
Mapping University Mathematics Assessment Practices Final Report

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1 Introduction

In 2011, a summit was held discussing various aspects of the state and future of the mathematics curriculum in higher education in England and Wales. Among the topics for debate were students' perceptions of their degrees, essential skills of mathematics graduates and the value of subject knowledge, memory and technical fluency for students on mathematics degrees (Rowlett, 2011). One particular theme was how we assess what we claim our degrees deliver, particularly at a time of major changes to higher education in England and Wales (Levesley, 2011). Questions of efficiency of assessment, its validity, its perception by students and the mix of methods were discussed. The summit report also echoes the concerns expressed by others (LMS, 2010) about the ownership of choices made about assessment patterns.

The *Mapping University Mathematics Assessment Practices* Project (MU-MAP) was developed to examine the current state of assessment in our undergraduate degrees. It was designed both to give a broad overview of practice, by looking across our higher education institutions, but also to have an eye to the future and alternatives. Our focus throughout is on summative assessment: while formative assessment is of great importance, the project was intended to explore the methods we use to make public judgements and statement about performance and attainment.

This report describes the activities and outcomes of the project. It also summarises the main findings of each phase.

2 Phase 1: Review of the assessment literature in mathematics

We undertook a comprehensive review of the academic and professional literature on assessment in mathematics at the university level. This involved searching a number of key research databases and then individually evaluating each item uncovered. The main literature items are described in the MU-MAP book and summaries of key papers are available as a searchable database on the MU-MAP website.

The main finding is that there is a dearth of serious empirical work aimed at providing an evidential base for deciding between assessment methods. There is a strong tradition of quality professional papers which describe different practices (particularly in the field of Computer Assisted Assessment [CAA]). There are also a number of thoughtful scholarly reflections on assessment methods and their different aims.

Analysis of the main papers also shows that common drivers for change include increased marking workload caused by increased cohort sizes, a wish to engage students continuously during the duration of a module, and pressure to assess not only cognitive skills in mathematics but also more transferable skills such as communication (written and oral), teamwork, IT literacy and programming, essay writing.

3 Phase 2: Patterns of current assessment practice

The second phase of the project focussed on an overview of the forms of assessment currently in use in mathematics departments in England and Wales.

We developed a systematic approach to gathering data from higher education institutions in England and Wales. We identified first, a list of mathematics departments (taken from a publicly available league table) and a list of the degree courses they offered. For each institution we identified the degree course which most closely resembled a three-year BSc in mathematics. In a small number of cases we did not obtain sufficient comparable information, but in most the information we needed was readily available and in others, departments generously provided the data.

Within this, we identified the modules taught within the mathematics department. We recorded the module title, year in which it was normally taken, its contribution to the mark for the year (normally in terms of the ratio the credit value for the module to the normal number of credits needed for the year), its contribution to the final degree classification, the assessment methods and the contribution of each assessment method to the final mark for the module. In the end, sufficiently robust data for quantitative analysis was obtained for 43 degree courses, involving 1843 modules.

In addition to this data, we contacted departments to invite a senior member of staff (the head of department or director of teaching) to take part in an interview about assessment on their degree programmes. This resulted in 27 interviews, which focussed on trends in assessment, different types of assessment practice, rationales for patterns of assessment and views on these assessment practices.

We found that the closed book examination remains by far the most prevalent method of summative assessment. The differences between assessment patterns in the departments we surveyed are differences of degree rather than substance: the median contribution of closed book examinations in modules counting towards the final degree was 72% and few departments have closed book examinations accounting for less than 50% (when averaged across all their modules).

Within this general dominance of closed book examinations there are a number of key areas in which other assessment methods play an enhanced role. These included final year projects, statistics and financial mathematics, computing, problem solving, history of mathematics, mathematics education and employability skills modules. Examples of coursework tasks we found in these areas included extended pieces of writing, presentations, open book examinations (especially for statistics modules), reports and logbook on open ended problems and the use of mathematics software for modelling.

The concerns of the LMS (2010) about the control of teaching and assessment and those of Levesley (2011) about an inherent conservatism are not wholly supported by the data we have collected. Discussion with heads of department suggest that the current assessment patterns are not simply the result of inertia or a low appetite for risk, but are the consequence of a belief that written examinations strike an appropriate balance between efficiency, validity and fairness - they are a 'gold standard' against which other assessment methods must be judged. However, it is

also clear that a number of alternative methods are in quite widespread use: projects, presentations, coursework, online quizzes etc. The pressures for change appear to come predominately from two areas: a concern for efficiency in an expanding sector and, to a lesser extent, institutional pressures. However, the drivers of change appear to be dominated by the committed individual. While heads of department noted widespread support and, in some cases, changes being developed after department-wide discussion, most alternative methods appear to have been developed by individuals interested in making a change in their own modules.

