Maths-CAA Series
April 2004

Embedding CAA and Support for Mathematics in a Web-based Learning Environment

Contents

Embedding CAA and Support for Mathematics in a Web-based Learning Environment

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Abstract: Use of web technology, as a means of providing students with information, knowledge and learning opportunities in mathematics, is widely recognised as fundamental to emerging e-learning strategies within HE. Fortunately, there exists within the Mathematics community a wide experience of implementation and development of Computer-Based Learning (CBL), particularly within CAA, over many years to utilise this technology effectively. The increasingly comprehensive access that students have to the internet, and software tools available for web authoring and management suggests that more traditional teaching, support and assessment mechanisms will be adapted in response to the increasing expectations of students and funding bodies. In this article, the provision of an integrated web-based learning environment for non-specialist mathematics students in Engineering and Science, introduced for the Service Teaching provision at the University of Nottingham, is outlined. The integration into the environment of pilot formative assessment mechanisms, consisting of diagnostic and interactive self-testing, is evaluated and discussed. Case studies on student use, performances and feedback on the environment from recent student cohorts provides information on different learning styles and preferences.

1. Introduction

The influential report 'Measuring the Mathematics Problem' [1] identified the decline in students' level of preparation in mathematics on entry to Higher Education during the 1990's decade and a variety of supplementary support mechanisms. In recent years, many universities have made significant progress in catering for the diversity of intake qualifications available in mathematics, and a digest of 'good practice' has been disseminated within booklets from the LTSN MathsTEAM [2], [3]. The importance of helping students at the school/university interface has been recognised within projects under the FDTL4 programme, and informed by earlier related projects such as those funded at Scottish universities by SHEFC. The Smith Report on post-14 mathematics education [4] identifies the shortcomings in pre-university preparation for students, both at GCSE level and under Curriculum 2000 in GCEs. Smith makes wide-

ranging recommendations to the Government but it is unlikely that many will impact on the HE student's entry competencies in mathematics for some years to come. Therefore enhancing existing support and developing further support for a diversity of students' background proficiencies remain imperative.

The deficiencies in mathematical knowledge and skills, and the increasing diversity of intake are particularly noticeable amongst non-specialist mathematics students in Science and Engineering, and this has been well catalogued for Engineering Mathematics in series of articles in successive IMA Conference Proceedings [5-8]. Catering for such non-specialists provides distinct challenges, as the intake is often large and diverse. Students are typically registered on many different degree programmes, each with differing requirements of intake standards and experiences in mathematics. Further, the Mathematics curriculum is tailored to the student's main degree programme, which allows little flexibility to provide tutorial support separate from their main subject. The need to help students to evaluate their current knowledge and skills ability in key, often assumed pre-requisite, mathematical topics on entry remains crucial, together with appropriate and accessible student-centred support to overcome any identified deficiencies. However, such provision is also useful throughout the students' studies, as prior-shortcomings naturally emerge as they progress to more advanced mathematics modules and encounter mathematical difficulties arising directly from studies within their Science or Engineering modules.

2. Web-Based Support and Assessment

The potential advantages of using computer-based technologies for teaching, learning and assessment to facilitate a flexible provision within Mathematics have been apparent for many years, and persuasive enough to secure significant funding from HEFCE for over ten years. Courseware provision authored within the nineties was based on the prevailing technology and resulted in a predominantly 'CD-based' format, although often deliverable over a network, with Mathwise, Transmath, Metric, Mathlectics and Calmat leading the way, e.g. see Pitcher [10]. This emerging approach addressed technical aspects of display and delivery, but also pioneered the pedagogic gains in embedding animation and user-interaction alongside delivery of knowledge to promote understanding and skills in mathematics. A strong motivational and feedback aspect was provided through embedded formative assessment and where feasible the gains in efficiencies gained by computer-based summative assessments. Extensive development in associated CAA work is notably successful within CALM and associated projects such as SUMSMAN. The maintenance of these as integrated learning environments remain important to those with strong local development interests but are now often restricted to a decreasing element of the HE mathematics provision. A more recent update on this approach is provided in the M4E-Disc [9], which supplements Transmath with motivational video clips and video tutorials exploiting the more powerful software utility capabilities of current DVD computer technologies. The most significant advance, however, is undoubtedly the widespread availability of internet technology, which provides an ever increasing access to linked facilities through high-speed broadband links, on and off campus, at times convenient to the students' learning preferences and timetable constraints. This extends to students accessing software outside of usual university terms and potentially from any worldwide connection. As noted in the overview article on assessment in Mathwise by Pitcher [10], the advent of the internet does not diminish the underlying influence of earlier major collaborative ventures in CBL within mathematics, but it would seem inevitable that the realities of limited student access and upgradeability issues for existing learning materials and formative assessments will restrict further direct development. The requirement of security on summative assessments tend to favour more limited local implementation although, as exampled in the HELM project [11], summative assessment is being actively promoted as a web-enable facility for widespread HE use.

