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Papers in MSOR Connections

The following papers, which were presented at CETL-MSOR 2008, will be published in a forthcoming issue of *MSOR Connections*. These articles will be accessible via **www.mathstore.ac.uk/newsletter** after publication.

e-Proofs: Online resources to aid understanding of mathematical proofs	**L Alcock**
Accessibility of mathematical resources: the technology gap	**E Cliffe & M Kiziewicz**
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Some issues on assessment methods and learning in mathematics and statistics	**N Ramesh**

Editor's Notes

The third CETL-MSOR Conference was held in September 2008. I have had the privilege of both attending and also editing the proceedings for all three Conferences. Once again I can record what a pleasurable and educative experience this has been (these two qualities do not always go hand-in-hand!). The breadth and quality of the papers in 2008 provided a rich experience.

A large number of referee's were once again employed – a minimum of two for each paper. Their expert comment went as long way to further enhancing some excellent contributions and provided valuable guidance as to how to ensure that each paper would reach its appropriate audience.

Almost all the papers presented at the 2008 Conference will appear in print in 2009 – either within these Proceedings or as articles in *MSOR Connections*.

Conference Papers in these Proceedings

A number of papers address the issue of support provision. **Gill and Greenhow** report on a project to run a 'maths café' during the revision period, aimed at reaching parts of the student community which other support initiatives cannot reach. Judging by student attendance numbers and feedback, this proved very successful, and there are lessons to be learned for the wider support community. **Gill** reports on a small-scale investigation in providing 'headstart' support for mature students returning to learning. A novel feature was in the use of a *Maths Self-Concept* scale as a means of determining the value of the intervention, rather than the traditional – and potentially demoralising – pre- and post-test assessment. **Mac an Bhaird** reports on an unusual case study using the History of Mathematics to support the learning of mathematics *for students with weak mathematical backgrounds*. The idea is to provide motivation, and also to counter questions such as "Why are there such crazy rules?" Why indeed. This project provides another useful tool for the support teacher, and there is the promise of more materials to come. **Symonds, Lawson and Robinson** present their findings into student usage of mathematics support (or failure to use it). This is an important and challenging issue, and their research provides some observations and pointers which will be of interest to many mathematical educators. **Wilson and Gillard** give a very clear description of some of the problems associated with providing a university mathematics support service and suggest ways in which they may be tackled.

Several papers have an assessment theme – formative or summative – ranging from having no technical content to being quite sophisticated technically. Taking them in that order (a subjective judgment), the first is the paper by **Bidgood, Goda, Hunt, Jolliffe, Marriott and Retkute** which provides a *tour de force* on variety in statistics assessment. This is well worth reading beyond those who actually teach and assess statistics. **King and Robinson** review the use of electronic voting systems in Higher Education in general and then report on their use in mathematics courses of engineering students at one university. Their results show a very positive reaction by the students. The need to engage engineering students in their own mathematics learning in lectures is widely recognised; their research provides some evidence to support the view that electronic voting systems deserve serious consideration. **Gwynllyw and Henderson** report on a web-based computer aided assessment system specifically designed for mathematics and statistics. Anyone who has been involved with such systems will know what a challenging area it is, and this paper outlines a promising way forward which others may like to pursue. **Hewson** provides an informative technical paper about using R and LaTex to generate unique (to each student) datasets and corresponding self-marking problem sheets. This should be very attractive to statistics lecturers who have the necessary technical skills themselves or have it available.

The theme of employability features in two papers. **Durrani and Tariq** provide an interim report on a three-year project exploring the role that numeracy plays in graduate recruitment, drawing on the views of both employers and graduates. There is a growing trend for undergraduates seeking help with preparing for numeracy tests so this paper will be of interest to many mathematical educators. Further results in the future from this HEA National Teaching Fellowship Scheme project should prove valuable. **McAlinden and Waldock** address the issue of developing students' employability skills – a matter of increasingly significance at the present time . Their approach is to embed Personal Development Planning into the curriculum. Readers involved with curriculum development will find reading about the authors' approach and experiences valuable.

Humphreys and Francis report on their work in using crime statistics to develop numeracy skills in criminology students, by introducing the idea of crime data as *numbers* rather than *case studies* or *interviews*. This report of their approach and findings will provide insight and ideas for others working with social science students.

Treffert-Thomas and Jaworski report on a somewhat unusual investigation which surveyed mathematics department staff who teach mathematics to undergraduates studying either mathematics or engineering. Although restricted to a single department, this nevertheless provides some interesting insight into the staff's attitudes to and perceived purpose of teaching and their views on the role of the lecture.