4 Phase 3: Case Studies of Alternative Assessment Methods

Phase 3 of the project involved identifying some of the alternative forms of assessment in use in institutions around the country. We approached heads of department and directors of teaching to suggest people who they knew were using assessment methods which they thought might be of interest to a wider audience. Each person was approached and many kindly gave up their time to take part in a discussion about the assessment methods they were using, their reasons for using them, how they went about implementing them and what impact the new assessment had. For this part of the project we interviewed 17 mathematics lecturers in 16 institutions. From this interviews and from the support material that many lectures made available to us we compiled 14 anonymised case studies, collected in the MU-MAP book.

There were a number of factors common across groups of these case studies and we see the lecturers developing alternative methods in response to a number of different concerns. In a small number of cases, it is because of institutional constraints, but more often it is a desire to improve efficiency. Increased student numbers and other pressures on staff time mean that there is a need to streamline the assessment and feedback process. In many cases, the use of CAA is discussed, particularly in relation to how these systems can evaluate more complicated student responses or give more targeted feedback. In some cases concerns about plagiarism and collusion lead to changes to project and coursework systems.

Other changes have come about as staff have wanted to assess different skills, whether those are related directly to employment or are areas of mathematical thinking which staff do not believe the closed book examination is able to test. A number of lecturers expressed their concern about student engagement and responded to that with alternative assessment methods, perhaps with more regular, small scale assessment or with forms of assessment which the students might find more appealing.

Of course, the case studies represent only the most opportunistic of samples and undoubtedly there are many other forms of alternative assessment in use, but the short descriptions here give examples of the solutions lecturers have developed to the problems of assessing in undergraduate mathematics degrees.

5 Phase 4: Assessment Projects

Phase 4 of the project looked deeper at the evaluation of some alternative assessment methods. Academics were asked to bid for resources from the MU-MAP project to either trial a new assessment method or to evaluate the impact of an existing one. By funding a small number of evaluation studies, MU-MAP allowed colleagues to address the extent to which alternatives did indeed achieve their intended outcomes. They explore whether approaches as varied as multiple-choice tests for assessing students' understanding of proof, peer judgement of pairs of scripts or oral examinations can address the concerns raised in the 2011 HE Mathematics Curriculum Summit.

MU-MAP funded seven small projects, described below. Each is described fully in a chapter in the MU-MAP book and many have been the subject of presentations at MU-MAP and other workshops attended by mathematicians and mathematics educators.

Audience Response devices for formative and summative assessment

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We conducted focus group and survey evaluations of students' experiences and expectations regarding the use of audience response 'clickers' in statistics and mathematics and classes. There was evidence that clickers can enhance learning by encouraging work on problems, by allowing all students time to work on problems, by providing quick feedback on success in problem solving and by allowing the lecturer to adapt the lecture according to common problems. We consider the types of assessment which can encourage engagement within lectures.

Assessing proofs in pure mathematics

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Many mistakes made by students in coursework and exams arise from poor notation, poor expression of ideas or common misunderstandings. Previous coursework used to assess proof explored their comprehension, clarity of expression, and appreciation of the importance of rigour, but was very time-consuming to mark. Moreover, in the last three years student numbers have doubled. These issues combined to mean that the assessment used in previous years was no longer viable. This project

sought to facilitate the implementation and development of an interesting and innovative assessment on mathematical proof that reduced the marking burden, but that was still educationally rich. The result was a test on mathematical proof which began as a conventional multiple choice quiz, but has now evolved somewhat. This test has dramatically reduced marking time, whilst maintaining student engagement in, and learning from, the process of writing proofs.

Evaluating assessment practices in a Business and Industrial Mathematics module

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Business and Industrial Mathematics at the University of Salford is a second year module in the mathematics undergraduate degree. This 20-credit module spans two semesters and the assessment is 100% coursework. A variety of assessments and delivery modes is used. Examples include open-ended problems, problem solving, group work, presentations, report writing, employer seminars and professional studies. The aim of the evaluation study is to investigate the students' perceptions of the various assessments and assessment practices used. We obtained both quantitative measures of the views of the different attributes of the assessments and hear the students' voices in their written comments on the practices they encounter.

