ICT in coping with diversity of undergraduates in UK Higher Education

Neil V. Challis
Sheffield Hallam University
Sheffield, UK
n.challis@shu.ac.uk
Adrian J. Oldknow
King's College, University of London
London, UK
a_oldknow@compuserve.com

In this paper we discuss some aspects of developments in mathematics teaching, learning and assessment within the current UK context, presenting some detailed illustrations through case studies of two different institutions.

Introduction

In the UK, as in many countries throughout the rest of the world, there is a wide range of developmental activity in the use of Information and Communication Technology (ICT) to enhance the teaching of mathematics. However the direction of these developments, and the thinking behind them, is inevitably informed not only by international work and collaboration, but also by the local context. Thus in this paper we shall report on certain developments with which we have been closely connected, but which also give some indication of the wider picture in the UK.

The UK participation rate in higher education has increased relatively rapidly over the last few years from 1 in 10 to 1 in 3, and this is still rising. In 1992 the so-called 'binary divide' between the autonomous universities and the locally controlled polytechnics was removed, with a consequent diversifying of stated mission among those bodies now allowed to call themselves 'university'. More recently, there has been a move from student maintenance grants to loans, and the introduction of partial charges for tuition - measures which are still controversial and the effects of which are still not entirely clear. As a consequence of this rapid rate of change, a Committee of Enquiry into Higher Education was set up under the chairmanship of Sir Ron Dearing with a wide remit. This produced an influential report in 1997[1]. We draw attention to just two of the issues raised in the report. There is a strong recognition of the role of technology; and there is a requirement for universities to address the widely stated need by employers that students should develop so-called 'key skills'. These may be categorized as (i) communication (written and oral), (ii) team working, (iii) problem solving, (iv) using IT, and (v) improving one's own learning. There has been increasing difficulty in recruiting students to technical (including mathematical) courses, as well as to teacher training courses in subjects such as mathematics and physics. There have been changes in the school mathematics curriculum to which universities are having to adjust, not only in mathematics degrees, but in the full range of subjects which require service mathematics courses e.g. [1], [2], [3]. Responses to these changes have been various, but many have recognized the possibilities of technology, albeit in widely differing ways. The state of competition for a declining number of students for mathematics

[1] http://www.ncl.ac.uk/ncihe/index.htm

courses is such that neither of our institutions can rely solely upon recruiting students directly from schools with good passes in mathematics at A-level.

At Sheffield Hallam University we have been attempting, through activities under the umbrella T-TIME project[2] (Technology for Teachers In Mathematics Education), to exploit a range of technology such as hand-held machines, symbol manipulators, spreadsheets and dynamic geometry packages, for both learning and doing mathematics. Our aim is to address the rapidly changing context, but also to show the full range of what constitutes doing mathematics, spreading beyond the manipulative algebra which is the major stated concern of much activity at present. We have been working at updating the curriculum, and the way we organize our teaching, learning and assessment, initially through our service teaching, and now through an innovative mathematics degree. We say more about this in the following section.

At University College Chichester the mathematics degree has been developed from modules originally prepared for the main subject content of Bachelor of Education degrees for intending school teachers. The mathematics centre at UCC has a considerable reputation for curriculum development in the field of the use of ICT at all levels in education - including work for the Prime Primary Mathematics Education), LAMP (Low Attainers Mathematics) and RAMP (Raising the Achievement in Mathematics) projects as well as Nuffield Advanced Mathematics. Again the undergraduate courses make extensive use of graphic calculators, data-loggers, computer algebra and dynamic geometry software.

There are of course many examples of the educational use of mathematical technology, the range of which may be sampled at the web site of this year's International Conference on Technology in Mathematics Teaching (ICTMT4)[3]. The web site of the CTI (Computers in Teaching Initiative) Centre at Birmingham[4] plays a very useful role in disseminating both technological and academic developments.

A time of rapid change such as this demands a good level of staff development activity. This need is one that is strange to many academics, who are of course used to continuous self development in their subject area, but less familiar with the idea of continuing to develop their teaching, learning and assessment skills. However the need is acknowledged in various ways at the highest level. For instance, following the Dearing report, the UK Institute for Learning and Teaching (ILT) has (very recently, and amid some controversy) been inaugurated[5], with the intention that it will become the normal accrediting body for those who teach in higher education. The retention of accreditation will depend on the member's ability to demonstrate continuing professional development in the area of learning and teaching. From another angle the UK Quality Assurance Agency signals the importance it attaches to staff development through its Subject Review process[6], by asking "What evidence is there of quality enhancement in terms of take up and application of staff development activities related to teaching, learning and assessment?"