Macdonald, Crighton and Craven report on a novel project focussing on raising awareness among tutors of significant or difficult parts of a course, and promoting good practice, using a wiki. This paper should be of interest to many as it includes a substantial list of recommendations based on the authors' experiences.

Whether you read the papers by theme, or in the author alphabetical order presented, or just by dipping, I am confident you will gain much enjoyment and insight.

David Green

Promoting variety in statistics assessment

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Abstract

In this paper we explore some of the factors that encourage variety in the assessment of the subject of Statistics within UK Higher Education, together with some of the pressures that militate against variety and foster uniformity. This paper was produced by a working group of the University Mathematics Teaching Conference in Birmingham, December 2007.

1. Introduction

It is widely recognised that when assessing students it is beneficial to incorporate a variety of assessment methods [1] [2]. Variety comes from a range of different sources. There is variation over time [3]. There is also variation between institutions: some departments develop a particular assessment technique that becomes standard practice across the majority of their courses, yet is quite different to what goes on elsewhere. In other departments there is considerable variation between lecturers, each having their own ideas on how best to assess their particular branch of the subject. There is variation between levels: whilst a multiple-choice test might be appropriate for assessing a first year elementary statistics module, it would probably not be suitable for a final year statistical modelling module. (Note that we distinguish here between a *module* and a *course*, the latter being a coherent collection of modules.)

2. Encouraging Variety

When designing an assessment strategy the Statistics lecturer has to respond to conflicting voices and demands. In this section we consider some of the factors that encourage the lecturer to adopt a range of assessment types.

2.1 Diversity of students

Students have different strengths and different approaches to learning [4] and it is only fair that the assessment process should give an opportunity for students to demonstrate their abilities. Some students under-perform in an examination setting; others struggle to write reports; others are unable to give an acceptable oral presentation. Consequently, in an ideal world, each module or course should adopt an assessment strategy that includes all these varied elements. Where a student is registered with a disability, it may be necessary for the lecturer to set a different but equivalent assessment for them. However, in the absence of any disability, it is thought to be totally unacceptable for some students to be allowed to present their assignment in writing while others present it orally. If the learning outcome being assessed is “Communicate technical ideas in writing” then this policy is understandable. On the other hand, if the learning outcome being assessed is "Explain complex technical ideas", then why should each student not be allowed to use his or her preferred method of communication? There is also a cultural dimension to the assessment process. Students from some cultural backgrounds are happy to formulate and discuss their own ideas and opinions, while others prefer to recite the accepted wisdom of "experts".

2.2 External guidance

The Quality Assurance Agency (QAA) code of practice for the assurance of academic quality and standards in higher education [5] includes a precept that students should experience a range of assessment methods that take account of individual learning needs. All higher education programmes now include intended learning outcomes, which include a list of transferable, professional, employability or graduate skills. Indirectly, of course, the pressure to include these elements has come from employers. This skills set typically includes problem-solving, communication orally and in writing, use of ICT, team working, and working to deadlines. Programme specifications have to include a map that shows how and where within the curriculum these skills are being developed and assessed. Given that oral communication and team working are generally forbidden in examinations, course leaders have no choice but to design into their programme opportunities for different types of assessment. Course designers, both in the mathematics area and more widely, often rely on the Statistics module to "tick the boxes" of the curriculum map.

2.3 Nature of the subject

At one time the subject of Statistics was usually assessed in a similar way to Mathematics, with an emphasis on formal examinations. Over the past forty years, as the subject has become more applied, it has lent itself to a more varied assessment strategy [6]. For example, students can be asked to collect and analyse their own data; they can be set realistic problems to solve either individually or in groups; they can complete weekly online quizzes prior to attending lectures or after group discussions; they can be asked to carry out simple experiments and simulations or to compile a portfolio as part of the assessment of long-term project; they can be required to communicate the results of statistical analysis to a non-specialist audience either graphically, verbally or in writing; they can critique the study designs and analysis methods of others. Different methods of assessment are appropriate for different elements of the curriculum. One would not necessarily assess knowledge of the laws of probability in the same way as the ideas of questionnaire design.

2.4 Influence of research

In recent years there has been increased recognition of pedagogic research and, as a consequence, lecturers have been encouraged to experiment with different approaches to teaching, learning and assessment, and to evaluate their experiences. For example, the Journal of Statistics Education has recently introduced a new section asking for accounts of the implementation of research findings [7]. The Statistics Education Research Journal "aims to advance research-based knowledge that can help to improve the teaching, learning and understanding of statistics or probability at all educational levels". Some interesting ideas as regards obtaining research data can be found in [8], while [9] and [10] list topics needing further research. The ARTIST (Assessment Resources Tools for Improving Statistical Thinking) software [11] is a good example of funded educational research bringing about a change in assessment practice.