The increasingly available technology associated with 'e-learning' is web-based, arising from its global accessibility and the growing implementation within HE Institutions of Virtual Learning Environments (VLEs). Such environments enable learning and support materials to be easily managed and uploaded by teaching staff, and readily link to other local, or possibly national or international, supporting resources. The initial experiences, such as reported by Foster [12], are hopefully less common, with the technological aspects now more mature and a greater ongoing awareness of the pedagogic requirements. The unprecedented levels of monitoring and tracking of student usage within a VLE can also help to identify student learning styles and preferences to promote the emerging pedagogic issues of good-practice in e-learning. An example of active use of detailed feedback is presented by Greenhow [13] where results from answer files to assessment tests are used to evaluate the learning experience of different cohort groups. Within a VLE, assessment aspects can be readily obtained but also linked to monitoring student access to support materials etc. Experience from earlier CBL projects suggests that CAA must continue to be used as an important formative tool, and that this can be maintained by utilising the appropriate VLE assessment tools, linking to a specifically locally authored utility or other web-enabled assessment utilities. A recent example of a local assessment utility approach, embedded within a locally constructed VLE (WALLIS) and piloted with a first-year honours mathematics group, is reported by Mavrikis and Maciocia [14]. The system incorporated an existing (AIM) assessment engine.

3. MELEES

MELEES is a web-based environment running under WebCT for providing learning support in mathematics. It was initiated within the e-learning strategy at the University of Nottingham. The Mathematics Electronic Learning Environment in Engineering and Science is being developed to support students from schools outside of Mathematical Sciences who take mathematics modules as a compulsory or optional element of their course. The environment also offers monitoring and evaluation of students' learning preferences, and increased communication between the teaching staff in the School of Mathematical Sciences, students on the modules and the students' home school. Detailed information on MELEES is given in the paper by Hibberd *et al.* [15].

Based on a Content Management System (CMS), MELEES provides a site that is configured to the students' mathematics module registrations, however, it also includes common elements that provide information on their module choices and common learning materials relevant to the transition between school/college and university. Figure 1 shows the home page of MELEES that gives gateway entry to the individually configured information sources made available. In this instance, access is shown from a login entry as a staff member, which gives direct access for staff to edit their registered materials (Designer Options) but also provides access to a variety of collated documents and useful 'bookmarked' web-based resources. Access is also configured to provide module attendance records for consultation by tutors in client schools.

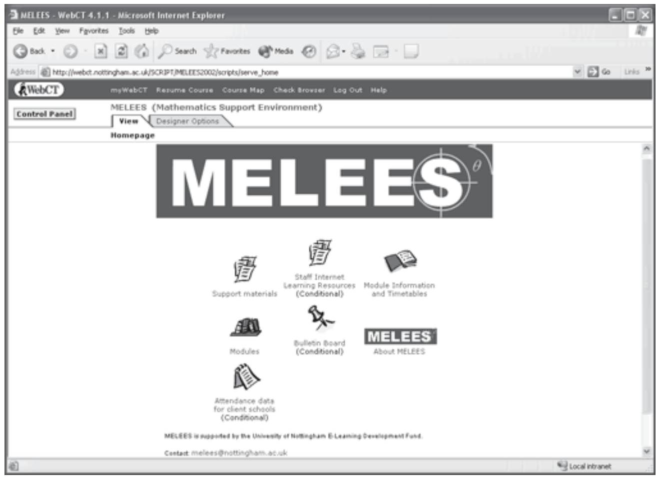

Figure 1: MELEES - Home Page

A separate icon provides extensive academic, administrative and timetable information to students on optional or compulsory modules available in mathematics. A further icon (Modules) expands to display icons for mathematics modules for which they are currently registered or have taken previously, these provide reference in terms of pre-requisite requirements. For students entering into first-year, an icon gives access to learning materials aimed at helping them make the transition into first-year mathematics modules (see Figure 2). This latter provision is, by requirement, varied, as the first-year must accommodate a selection of modules catering for students with different prior mathematical experiences and levels of preparedness.

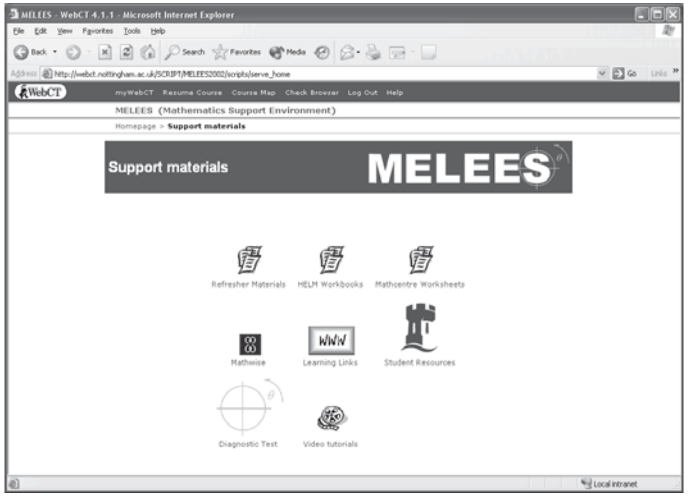

Figure 2: MELEES – support materials

Traditional lectures remain the primary means of teaching service mathematics, but MELEES is available as an integrated framework of support to help students to attain high levels of achievement and it includes:

- information and advice about the mathematics provision and current timetable information
- access to support materials to help with the transition to university-level mathematics
- access to module specific learning resources
- support e-learning materials provided locally, nationally and internationally

- access to module assessment materials and their solutions (e.g. past examination papers, past assessed coursework, notes on plagiarism)
- provision of feedback to students
- information on student progress for students' home schools

Materials available to students vary between modules although typically there are lecture notes, copies of OHTs, worksheets, past exam papers with solutions, assignments with timed release solutions and links to further resources. The variation between modules is due to a lecturer's requirements and the materials available. Some modules include interactive assessment elements, which students can use to assess their own progress through the module as well as for revision purposes. There are also bulletin boards available for communication between students, lecturers and MELEES staff, although these seem little used at present. An example of a module template is provided in Figure 3 for the first-year module HG1M01; this module will be discussed within a Case Study later in the paper.

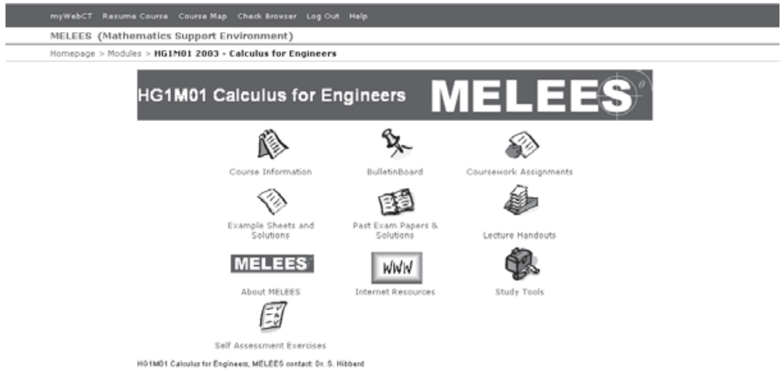

Figure 3: Module support (HG1M01)

The MELEES provision was initiated in the Autumn Semester of 2002 with a pilot module, HG1M01, and extended in the Spring Semester to provide support for a further three modules. Evaluation of the implementation and use of MELEES was conducted on technical, content and some pedagogic aspects with students and staff. For the session 2002-3 a module 'template' was developed to underpin the provision and include a wider CAA provision, although currently this is focussed on formative assessment, together with developmental support through:

- guidance on 'good practice'
- workshops informing and involving module teaching staff
- specifying minimum core requirements for each module
- provision of exemplar materials available to module staff
- project officer support to module conveners.

There are currently 18 modules within the MELEES environment and 1,910 new students have been registered onto the system, bringing the total number of students registered for this session to 2,310. These students are primarily in their first or second year, and attending modules that are compulsory for them, although there is also one optional module taken by over 150 students in their third year. Usage of MELEES has been excellent, with 83% of students using the system regularly and 4% logging on once; the remaining 13% of students did not log into MELEES but much of the problem here is due to inaccurate student registration details! Significant use of the system was recorded with 1380 students logging into the system between the end of formal teaching and the module examinations. In an email survey to obtain student feedback, over 100 replies were received; some 96% of students reported that they found MELEES easy to use and 97% perceived it to be helpful with their studies. Some student 'free format' comments included:

> *"The best module website I have available to me."*
> *"All inclusive, well organised web site, a perfect example on excellent teaching resources, which other modules could follow"*
> *"A brilliant, useful website that has helped a lot. It is the most organised, professional module I have been lectured."*
> *"Very useful, as I have access in my room, and it's easy to look up if I am stuck with anything."*
> *"Good job! Thanks a lot for creating the MELEES website! I feel it is much more convenient for collecting useful information if there's no lecturer at hand! Do wish you go on making the site better!"*

The benefit of using a VLE as a platform for providing learning support has been well accepted by the students. Moreover it has been embraced by teaching staff as providing an integrated and versatile support mechanism. In concert, the detailed provision for each module is changing and developing as teaching staff become more familiar with the system and as their confidence increases with feedback information on how students use it. A culture is developing in which students are using the environment extensively and this provides an opportunity for us to both develop 'e-learning' activities, such as interactive assessments, and monitor student preferences in types of learning. The monitoring and tracking facilities have provided us with the opportunity to try to develop the site according to student use, and to identify perhaps characteristic preferences of particular cohort groups. Aspects that have been developed include formative assessment, to provide students with initial self-assessment of their active knowledge of key topics on entry (e.g. diagnostic test), self-assessment tests, on key topics areas within modules, and revision aids.