One route for channeling staff development opportunities in the UK is the Undergraduate Mathematics Teaching Conference (UMTC), a sister conference to DELTA, currently running at Sheffield Hallam for the third year - having moved from Nottingham University which had been its home for the previous 22 years[7]. The format has been tried and tested, and is based

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[2]http://www.shu.ac.uk/maths/
[3]http://www.tech.plym.ac.uk/maths/ctmhome/ictmt4.html
[4]http://www.bham.ac.uk/ctimath/
[5]http://www.ilt.ac.uk/
[6]http://www.qaa.ac.uk/
[7]http://www.hull.ac.uk/mathskills/umtc/

mainly around working groups who focus on particular issues. For instance issues studied over the last two years include "Modern approaches to teaching calculus - sharing good practice", "The Impact of Technology on Assessment", "Students talking Mathematics", "Teaching Mathematical Concepts using Puzzles and Games", "How best to prepare mathematics students for work", "Student Projects in Pure Mathematics", and "Increasing Student Involvement In Their Own Learnin". The working groups largely draft their reports during the week, which makes it a very hard week's work (as those who have attended will testify, particularly those who have been elected as scribe to one of the working groups!). The conference also has one or two plenary speakers, and a few presentations. Publications arising from the work of the conference are available, with details on the web site, and we would like to take this opportunity to say that we welcome colleagues from outside the UK to come and join us and share ideas (and the workload!).

A case study: developments at Sheffield Hallam

At Sheffield Hallam over the last 5 years, we have carried out a range of innovations, trying not to resist technology, but to integrate the best of it into our practice, and to design our curriculum assuming the use of the latest technology. Developments started with service teaching to large groups of engineering students, see e.g. [4], [5], [6] and have now informed the design of an innovative mathematics degree programme. We have drawn the many developments together under the umbrella title T-TIME. So what are the ideas that drive us?

We do not become devotees of a particular technology, but utilize a wide range, with the critical choice of the appropriate tool being an important skill. We encourage our mathematics students to buy the latest hand-held technology (we hesitate to use the word 'calculator' here because this technology has now advanced far beyond the connotations carried by that word - 'platforms' would be more correct), and many students now possess the 'wolf in sheep's clothing' that is the TI-89[8]. Others possess a TI-83/5/6 or TI-92, as appropriate, but our emphasis is not on what a particular technology can do, but on making the most of what you have to help you to grasp the mathematical ideas. We, and our students, make use of the related data-logging CBL/CBR technology[9] to gather real data for modelling studies to bring the mathematical ideas to life. We incorporate the use of a symbol manipulation package through the TI-89 or TI-92, or Derive, although the networked use of Mathsoft Studyworks[10] gives students inexpensive access to a Mathcad environment. Finally we have found a rich vein of approaches to mathematical and statistical ideas via a spreadsheet (in our case Microsoft Excel), e.g. [6], [7], and we edit the Spreadsheet User journal[11], which demonstrates the range of our current ICT usage.

We try to incorporate three key ideas:

- **The use of mathematics for modelling in real contexts.**
  Approaching mathematics through modelling is now widespread, although the technology opens up many new possibilities, from cheap and easy data gathering for model validation, through simplified symbolic, numerical or graphical solutions, to extensive visualization facilities.

[8] http://www.bham.ac.uk/ctimath/reviews/Nov98/ti89review.pdf
[9] http://www.ti.com/
[10] http://www.bham.ac.uk/ctimath/reviews/feb99/swreview.pdf
[11] http://www.shu.ac.uk/maths/

- **The integration of key skills development.**
  The key skills as listed above arise naturally in modelling problems, and it may be argued that mathematics is one of the few disciplines able to deliver all the key skills in an integrated way [8]. For instance a modelling case study could involve formulating the problem, choosing a solution method or technology, working with others to solve it, presenting results in writing or orally, with discursive as well as formal components, identifying learning required to solve a problem, and so on. It is worth mentioning here that the mathematics community in the UK has made a broad attempt to address the key skills issue via the so-called Mathskills project[12].

- **A combination of symbolic, numerical and graphical approaches to mathematical ideas.**
  We label this "Going for a SONG" (with the O standing for Oral, to emphasize the importance of being able to speak mathematics), which is partly in reaction to what may be perceived as an over-emphasis on symbolic approaches. However there is more to it than that. The technology again allows less dependence on formal symbolic techniques, as well as excellent possibilities for implementing numerical methods through say Excel, and for providing the kind of visual facilities we could only dream of as students.