2.5 Concerns about plagiarism

The recent PiSA (Plagiarism in Statistics Assessment) project [12] revealed how concerns about plagiarism are having a strong influence on the assessment strategies of Statistics lecturers. A positive effect of this concern is that lecturers have become more imaginative about the type of assessments set. For example, a lecturer may set essentially the same assignment every year but vary the format of the submission: one year a written report, the next year a poster, the next year an oral presentation. Alternatively, if a written submission is essential, one year it is in the form of a research paper, another year a newspaper article, another year as a pamphlet for schoolchildren, and so on. Topicality can be used to avoid plagiarism from students in previous years, by requiring students to gather and process information presented, for example, in recent newspaper articles and scientific reports they have read [13]. Setting individualised assignments for students is now quite common. One approach is where each student is allocated a different subset of a large dataset to analyse and/or is allocated a set of tasks with randomised elements or parameters [14].

2.6 Student voice

More than ever, lecturers feel under pressure to bow to student opinion, to avoid the risk of poor student feedback on their teaching. Unfortunately this is a two-edged sword. Increasing the variety of assessment methods pleases all the students some of the time, whereas using only one method of assessment pleases some of the students all the time. On balance, student influence probably has a positive impact in leading to more imaginative and interesting assessments, although students may show dislike for realistic and open-ended assessments even though they recognise their value [15].

2.7 Teaching innovation

There is a common perception of the university lecturer as someone who teaches from the same parchment-like notes for the whole of their career. The reality is that many lecturers are constantly reflecting on their teaching methods and regularly introducing new materials and approaches, even if the content has not substantially changed. They see this as the essential creativity of the job. This "spark" is a great promoter of variety in assessment, although regrettably there is often as much reinvention as invention. Recent years have seen the retirement of a whole generation of Statistics lecturers who entered the profession during the expansion of higher education in the late sixties, making way for "new blood". The new intake to the profession, albeit much smaller in number, are those who have been brought up in the computer age. In time they will probably devise assessment methods that the old guard never dreamed of – for example, use of virtual experiments [16].

2.8 Technological advances

The last 20 years have seen extraordinary advances in the field of multimedia computer technology and communications. The Internet has brought the world to our desktops, affording an almost boundless resource. Statistical software has greatly expanded the range of analyses that students can conduct almost instantaneously. This has revolutionised assessment in Statistics and will continue to do so. Electronic voting systems [17] can already be used to bring instant feedback to the students and automatic marking to the lecturer. Computer based virtual environments can be used to create simulations which mimic the real world and provide students with individual data sets [18]. Voice recognition software should make it possible in the near future for students to engage in simulated role-play, with the computer acting as the client requiring statistical advice and the student as the consultant.

3. Discouraging Variety

Notwithstanding the above ways in which variety is encouraged, the Statistics lecturer must also respond to various pressures and constraints that discourage and deter variety in assessment. These include the following.

3.1 Administrative pressures

Variety in assessment is limited by administrative rules and procedures. For example, an institution or school or department could decree that all modules must have 20% coursework and 80% examination. Any attempt to argue for an exception to be made is likely to be met by rigidity. A similar decree might require no more than two or three assessments per module, or even set tariffs as to what proportion of a module's assessment is taken up by a one-hour test, a 1000 word essay or a 15-minute presentation. The net result, as presumably intended, is less assessment and hence almost certainly less *variety* of assessment. Mention having two individual assignments, one group presentation, one computer-based practical test and a final examination – not uncommon at one time – and the corporate hands go up in horror. The lecturer is left to select which two or maybe three of these assessments can be retained. This rigidity may also extend to the official module descriptor, which is required to state the detailed type, timing and weighting of each assessment. The lecturer cannot decide to change the style of assessment one year, unless he or she applies to the relevant committee to have the document amended. Once the document is engraved in stone it is easier to leave it unchanged until the next review in five years time, by which time other factors might have changed so that the proposed change of assessment is no longer appropriate.

3.2 Concerns about plagiarism

Whilst concerns about plagiarism have spurred some to be more creative, many lecturers have reacted by abandoning take-away assignments altogether. Commercial cheating services are openly available on the Internet, providing solutions to questions, model essays, and even bespoke assignment consultancy – at a price. Hence, no matter how ingenious the assignment, there can be no guarantee that students have not paid someone else to complete it on their behalf. The natural response to these concerns is to resort to supervised time-constrained assessments.