4. Diagnostic Test

A well-established practice, particularly given the inhomogeneity of student intake associated with service teaching, is the provision of diagnostic tests. The rationale and variety of existing approaches are well documented in the MathsTEAM publication [2]. At Nottingham, a computer-based diagnostic test has been made available for many years based on the approach detailed in Brydges and Hibberd [16]. Further development of the test with colleagues at Keele, as discussed in Hibberd *et al.* [17], strongly identifies the role to be played by linking testing to suitable 'support' materials. The article by Quinney [18] highlights the fact that implementation of diagnostic testing is limited without providing support; further, he comments that in delivering a computer-based test, it may seem appropriate to use a computer-based element to provide an efficient mechanism for flexible support. The existence of a web-based VLE underpinning MELEES can be fully utilised to provide the support structure for students through developing a compatible web-based test. The existing diagnostic test was written in Authorware, however, the issues raised in implementing this over to a web format, in terms of conversion, use of plug-ins, accessibility and monitoring, meant that rewriting the test directly for web was a far more attractive option. Experience of usability, simplicity and flexibility of the previous diagnostic test would be retained.

MELEES already benefits from access to a computer-aided assessment mechanism within WebCT, but although used for interactive self-assessment, as described later, a web-based test with a greater diagnostic and feedback capability has been developed. The test was authored using the PHP scripting language, which uses standard server-side software, and MathType was used to create GIF equation graphics; consequently, overheads for setting up and running the test are low. The original multiple-choice format has been maintained, it includes diagnostic capabilities improved by utilising information from both the correct and incorrect answers to give a 'profile' of student attainment. The test system attempts to give each student a graphical indication of their performance in a number of key topic areas and follows this with recommended support topics. An overall diagnostic test score is provided that incorporates the use of negative marking to deter students from indiscriminate guessing.

The development has focused on producing a test that is as flexible as possible and could provide a re-useable template for other assessments. As much of the test as possible, including the logos, the questions, the topics and the advice given, is easily customised by a non-expert computer user. Past experience suggests that, for an intake diagnostic test, it is significantly better to construct a test with a restricted total number of questions, as this allows detailed comparison between annual cohorts and also, particularly in the case of an optional test, it will be readily available and not too time consuming. The test was created with 45 questions in five categories: Algebra, Functions, Co-ordinate Geometry, Differentiation and Integration. Each test is dynamically configured with 15 questions covering each area and includes questions in three categories of difficulty. This pilot test was designed to be completed in approximately 30 minutes and was targeted at first-year undergraduate Engineering students who did not have a recent A-level qualification in Mathematics. Feedback advice directed students to HELM [11] and Mathcentre [20] materials on the MELEES system.

The diagnostic test interface is shown in Figure 4. Questions are selected from a fixed question bank pseudo-randomly, and the labelling of the possible answers (a)-(d) is pseudo-randomised also. These two 'randomisation' features have been found to be sufficient for the generation of independent tests, to be taken by many students simultaneously or by the same student several times, if required. Confidence in this approach is shown by the good correlation obtained in a comparison of the performance of such a computer-based test with a written test, as undertaken by Quinney [18] on the topic of differentiation.

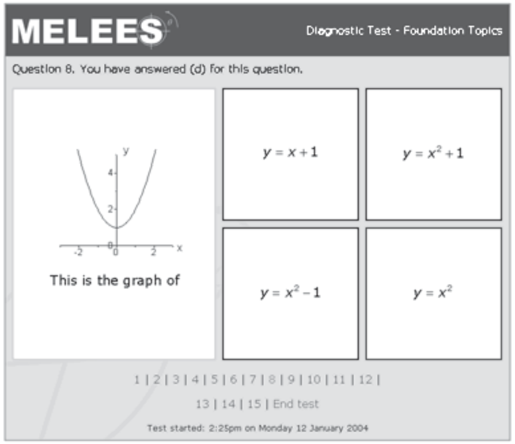

Figure 4: Diagnostic test interface

Each answer has an associated profile, which gives 'grade' marks according to difficulty in a selection of topics. Therefore, if the student were to answer an 'easy' question incorrectly, they would lose more points in that topic than if they were to answer a 'difficult' question incorrectly. Further and different distractors may carry different levels of penalty, depending on the level of misconception. With a restricted number of questions, this system is believed to greatly enhance the diagnostic capabilities of the test. A demonstration version of the diagnostic test is available [19].

On completion of the test, the student is given a (printable) Diagnostic Report, such as illustrated in Figure 5. This contains the graphical analysis of the student's performance in each topic, the number of correct and incorrect answers given, the time taken to complete the test and a weighted percentage score. For student responses below a threshold level, the three topics for which the student has least score are highlighted, with suggestions for remedial or revision materials. There are two levels of advice given, according to the severity of the score, and these are targeted to direct students to either look at 'revision' material or take 'action' in areas where more substantial work is needed.

In addition to the interactive computer-based test, an accessible interface is available. In particular, this enables students with disabilities to print out a version of the test, with answers, and thus gain some diagnostic ability offline. In addition, an accessible interface is available for students to input these answers for a full Diagnostic Report.

