module, within the first term. It ran alongside a laboratory course that was designed to thoroughly introduce the students to the laboratory equipment that they would need to use for the remainder of the course, and to illustrate the fundamental theoretical principles as widely as possible.

Since this study package was intended to lay solid foundations for successive study, it was decided to confirm the students' comprehension of its content by means of two (summative) phase tests, each preceded by (lightly weighted) 'homework' activities to encourage engagement. The phase tests were mutually exclusive in the material that they assessed, although they were also incremental in that the second one expected students to be able to utilise fundamental concepts and methods evaluated by the first. For example, the study leading up to the first phase test would develop the principles of circuit analysis using DC circuits, which do not involve 'complex' algebra. Then, the second test would assess the extension of the same underlying analysis tools to AC circuits, which do require the use of complex algebra. Altogether this study package was weighted at 27% of the total module mark, and gave feedback to the students about their performance throughout the early stages of the module.

2.2 Evaluation of 2005/6 results of the study package, and modifications for 2006/7

The results of the first year of operation of this study package are given in Figure 1. The results for phase test 1, phase test 2 and then the overall marks for this study package (including the homework activities) are plotted as histograms for the students of the 2005/6 cohort in Figure 1(a), 1(b) and 1(c) respectively. A total of 33 students are included in this data.

A glance at the histograms in Figure 1 reveals that all three sets of marks exhibit a degree of bi-modality, which suggests that students are divided into those that have successfully engaged with the material, and those who have not. This is a fairly typical sort of distribution at first year level in an undergraduate programme. Figure 1(c) reveals that population of students who have fallen below 40% is rather large, but a significant number have marks that would allow them to recover in the remainder of the module, assuming that they respond well to the feedback given by these marks.

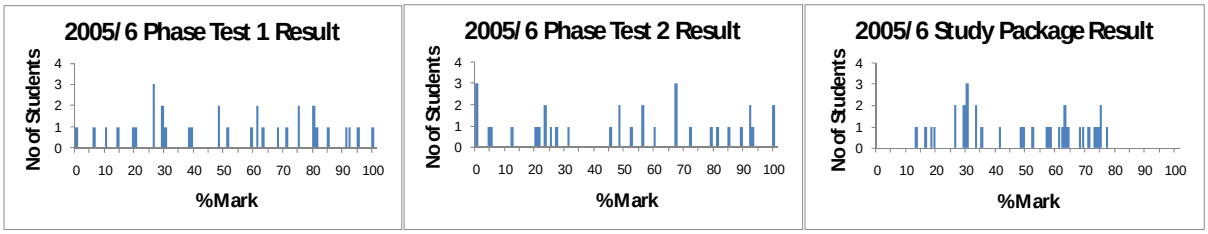

Figure 1. Histograms of results for 2005/6 cohort;
(a) Phase test 1; (b) Phase test 2; (c) Overall marks for the study package, respectively

Hence in its first year of operation, this study package gave no particular cause for alarm. It was recognised, however, that the marks for the open-book assessed homework activities falsely elevated the impression of the students' capabilities compared to the individual assessment in the phase tests. It is assumed that this is because students collaborated in preparation for the homework activities, and rapidly disseminated the best solutions to individual problems. However, this behaviour did demonstrate, at least, a willingness on the part of most students to engage with the study of the topic.

Since both phase tests were operated during the second term of this academic year, with the last one taking place just before the end of the spring term, there was concern that they were occurring too late in the year to allow the students to benefit from the feedback that they provided, other than in the final revision phase of the module. This would be particularly significant for the population of students with marks from the overall results of the study package that was centred about 30% (see Figure 1(c)).