3.3 Staff workload

It is difficult to obtain objective evidence about lecturers' workloads and undoubtedly there is huge variation between institutions. It is common for lecturers to work 50 hours or more a week, regularly. The effect of excess workload on assessment is twofold. First, the lecturer does not have time to devise new assessments and probably has no choice but to recycle a previously used assessment, hopefully not from last year! Second, the lecturer does not have sufficient time to mark assessments, so is more likely to set a multiple-choice test than, say, an open-ended modelling assignment. Hence variety is squeezed from both ends.

3.4 Lack of support

It is a courageous lecturer who undertakes a computer-based examination without a dedicated technician present throughout. Who is left to pick up the pieces if the network fails halfway through the examination? Lack of confidence in technology, infrastructure and support services is a great deterrent to innovation and variety in assessment.

3.5 Student numbers

The survey conducted by the PiSA project revealed that many Statistics lecturers had resorted to in-class tests and examinations as the only form of assessment because of the large number of students in their classes. It is not unusual to have more than 500 students on a service module. Trying to organise presentations for 500 students would certainly be a challenge. As mentioned earlier, having to mark, moderate and return assessments within a short space of time means it is nigh impossible to set anything that produces a submission of more than two or three sides of A4. Large numbers also militate against computer-based assessments since it is usually impossible to assess all the students simultaneously. Testing them at different times would normally mean setting different tasks, which adds to the workload and raises potential issues about fairness. It is easier just to have a traditional pen and paper test.

3.6 Reduction in class contact

In many universities, the weekly class contact time is now much smaller than it was ten or twenty years ago. Reductions in the student working week from 18 hours to 12 hours per week are not untypical. This reduction has had a disproportionate effect on Statistics in the curriculum. In Mathematics degree courses there was a tendency to cut the hours for the "comparatively less important" statistics modules rather than for the "essential" mathematics modules. In other disciplines Statistics was commonly either removed from the curriculum altogether, embedded within other modules, or given a greatly reduced allocation of time. This reduction in class contact time has been the death knell for much of the interesting practical and experimental work that used to take place, particularly in the former polytechnics. In the late sixties Statistics was openly viewed as a laboratory-based subject. At Sheffield Polytechnic, Gopal Kanji's (unpublished) laboratory manual contained 50 experiments to be carried out by students using a plethora of equipment including stopwatches, bottles of aspirin, playing cards, shove-halfpenny boards and much more. Similarly Murdoch and Barnes at Cranfield published a set of 20 experiments based on a commercially available statistical kit of equipment [19]. Being unable to use class time for assessment-related activities reduces the lecturer's scope to conduct interesting practically based assessments.

3.7 Reassessment issues

It is generally the case that the resit assessment for a module must be of the same style as the original assessment. Resits often take place over the summer period when many staff are on vacation or absent at conferences. In many cases there will not be more than one or two candidates per module. It is therefore not practicable to have group work, peer assessment, or oral presentations as part of the resit, and hence better to avoid them in the first place.

3.8 Semesterisation

There are additional constraints on assessment at those universities where the academic year comprises two semesters. In some institutions there is a rule that there should be no examinations in the first semester. The length of the semester dictates that a large part of the assessment occurs near the end, yet there may be pressure to avoid having several deadlines within a short period. Also the lecturer is under pressure to mark the work quickly in order to give feedback to students before the examination. This discourages assessments that are time-consuming to mark and makes it difficult to assess topics that are taught towards the end of the semester. In a year-long module there may be several in-course assessments spread across the year and it is easier to set more varied tasks that cover several sections of the course.

3.9 Staff priorities

The overwhelming priority for lecturers in the longer established universities is to complete research projects and write research papers. Devising innovative assessments does not generally attract the same research funding or academic kudos. In these institutions marking of assessments will often be carried out by postgraduate students and so there is again pressure to set straightforward tasks that can be marked quickly and easily.

3.10 Student preferences

As mentioned earlier, pressure from students can have a positive effect in enlivening teaching and assessment methods. However, it can also have a negative effect. Mature students with family responsibilities often dislike group assignments, complaining that it is difficult for them to arrange group meetings. Students who have to undertake paid employment whilst studying are quick to complain about assignments that are too open-ended and take too long to complete. Against this backdrop it is much safer for the lecturer to resort to unimaginative but popular assessments. Indeed, it now seems quite common for tests to be delivered over the web, which students take unsupervised at a time of their choosing, despite the clear risk of plagiarism discussed earlier.

