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2007-01-01

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Aidan O'Dwyer
Dublin Institute of Technology, aidan.odwyer@dit.ie

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Recommended Citation
O'Dwyer, Aidan : Experiences of assessment using multiple choice questions on a first year engineering module in electrical engineering. Proceedings of the International Symposium for Engineering Education, Dublin City University, 2007,pp. 189-193.

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EXPERIENCES OF ASSESSMENT USING MULTIPLE CHOICE QUESTIONS ON A FIRST YEAR MODULE IN ELECTRICAL ENGINEERING

Aidan O'Dwyer,
School of Control Systems and Electrical Engineering, DIT, Kevin St., Dublin 8

ABSTRACT
This contribution will report on, and evaluate, the use of multiple-choice questions, in both continuous assessment and terminal examination modes, on a first year module in electrical engineering at Dublin Institute of Technology. The author's experiences are that multiple-choice questions tend to be student friendly (e.g. given a choice in a terminal examination, students will opt to attempt the questions with multiple choice parts). The author has used the assessment method over three academic years, and some assessment data is reported and analysed in the contribution. The pedagogical approach is explicitly pragmatic.

INTRODUCTION
The assessment method is used, in both continuous assessment and terminal examination mode, with students on the Electrical Systems module in the first year of a three-year, Level 7, degree programme in Electrical Engineering. Level 7 programmes were previously referred to as technician programmes; candidates apply for such programmes (in common with all higher education programmes) through the Central Applications Office (CAO), in which points are given for examination results in six subjects taken in the Leaving Certificate, or equivalent. The maximum point score possible for a candidate is 600, with 54% of candidates scoring more than 300 points in 2006, for example [1]. Minimum points levels for programmes are set by student demand for the limited number of course places; in common with worldwide trends, student demand for many technology courses is decreasing, leading to, for example, a minimum points level for the programme of 115 in 2006, with a median points level of 275 [2]. Though there is some debate as to whether the points scored by candidates in an examination process dominated by a terminal examination is the best predictor of subsequent success on an engineering programme, nevertheless it is clear that many, if not most, of the students entering the programme have lower academic ability when compared to their wider peer group.

In a typical year, 40 learners commence the degree programme, the vast majority of which come directly from second-level education; there are a small number of students who are mature learners (categorised as students over 23 years of age) and a further small group of international students.

Finally, Level 7 programmes are distinguished from Level 8 programmes, which in Engineering are four years in duration, require a much higher minimum standard in Mathematics at the Leaving Certificate examination (or equivalent) and allow successful graduates to work directly for chartered membership of engineering professional bodies. Successful Level 7 graduates in engineering may directly achieve associate (or equivalent) membership of the professional bodies.

DESCRIPTION

Multiple-choice questions are an efficient means of knowledge assessment (particularly in well defined subjects that do not change with time). They are appropriate for assessing a large number of candidates. They are a widely used assessment methodology (e.g. in aptitude tests in first and second level education or in entrance examinations such as some parts of the TOEFL test), but they tend to be less used in assessment at third level, except in some knowledge-based disciplines such as medicine.

Multiple-choice questions can have two choices of answers (true/false), though, more commonly, four choices of answers are available. It is recognised that raw scores from these tests should not be used directly. The reason is that, for example, in a test with four choice-questions, a student may know the answers for 20% of the questions and guess the answers correctly for one quarter of the rest of the questions, passing the examination. Scaling may be done using a probabilistic approach ([3], [4]) or a simpler approach (which employs negative marking). The scientifically sound probabilistic approach suggests that the optimum number of choice of answers for questions is 4. In addition, if the number of questions is greater than 18, for example, there is less than 1% probability of obtaining a scaled mark of 40% by pure guesswork. This probability falls to less than 0.01% if the number of questions set is greater than 48.

The Electrical Systems subject, in common with many first-year subjects in programmes with Level 7 awards, is knowledge or fact-based. In this subject, students learn about basic electrical concepts (e.g. voltage) in simple circuits. Such knowledge is suitable for assessment using multiple-choice questions. Of course, other concepts in the module (e.g. describing phenomena, solving problems) are less suitable for assessment using this method, though the other assessment methods employed address this issue.

Electrical Systems is a central technical subject in the programme, and learning in the subject is progressed further in the remaining two years of the programme. The subject is divided into two thirteen-week modules; in each module, students attend two hours of lectures and two hours of laboratories in the subject each week. Presently, the subject is assessed in the following manner; this assessment regime has evolved somewhat over the part three years:

- Terminal examination (50% of subject mark), held after the completion of the second module. This examination has a compulsory question and five other questions, three of which are to be attempted. Two of these five questions are presently in multiple-choice format.
- Laboratory work (25% of the subject mark); this is assessed continuously.
- Individual student project work (12.5% of the subject mark), assessed near the end of the first module.
- Module 1 assessment (12.5% of the subject mark); in 2006-7, this was an exclusively multiple-choice examination, held after the completion of the first module.