As a result, the planning for 2006/7 operation brought the phase tests forward, with the first in the penultimate week of the first term; - two weeks after the completion of the delivery of the study pack material. 'Homework 1' was released, as before, with a submission deadline four weeks into the term, and was then marked and returned to the students as FORMATIVE feedback only. The scope of the first phase test was widened to incorporate the whole syllabus content of the study package, but at what was considered to be a relatively simple level, so that students would get feedback about their understanding of the whole study package much earlier; - shortly after Christmas. Phase test 2 was scheduled to take place at the same time as the previous year; - just before the end of the spring term. Its planned scope was to use the fundamental principles in a more application-oriented context.

This plan required the students to engage with the study of the material as it was being delivered, and would reward them for that with early feedback on their level of capability, which could then be fully exploited in the subsequent study of the application-oriented themes of "electronics" and "power". Hence it was entirely consistent with the cohesive study philosophy of the "new portfolio".

3 THE PROBLEM OF ENGAGEMENT REVEALED

The 2006/7 cohort of students numbered 24 students. Early warning signs included reports from the lecturer responsible for delivery of the study package regarding the students' perceived lack of engagement with the material, as evidenced by their response to the formative 'homework 1'. However, the extent of the problem was fully revealed when the first phase test marks were reviewed in December 2006. That set of marks is illustrated by the histogram of Figure 2(a).

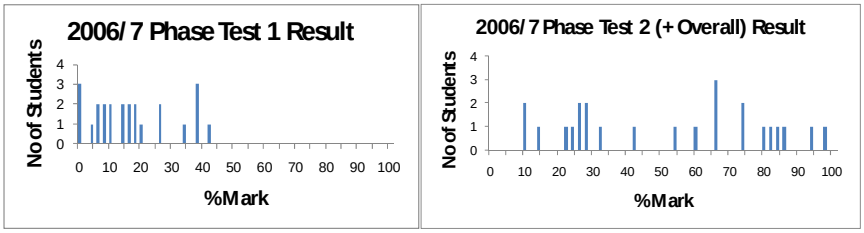

Figure 2. (a) Histogram of results of phase test 1 for 2006/7 cohort;
(b) Histogram of results of the (remedial) phase test 2 for 2006/7 cohort.

Figure 2(a) reveals that only 1 student exceeded the expected pass mark of 40%. Clearly this did not demonstrate that the cohort had achieved mastery of the subject matter, as hoped (and required).

3.1 Emergency remedial action in 2006/7

This shocking result called for concerted remedial action, which started by giving the students the phase test again (in lieu of 'homework 2') through the early weeks of the spring term. Then a detailed tutorial was given on each of the questions as preparation for phase test 2, which had to be written as a new set of questions with similar scope to that of phase test 1. The results for phase test 2 had to be used as the sole indication of the students' performance on the study package; see Figure 2(b).

One positive message from this debacle was that it was possible to draw the attention of the students to their demonstrable lack of understanding of the material in the study package early enough to plan and deliver a course of remedial action; - as an in-course referral activity. This meant that we could be reasonably confident that (most) of the students had met the learning outcomes of the study package in the end. This is no small benefit, but it represents cold comfort indeed and meant that we were back to square one in terms of delivering this evaluation at a time when the students could benefit from it in terms of integrating it within their study of the successive application-oriented themes.

4 FOREWARNED IS FOREARMED; - THE NEW PLAN FOR 2007/8

Clearly a major re-think was required to avoid a repetition with the 2007/8 cohort, which recruited even lower numbers of students, with only 16 reaching the end of the study package.

It was hypothesised that the key to achieving successful comprehension of this study package in a way that was compliant with the philosophy of the "new portfolio" was 'real-time engagement' with the topic. Students would have to make sure that they became confident with their understanding of the material, as it was being delivered, in 'real-time'.

The method chosen to achieve this objective was the replacement of homework with a high density of computer moderated quizzes. Such a quiz had been trialled in 2006/7 as a way of getting the students to engage with the familiarisation of the laboratory equipment at the very start of the laboratory spine of the Electronics and Power module, which needed to grab the students' attention quickly.