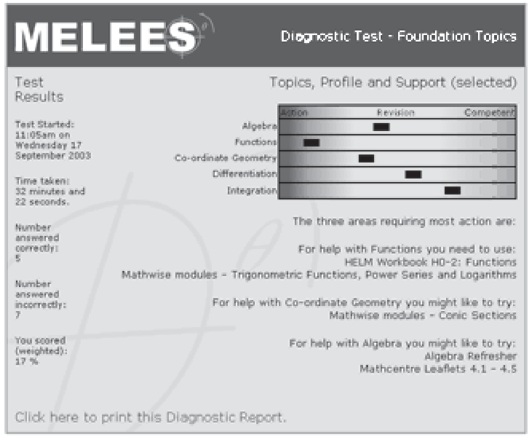

Figure 5: Diagnostic test report

Access to the test is provided directly from MELEES and data from the test is stored in text files to enable students to view their previous scores, retake the test as needed and to provide comparison scores. A results viewer is available for staff wishing to view results data from the test. This includes data on overall student performance, together with information on individual students and question-by-question analysis. This can be viewed online or downloaded in CSV format, suitable for input into a spreadsheet package such as Microsoft Excel for further processing.

The diagnostic test was available to MELEES students through the Autumn Semester on an optional basis. Recorded student behaviour on encountering the test was similar to previous experiences with the original test format, with many students choosing to familiarise themselves with the test briefly before retaking it. Of about 250 instances of test activation, 145 exceeded the requirements for a 'valid result', i.e. taking at least 5 minutes and answering at least 5 questions, and these are used for evaluation. The time taken by students to complete the test was on average about 20 minutes and the distribution of times is shown in Figure 6. The corresponding mark scores are shown in Figure 7.

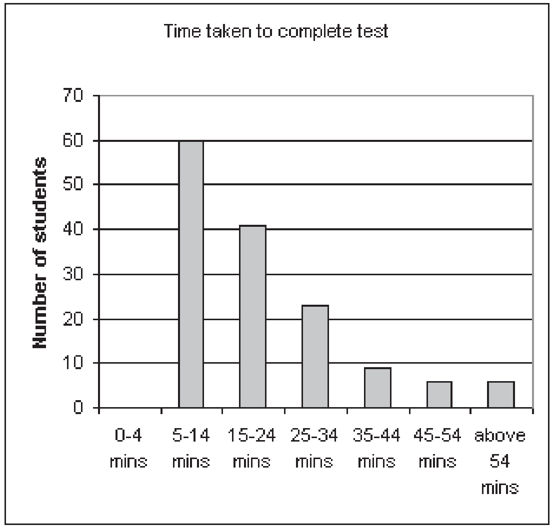

Figure 6: Time taken to complete the test

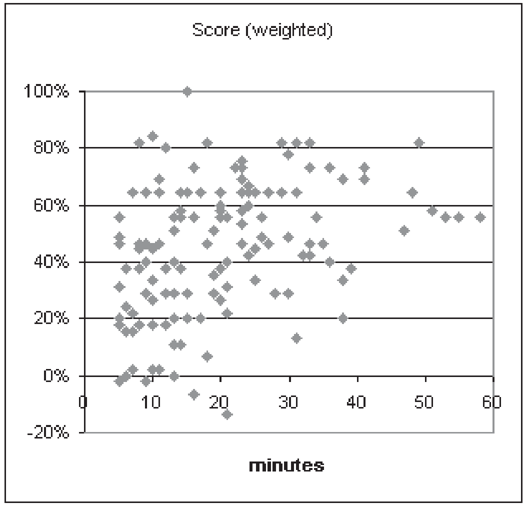

Figure 7: Percentage scores with time taken

As can be seen from Figure 6, the results indicate that the majority of students (70%) completed the test in the target time of 30 minutes. Figure 7 identifies a wide range of scores for students taking a 'rapid response' approach of completing the test in less than 15 minutes. For 'average speed' students, taking 20-40 minutes to complete the test, the results are more compact but vary mainly between 20%-80%. A small cohort of 'slow but sure' students took over 40 minutes but attained uniformly high scores. The overall test average was 44.0%.

Bar charts of the graded scores obtained by candidates within profile categories of Algebra, Functions, Co-ordinate geometry, Differentiation and Integration are included in Figure 8. Results for Functions and Co-ordinate Geometry show few negative marks and large numbers of students with positive scores. Differentiation and Integration had large numbers of students scoring zero (abstention over the whole category, or marks cancelling out). This particular area of weakness is consistent with the results obtained by Quinney [18] for his latest two reported cohorts (2001 & 2002). The results for Algebra are a little more varied; the majority of scores were positive, but the negative scores are far more evident than in Functions and Co-ordinate Geometry. This suggests that the students were confident enough not to abstain from attempting the algebra questions, but that their abilities were perhaps lower than they believed them to be.