What issues are raised by these innovations? Some current preoccupations include these questions:

- What are the best ways to assess our students in new approaches to learning, teaching and doing mathematics, bearing in mind the often conflicting constraints of economics, validity, plagiarism, justice, and the need to incorporate key skills? Underlying all this is the fact that the way we assess students sends a message about what we really value, and also increasingly sets the whole agenda for students who have to do paid work as well to fund themselves through our courses.

- Within the time available to us, how do we reconcile the aim to make students employable, with the more traditional academic aims of mathematics courses? What should the curriculum content be now? What range of skills should we aim to develop? What do we (or the students) mean by "doing mathematics"?

The SHU course has not been in existence long enough to have produced sufficient graduates for any reliable assessment of employment record yet. However recruitment has risen substantially. All courses are now reviewed on a regular basis for Teaching Quality by the Quality Assurance Agency, and the SHU mathematics course received one of the highest national ratings. In addition the T-TIME approach practiced at SHU was internationally recognised through a special award at the ICTCM conference in Chicago in 1998.

A case study: developments at University College Chichester

The ethos at UCC is quite distinct from that at SHU. The institution was formed from the merger of two teacher training colleges (Bognor Regis College of Education, and Bishop Otter College, Chichester) at a time in the 1970s when the UK government realised that the production of teachers was outstripping the needs of a declining population. Under the watchword

[12] http://www.hull.ac.uk/mathskills/

of 'diversification', such new institutions were encouraged by the Government to cut back dramatically on intakes to teacher education and to develop new degree courses, mainly in the liberal arts. Previously under the rather paternal eye of neighbouring universities, these new 'Institutes of Higher Education' now sought validation for their new courses through the (now defunct) Council for National Academic Awards (CNAA). Within that process of peer review there were no over-riding preconceptions about what a course with the word 'mathematics' in the title needed to contain. Provided you had the confidence, commitment, convincing rationale and resources to support what it was which you wanted your course to achieve, then you would receive (perhaps limited) approval.

Thus we were able to develop a range of modules reflecting the techniques of pure and applied mathematics within the subject's philosophical, historical and cultural context. There were no engineering, or hard-science courses, to provide service teaching or cross-fertilisation. There were, though, degree courses in sports and health studies which provided opportunities for service teaching in statistics, as well as inter-disciplinary studies in bio-mechanics, pharmacokinetics and modelling. Modules now became open to a wide range of students taking courses such as BA(Ed) in secondary school mathematics, BA in Art with Mathematics, BA in Music and Mathematics, BA in Mathematics with Education and, finally, BA Mathematics. With the closure of CNAA we first obtained validation for our own degrees under the regional scheme established by Southampton University, and more recently achieved from the Higher Education Funding Council (HEFC) our own degree awarding powers - with the consequent change of name from Chichester Institute of Higher Education to UCC.

The mathematical background of our students, as well as their age and education, is widely varied and so it is very difficult to assume common starting points, particularly in applications of mathematics. Hence we have concentrated on Mathematical Modelling as a means of drawing examples from fields such as physics, demography, economics, finance, planning. All students either purchase, or are loaned, hand-held technology such as TI-83/85/89/92. The mathematics centre has site licences for Derive, Geometer's Sketchpad, Mathcad and Mathsofts Studyworks, and student versions are available at low cost. The hand-held devices are used extensively for modelling [9],[10],[11], together with CBL/CBR, and for statistics [12]. Geometer's Sketchpad is used not only in geometry and history of mathematics [13],[14], but also for linear algebra, analysis, modelling and dynamic systems [15],[16]. Not only is computer algebra (TI-89/92, Derive and Mathematica) used extensively - but also students consider the implications of its applications, and study the basis of some of the CAS algorithms [17],[18],[19].

A major feature of the UCC mathematics modules is the variety of assessment modes applied. It may be that some of these are functions of scale which could not be retained if group sizes became significantly larger than at present (maximum is 30). Clearly when techniques need to be learned then timed examinations and tests are appropriate instruments. However many modules result in some form of written or oral communication, or both. Often students will prepare written reports incorporating output from ICT, and they may give oral presentations on their work using e.g. Powerpoint - or the LCD display pad from a hand-held machine with an OHP.

Conclusion

The current climate of attention on, and accountability for, teaching quality requires the UK Higher Education sector to review its methodology, assumptions and traditions in all subjects. The diversity of the student population in mathematics compounds this situation and most, if not all, of the sector will need to consider what benefits ICT may, or may not, bring. The experience of a wide range of ICT use in our own institutions (SHU and UCC) should make a useful contribution, together with those of others, including the CTI centre, as the new structure for continued professional development for mathematics lecturers unfolds.

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