The quiz was devised using a range of question types that could be administered using the Blackboard VLE (known at Brighton in a customised form as 'studentcentral'). The idea was simply to get the students to engage with the comprehensive documentation provided, rather than simply collecting it and then filing it! The idea was to stimulate engagement by asking the students questions based on simple observation of the content of the relevant document. Students would be rewarded for their efforts by the ability to earn summative coursework marks. The computer system would mark the student's attempt at the quiz and would securely record the results.

This strategy had appeared to work well, and to be well received by the students in 2006/7. There were occasional glitches with students locking themselves out of the quiz session, but these could be easily resolved from any computer with access to the internet. It also had the advantage that once the quizzes had been generated (which is a task NOT to be underestimated), the administration load was

primarily borne by studentcentral, and the staff involvement was limited to a quick inspection of each submission to see if any re-grading was necessary. This was a wise precaution, since it would be counterproductive to cause students to lose marks simply because of trivial misspellings, etc.

4.1 Use of computer moderated quizzes to develop a 'real-time engagement' culture

So, it was decided to develop a series of quizzes that would be rolled out as the material of the study package was introduced to the students, like a 'creeping barrage'. Five pieces of "Guided Reading (GR)" [1] were prepared to support the delivery of the study package in a phased way. Each piece of guided reading was supported by a matched quiz that would make sure that the students had to visit EVERY page of the GR document AT LEAST ONCE, and making sure that all the key concepts were covered. The quiz would be 'opened' for access on the day that the particular GR document was first distributed and would close TWO WEEKS later (to reinforce the 'real-time' element of engagement). The student would not be able to access the quiz after it had closed without negotiating permission with the lecturer in an ad-hoc fashion. Permission was always granted, because the aim of the time-limited availability was the solely related development of a culture of real-time study, rather than a time-limited assessment mechanism. It should also be noted that students were only able to attempt each question ONCE (to encourage them to take care over what they were submitting), although they could stop and start the quiz and complete it in multiple sessions. Most questions were rated at 1 point each and there were 20, 25 or 30 marks per quiz; the total for all five quizzes was 125 marks.

The final element of the approach was to provide the students with carefully focussed tutorial questions that were rigorously re-named as "Self-Assessment Questions (SAQs)" to implicitly reinforce a sense of ownership. In the past it had been found that students would tend to wait for some 'tutorials' to be worked through by the lecturer, rather than attempt them themselves to help develop their understanding. It also seemed that this effect could be aggravated if there were too many questions posed, presumably because this could have a demoralising effect. Hence the SAQs were carefully chosen so that there were never more than two pages of questions, and that they covered all the key points without excessive repetition. The GR documents also included gaps for worked examples, etc., to be added by students during the lectures.

This whole regime was strenuously publicised to the students at the start of the module. They were given clear guidance that they would be able to earn coursework marks (40% weighting) by engaging with the GR material through the quizzes to supplement their phase test marks (60% weighting).

4.2 Results and discussion

The level of participation in the quizzes was very high; - ultimately reaching 97.5% (i.e. after some chasing-up of stragglers, 2 out of 16 students missed 1 quiz each out of 5). The total scores, expressed as %, are plotted as a histogram in Figure 3(a); - clearly the students performed very well in this.

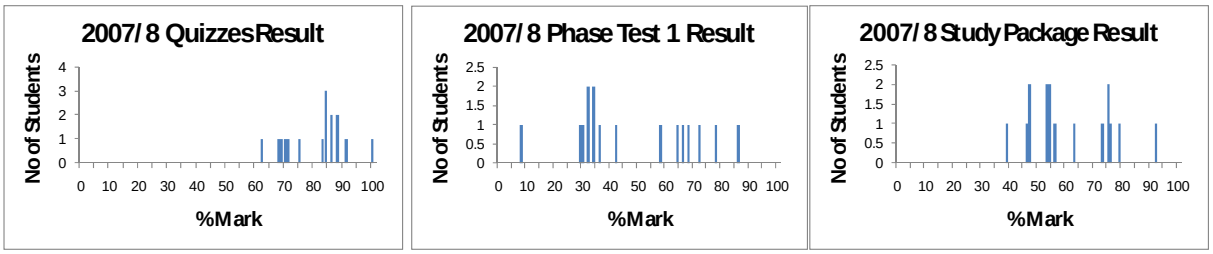

Figure 3. Histograms of results for 2007/8 cohort;
(a) Quiz Coursework; (b) Phase test; (c) Combined mark for the study package, respectively.