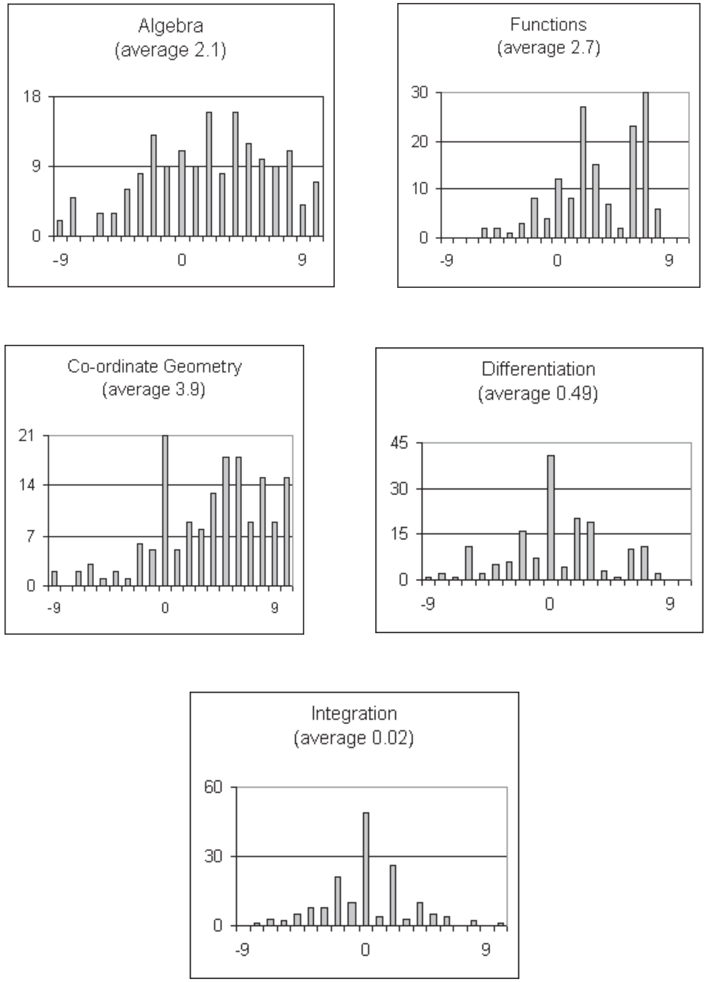

Figure 8: Profile scores for each category of question

The responses to each of the 45 individual questions, taken from students' test attempts during the Autumn Term, are shown in Figure 9. For each question the correct answer is (a). The plot shows a relative comparison of responses for each of the four answer options and 'abstain'. Those attaining the correct answer are generally considered to have adequate knowledge of and competence with the topic, while those choosing to abstain are likely to lack confidence or knowledge. The scale of response to each of the distractors helps to identify general areas of previously identified misconceptions.

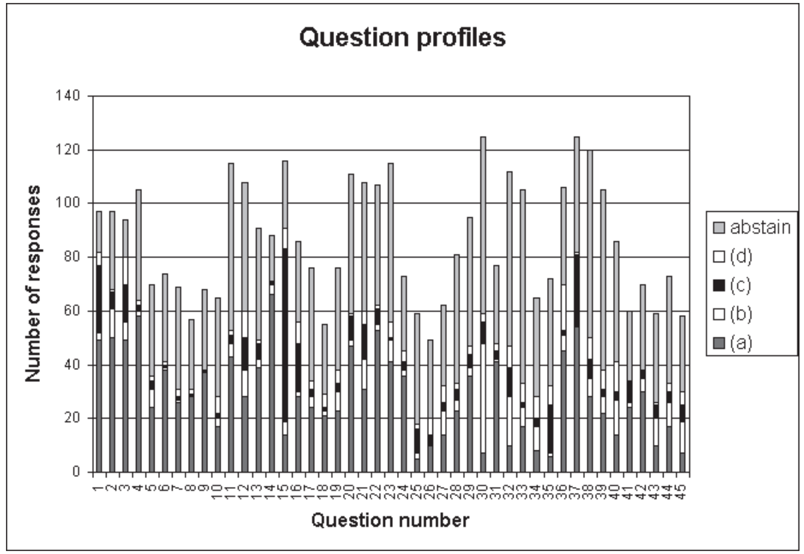

Figure 9: Question profiles detailing answer responses [correct answer is (a) in each case]

5. Interactive Self-Tests

Interactive assessment environments can be readily constructed and incorporated into MELEES using standard question software utilities without the need of high level technical expertise. WebCT offers the user a quiz/survey tool to facilitate the construction of mathematically-based assessments. This tool allows the direct input of mathematical equations using an equation editor, it supports both text and html input and allows the insertion of images. Various question formats are supported by the tool, namely multiple choice, matching, calculated, short answer and paragraph, and there is a facility to allow feedback to be given to the student once the assessment has been submitted and graded. The student is free to use these interactive environments at any time and may save their answers with a view to returning to complete the test at a later time; they may also review their past submissions.

MELEES used this WebCT facility to construct an exam-practice assessment environment for a module containing a multiple-choice section in its final examination. This practice assessment randomly generates the order in which possible solutions are presented to the student and so has benefit in that it can be taken on more than one occasion. In the first presentation of this resource it proved popular, with some 90 students submitting 186 tests for grading. Figure 10 shows the student view of results and feedback. The correct answer is deliberately not revealed to encourage recalculation of the problem, however, feedback is given as to the manner of the student error in order to assist the student in identifying their mistakes.