Summative peer assessment of undergraduate calculus using Adaptive Comparative Judgement

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Adaptive Comparative Judgement (ACJ) is a method for assessing evidence of student learning that is based on expert judgement rather than mark schemes. Assessors are presented with pairs of student work and asked to decide, for each pair, which student has demonstrated the greater proficiency in the domain of interest. The outcomes of many pairings are then used to construct a scaled rank order of students. Two aspects of ACJ are of interest here: it is well-suited to assessing creativity and sustained reasoning, and has potential as a peer assessment tool. We tested ACJ for the case of summative assessment of first year undergraduates' ($N = 168$) conceptual understanding of a specially designed calculus question. We report on the relative performance of peer and expert groups of assessors, and the features of student work that appear to have influenced them. We consider the implications

of our findings for assessment innovation in undergraduate mathematics.

Mathematics Lecturers Practice and Perception of Computer-Aided Assessment

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This case study investigates, from the practitioners' point of view, the advantages and disadvantages of Computer-Aided Assessment (CAA), and how lecturers that use this type of assessment deal with the issues involved. Data were collected through a questionnaire and follow-up interviews with lecturers that use CAA in their first year mathematics modules at a large university. Some of the advantages lecturers mentioned were time-saving in designing and marking tests and giving feedback to large groups of students, student motivation, socialisation of learning and peer support, and students having a more relaxed way of being assessed (when tests were not invigilated). On the other hand, lecturers noted the procedural nature of CAA tests, poor quality feedback and the inability to change an "antiquated" system. Lecturers using CAA make compromises in order to retain the advantages of the system by, for example, reducing the contribution that CAA tests have in the overall assessment scheme or testing conceptual understanding through other means; but it is clear that they would welcome a simpler, more effective system that could address the shortfalls of the current one.

Towards an efficient approach for examining employability skills

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A student's approach to an open-ended problem, one with no necessarily right or wrong answer, is crucial to their employability. Indeed the value of a mathematics graduate to an employer is in his/her problem-solving skills, and exercises assessing these usually form part of graduate assessment days. The scope for open-ended problems within a mathematics degree is large, yet traditionally these and other transferable skills are not extensively assessed until final-year projects. The post-2012 funding shift has significant implications for student recruitment and a fundamental change in the treatment of employability skills is needed in response. The assessment of transferable skills is always possible within extended pieces of coursework, but the marking of these requires a substantial time commitment from staff when class sizes are large. This small study looks at whether it is possible to

assess the skills associated with open-ended problems within traditional and time-efficient examinations.

**PAMPER:
Performance Assessment in Mathematics Preliminary Empirical Research**

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This study outlines the experience of introducing a form of oral performance assessment into an undergraduate degree module. While oral assessment is commonplace in many countries, it has all but disappeared from undergraduate mathematics in the UK and we explore some of the issues regarding implementing this form of assessment, some of the potential advantages, and how this particular form of oral assessment was used with a group of first year undergraduates. We outline the outcomes in terms of students' performance and student and tutor views of the assessment process.

6 Project outcomes and deliverables

The MU-MAP project led to the following outcomes:

1. The MU-MAP website at <http://www.uea.ac.uk/edu/mumap/>. This website houses all outcomes of the project including the MU-MAP book, workshop presentations and a searchable database of literature on assessment of mathematics at university level.
2. The MU-MAP book "Mapping University Mathematics Assessment Practices".
3. Presentation of the project and launch of call for mini-projects bids (Loughborough University, 17.11.11). Dissemination of findings at the British Mathematical Colloquium (Kent University, 16-19 April 2012). Details of both meetings are posted on the MU-MAP website.
4. Conference dissemination. Some of the findings of the project were presented at a specialist mathematics assessment day conference at Loughborough University (16 May 2012) and will be disseminated at the forthcoming conference of the British Society for Research into Learning Mathematics (Sussex University, 09.06.12) and at the CETL-MSOR Conference (12-13 July 2012).

5. A number of professional papers and research papers are planned, particularly from the projects in phase 4. The paper ‘Oral Assessment in Mathematics: Implementation and Outcomes’ (Iannone and Simpson) has been submitted to the journal *Teaching Mathematics and its Applications* and it is currently under review.

References

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