The results of the students' attempts at the unseen phase test that was set to cover the whole of the scope of the study package are seen in the form of a histogram in Figure 3(b).

When combined together (with the published weighting of 40% for the quizzes and 60% for the phase test), the overall marks for the study package are seen as a histogram in Figure 3(c).

The phase test performance is a major improvement on the phase test results achieved in 2006/7; - compare Figure 3(b) with Figure 2(a). Clearly the quizzes had encouraged the students to engage with

[1] The GR terminology was RIGOROUSLY adopted to avoid the negative attributes associated with the concept of 'hand-outs'; - e.g. handed out, filed and forgotten.

the study package. 9 (56.25%) of the students exceeded the pass mark outright, and a further 6 (37.5%) were above the threshold level of 30%. 1 student (6.25%) recorded a major failure, but that student transferred to another degree programme soon afterwards.
The students received the results of this phase test at the very beginning of the spring term, when only 1 week (out of 16 available) of study had taken place on the application-oriented themes of "Electronics" and "Power". Results for the quizzes were given by quiz topic and for the phase test by question number. Hence all students were in possession of topic-specific quantitative feedback on their strengths and areas for development with respect to this critical study package with 94% of the available study time for the follow-on application-oriented themes remaining. Students were able to be tutored on any specific area that concerned them for the remainder of the module.
2 more students withdrew from the programme before the final assessments of the module were completed, leaving 13 students. Of these, 10 (77%) passed the module outright and 3 (23%) were referred. None of the referred students successfully completed their referrals in September.

5 CONCLUSIONS

The students seemed to like the quizzes and the participation rate was excellent. The very high level of participation in the quizzes can be regarded as a major success, in encouraging engagement, for the computer moderated quizzes; - they did generate a culture of engagement with the subject matter.
There was an emergent property of publication of the quiz results as soon as possible after the quiz closed; - this policy engendered a competitive spirit amongst most of the students in the cohort, which motivated them to do the very best that they could on the quizzes, and to complete them quickly.
The effort involved in generation of the quizzes should not be overlooked. It is estimated that each quiz took roughly 8-12 hours to prepare. A method of automatically importing quiz questions from a Word™ template into the VLE test management environment would be very beneficial. Fortunately the quizzes could be debugged relatively easily, and when stable they can have a long life.
The overall delivery method of the study package is now compatible with the cohesive study philosophy of the new portfolio development, and supports its achievement. Detailed feedback is delivered to students in good time to allow them to correct any areas for development during the application-oriented phase of the module. 1 student moved from the sub 40% band to the pass band by the end of the module, and none fell back. However, it is not all positive; - one student declared himself totally satisfied by the confirmation that he had achieved an overall pass in the study package, even though he only scored 34% in the phase test.
Nine students supplied feedback at the end of the whole module. On a scale of 1-5, average scores of 3.9 (= 'Interesting'), 4.1 (= 'Challenging', but not "Too much material") and 4.1 (= 'Good') were recorded for "Interest", "Challenge" and "Presentation", respectively. Qualitative feedback that related to the taught content of the module was "Some of the concepts are very difficult, but are necessary", "he is trying so much to see we actually pass his module, which makes me feel like I owe him a good grade", "clear communication; - clear targets".
The 'real-time quiz' methodology could be used more extensively to aid the understanding of underpinning knowledge in many other areas within design courses.

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