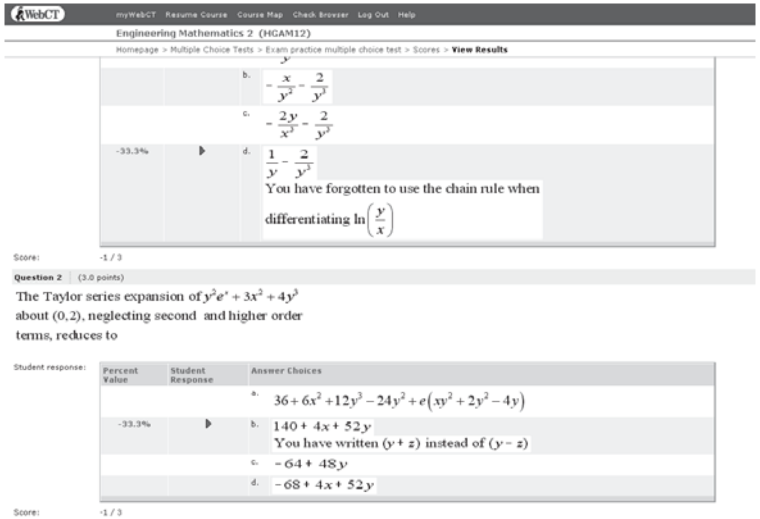

Figure 10: Feedback screen from WebCT-based MCQ test

Interactive assessment objects can also be constructed locally using 'third-party' software tools and imported into MELEES. Such utilities may provide more functionality, better importing capabilities or simply have more advanced editing and construction tools. Respondus [21] is an application that offers the same range of question types as the WebCT quiz tool but it has its own more user-friendly equation editor and the user can also opt to import mathematical text from the popular MathType editor. Respondus also has the capability to import questions from a text file, in an appropriate format, and convert them into an interactive assessment. The benefit of authoring locally and exporting to the VLE is the element of re-usability, this can be readily utilised within a service teaching environment where often similar modules are provided to different programmes. Question databases can also be constructed within WebCT, allowing the user to simply select a set of existing questions and construct a new assessment. These databases can either be populated with questions from existing assessments or by importing question sets. The MELEES

resource has a database that includes questions imported from the e3an database [22], again promoting the use of Re-usable Learning Objects (RLO's).

Production of self-assessments as RLOs is an efficient use of resource. An example, used within two separate modules (probability and statistics) in MELEES, is the provision of an interactive self-assessment on the use of the table of normal distribution. The test was generated in Respondus and is directly accessible from each of the module home pages. The test is shown in Figure 11 in a short answer format where a student enters a numerical value. There is some built in error checking of entered values and more than one feasible correct response, e.g. 0.7 or 0.71 will be accepted as correct.

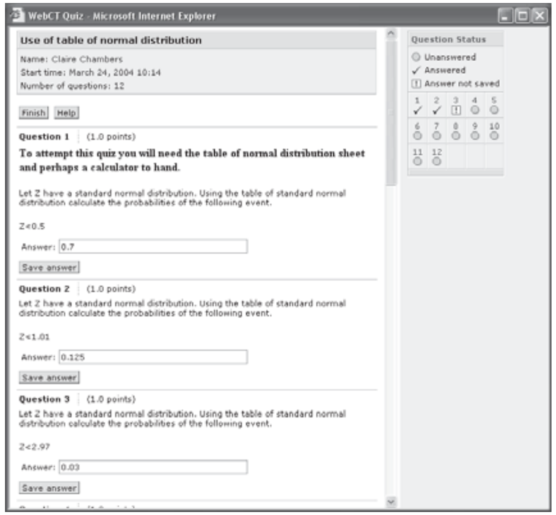

Figure 11: Format of self-assessment test for use of Normal tables

6. Case Studies

The development of MELEES as a mechanism for mainline support of students remains in a formative stage but it has already impacted on a variety of the (student) users and stakeholders.

6.1 Involvement of client schools

First-year undergraduate students of the School of Electrical and Electronic Engineering were encouraged by staff in their home school to take the MELEES diagnostic test in their own time. Around 70 of the intake of approximately

130 students took the test. Staff of the school arranged remedial workshops (separate from provisions on MELEES) that all students were invited to attend. Targeted invitations were sent to around 30 students who had answered less than 10 out of 15 questions correctly on the test or had less than a grade C in A-Level Mathematics on intake. However, only four students attended the workshops. An investigation of those students' habits on MELEES suggests that they made greater use of the materials provided to their cohort, through the web-based support resource, than their peers. This suggests that these students were actively seeking remedial work through the MELEES resource, and certainly making an effort not to ignore the issue of their apparent difficulty with mathematics. The staff running the workshops reported that the students who attended responded positively to having someone prepared to "debug" their maths. However, it is not difficult to conjecture why some students might find an online resource more convenient. Students can get remedial materials at any time and work at their own pace to suit their situation. Additionally, students might feel that the MELEES resource is a more anonymous method of getting support, compared to the rather more intimidating formal and public classroom setting for seeking help. Additional encouragement to use the Diagnostic Test facility will be given through personal tutorials in the School of Electrical and Electronic Engineering and further evaluation is planned for the next student intake.