In addition, formative assessment, using a mixture of multiple-choice and 'conventional' engineering questions, is given in Week 7 of each module. These assessments are graded, handed back to the students and the correct solutions to the questions are explored in the lecture environment in Week 8 of each module.

RATIONALE IN TERMS OF EDUCATIONAL IDEAS

As mentioned, the assessment regime in the subject has evolved to some degree over the three years in which the author has taught the subject. For example, in the 2005-6 academic year, the module 1 examination was a formal one-hour examination held in January 2006. In this examination, students had to attempt all questions. A multiple-choice question with 20 parts was set (with 40% of the assessment marks attached) and three other, more traditional descriptive and/or calculation questions were set (with 60% of the assessment marks attached). Figure 1 shows some data from the assessment.

It is striking that, for all students who sat the assessment, the marks scored in the multiple-choice question far exceeded the marks scored in more conventional engineering questions. This is particularly remarkable as the multiple-choice question tested student knowledge of material covered in all thirteen weeks of the module. The author suggests that the transition to third level study, recognised to be a challenging one for many students, means that little time can be devoted by students to detailed work in the subject; however, the multiple-choice format allows such students to be confident that they can demonstrate they have learned the fundamentals of the subject in laboratories and during lecture periods. Good performance in multiple-choice questions raises the confidence of perhaps less well-prepared students and helps sustain their retention on the programme.

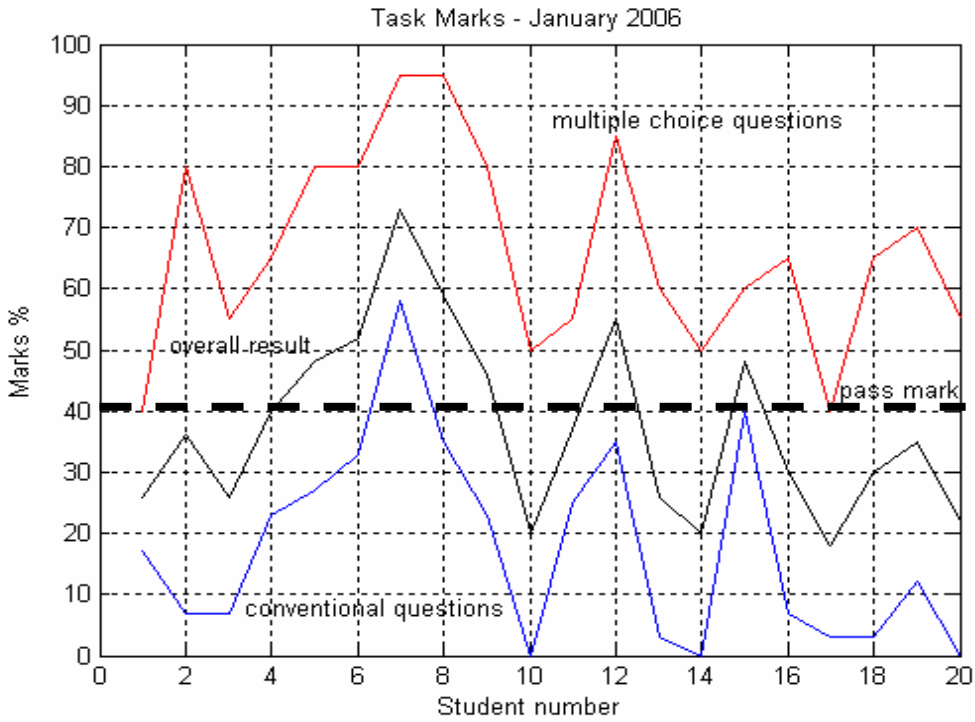

Figure 1: % marks obtained versus student number (anonymous marking)

At the beginning of the second module in the subject, the solutions to the assessment questions were explored with the students in the lecture theatre, allowing precise feedback to be given and simultaneously re-emphasising the importance of fundamental knowledge in the subject prior to the exploration of more advanced ideas.

Multiple-choice questions were also employed as an assessment tool in the terminal examination. In the 2006 terminal examination, for example, students were required to attempt question 1 (a five-part obligatory question, in 'conventional' format) and three of five other questions, two of which were in multiple-choice format. Most students chose to attempt the two multiple-choice questions; figure 2 shows that, in most cases, students scored better in their answers to multiple-choice questions.