6.2 Use of interactive tests for revision

Summative assessment within most first-year modules includes multiple-choice papers that are marked using an Optical Mark Reader system. Sample MCQ assessments of both Coursework Tests and Module Examinations (in part) have been provided, using Respondus on MELEES, as interactive tests and have proved very popular with students, particularly within revision periods. The test uses negative marking, in concert with the summative tests, but provides feedback on incorrect responses, as shown in Figure 10. A pilot provision was incorporated into the module HG1M01, which is aimed at first year engineering students without a recent A-level in mathematics and correspondingly has a high proportion of diversity in student intake qualifications and background. The curriculum and support are more tuned to these students than to the more homogeneous grouping of the remaining 550 students studying engineering mathematics within their first year.

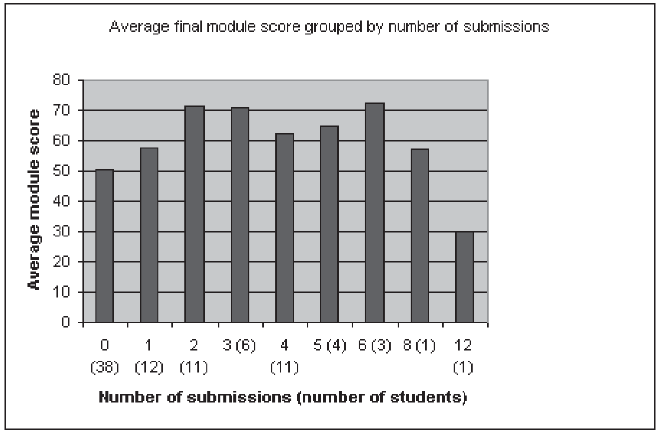

Figure 12: Use of interactive revision test and corresponding average final module score

Within a pilot provision 56% of students (50) opted to use the test, and the pattern of repeated usage and average score is illustrated in Figure 12. Groups are based on the number of test submissions, the figures in brackets show the number of students in each group, and are compared with the average (final) module score for the submission group cohort. Students prepared to use the test have generally achieved better results and many students have felt the test to be worthwhile enough to use on multiple occasions; with only a small proportion perhaps going for the Nintendo syndrome, as first identified by Greenhow [13].

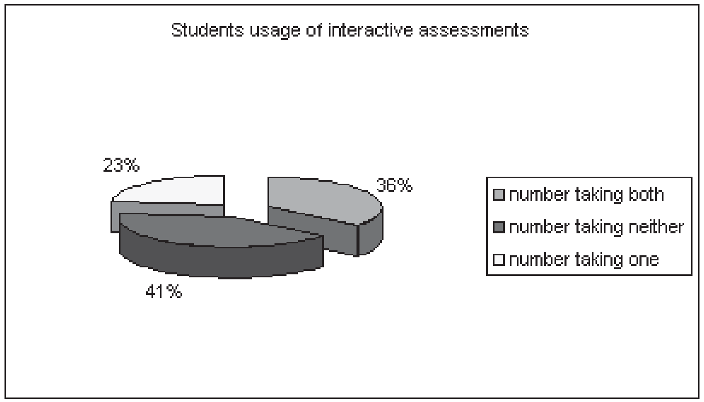

Figure 13: Use of interactive revision assessment tests (HG1M01)

In the same module a coursework test interactive assessment resource was made available. Of the 90 registered students 39% (35) used this resource, submitting some 68 completed tests.

The chart in Figure 13 indicates what proportion of students used each interactive assessment, with a group of 36% choosing to utilize both.

7. Conclusions and Future Development

A recent survey across leading HE institutions [23] suggests that lecturers, "strongly believe that a blend of online learning and classroom-based teaching is vital if the education system is going to meet the demands of students today". The School of Mathematical Sciences at the University of Nottingham is well advanced in developing MELEES as a web-based learning environment to support students from schools outside of Mathematical Sciences taking mathematics modules as an element of their course. Lectures remain, and will remain for some time, a well-developed approach to mathematics teaching, but these are now being enhanced by support from an e-learning environment, under-pinned by a CMS, to provide module-specific support and specialist e-based materials from other internal and external initiatives. Student feedback on MELEES has indicated high levels of enthusiasm for the provision of self-assessment facilities coupled with support materials. Both staff and students praise the integrated and easily managed environment. In developing MELEES, the project-coordinators have become aware of the increasing emphasis on the provision of Learning and Teaching associated with the Special Educational Needs and Disability Act (SENDA), and of the potential that MELEES could offer with respect to targeted support for mathematical modules. Within Mathematics it is recognised that research and evaluation studies of the difficulties that students have in mathematics have not attracted the same levels of attention as in predominantly text-based subjects. Additional development is planned to make further use of facilities available directly from the VLE infrastructure, in terms of monitoring and tracking student usage, to improve the effectiveness of student learning and gain efficiency from the reusability of learning and assessment elements.

References

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