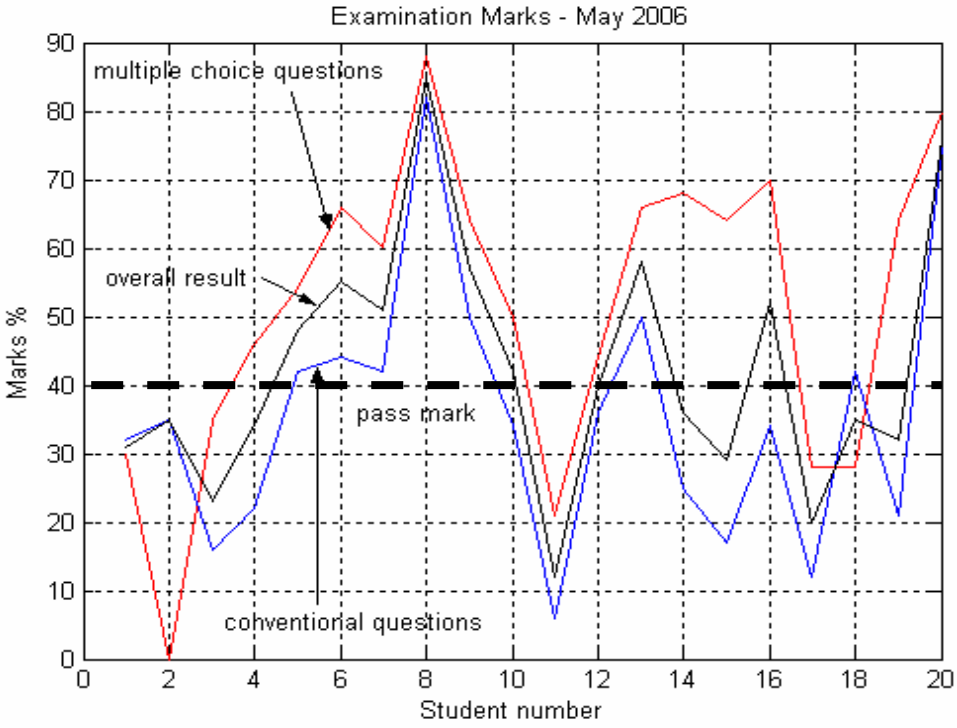

Figure 2: % marks obtained versus student number (anonymous marking)

The pedagogical rationale for the use of multiple-choice questions is pragmatic i.e. students perform better, on average, in answering such questions than in answering more conventional engineering examination questions. In a general comment, the average student that the author encounters tends to be less well prepared for subjects such as Electrical Systems than was the case a number of years ago. Reference has already been made to the points level achieved by entrants to the programme in 2006; the CAO website also allows information over the past five years to be collated. Table 1 shows the median points level and minimum points level of candidates entering the programme over the past five years. Overall, the number of prospective students scoring over 300 points (out of a maximum of 600 points) in the Leaving Certificate examination has varied from 52% to 54% during this period.

Year	Median points level	Minimum points level
2006	275	115
2005	285	175
2004	315	160
2003	325	175
2002	340	140

Table 1: Selected data about student performance

The information in the table is self-explanatory. If a longer-term view is taken, one striking statistic that emerges is that in 1998, the minimum points level of students entering the programme (of 280) is greater than the median points level of students entering the programme in 2006.

EVALUATION AND CONCLUSIONS

In conclusion, multiple-choice questions are suitable for the assessment of knowledge, analytical ability and numerical skills, particularly for a large number of candidates. Many Level 7 technology programmes (in particular) have learning outcomes that make multiple-choice questions suitable as an assessment strategy (as part of a suite of assessment options). A straightforward, scientifically sound scaling scheme is available to convert the raw scores from the solutions of the multiple-choice questions.

Multiple-choice questions tend to be student-friendly, as the data clearly shows. They assist in improving retention rates, and assist in increasing student motivation. Exploration of the solutions of multiple-choice questions assists students with monitoring of their own learning. The beneficial feedback given to the students is particularly important in the first year of the programme, when students may worry that they have not chosen the programme that makes best use of their skills and abilities. In the author's experience, educators in science and technology often bemoan, in an anecdotal manner, lack of student knowledge of fundamental topics; multiple-choice questions directly examine students in the broad range of basic ideas. Subsequently, students have the opportunity to build on this fundamental knowledge in subsequent modules in further years of the programme.

There is a concern that multiple-choice questions examine a superficial and limited understanding of the subject area. Certainly, the author's experience is that even better students now struggle to solve questions in the subject area that would have been regarded as routine examination questions when the author first started teaching this subject thirteen years ago. The author's contention is that assessment regimes must be more creative than heretofore. The use of multiple-choice questions is one tool in such an assessment regime; a balanced use of assessment strategies is required to maintain educational standards in an era of mass higher education, in an environment where higher education institutions wish to increase retention rates on programmes and provide validation of student effort.

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