4. Variation in Examinations

Currently the standard statistics assignment typically involves the computer analysis of a set of data, either supplied by the lecturer or collected by the student, and a report of the results in writing. For many reasons outlined above the future of this type of assessment is in jeopardy. In its place lecturers might consider a variety of different examination styles that seek to assess the same learning outcomes but are different from the timed closed book examinations set in the past. Some of these newer styles are described below (and see [3]).

Examinations can be open book, either allowing students to bring in unlimited resources or perhaps restricting the material to one or more pages of A4 paper. Students can be supplied with comprehensive formulae sheets. Examinations can include extensive reading time, to allow students time to think and plan. Students can be issued with a data set or research paper a few weeks before the examination so that they have an opportunity to study it in detail without the constraints of time, before being faced with unseen questions on it in the examination. Examinations can be computer-based allowing all students to analyse the same set of data with less risk of collusion or plagiarism. Examination papers can contain computer output derived from various possible models, allowing students to select and assess models without actually fitting them themselves.

5. Conclusions

The pressures to reduce the variety in assessment methods appear to outweigh the forces driving innovation. It is unrealistic to expect resources, either human or material, to increase sufficiently in the immediate future to make a real difference to lecturers' behaviour. It is equally unrealistic to expect class sizes to fall. To increase the variety of assessment requires action by organisations such as the Mathematics, Statistics and Operational Research (MSOR) Network, the Royal Statistical Society and the Teaching Statistics Trust to facilitate the sharing of ideas and experiences, and the pooling of assessment tasks and examination questions. This is particularly critical in the light of [20], which highlights the parlous state of many Statistics departments/groups in UK universities.

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Employers' and students' perspectives on the importance of numeracy skills in the context of graduate employability

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Abstract

This paper explores graduate employers' and undergraduate students' perspectives on the significance of numeracy skills to graduate employability, using two online surveys. Respondents to the employer survey represented a range of business sizes and sectors, while respondents to the undergraduate survey represented a diversity of academic disciplines and were all enrolled at the University of Central Lancashire.

One in two employers use numeracy tests in their recruitment procedures for posts, ranging from elementary and skilled trade positions to professional occupations. Although almost two thirds of students recognised the importance of numeracy skills to their employability, about 40% were unaware that employers are increasingly adopting numerical testing, and almost half were anxious about attempting such a test.

1. Introduction

Enhancing undergraduates' employability skills has become a priority in UK higher education policy [1], as growing numbers of graduate employers place an increasing emphasis on such skills, in addition to subject-specific knowledge and skills [2,3]. Although the list of employability skills sought is not exhaustive, many studies have highlighted the importance of numeracy skills. For example, the Council for Industry and Higher Education reported that 68% of employers consider numeracy to be important [3]. Similarly, 500 directors belonging to the Institute of Directors (IoD) ranked 'numeracy skills' as the sixth most important employability skill [4].

Employers are increasingly using a range of psychometric tests, including numerical reasoning and computation tests, to evaluate applicants' employability skills, since many of the latter are difficult to assess through more traditional interviews and *curriculum vitae* [5, 6]. What is particularly worrying is that, while 97% of employers responding to the IoD's survey rated numeracy skills as 'important' or 'very important', 21% believed that such skills are only 'occasionally' or 'never' demonstrated by graduates [4]. Further, research indicates that a rapidly changing, competitive and globalised economy demands the involvement of more employees in numeracy-related activities [7]. However, what is not clear from the literature is the extent to which the numerical skills of graduates influence their employment prospects. In addition, very little is known about what employers actually mean by 'numeracy skills'. This paper attempts to bridge this gap, by bringing into focus the role applicants' numerical skills play in obtaining graduate employment and identifying the generic numerical skills required by graduate employers. In addition, it explores undergraduates' views on the value of numeracy skills to their future employability and their levels of confidence in their numerical capabilities.

2. Methodology

Two online surveys were created using Bristol Online Surveys (BOS) [8], one for graduate employers and the other for undergraduates at the University of Central Lancashire (UCLan). The employer survey was piloted with a sample of employers from the *The Times Top 100 Graduate Employers* [9], before being launched in March 2008. Graduate employers, contacted via email and telephone and asked to complete the survey, included those listed in (i) *The Times Top 100 Graduate Employers* [9], (ii) *GET 2008 Directory of Graduate Employment and Training* [5], and (iii) the '*Prospects.ac.uk*' website [10]. The Lancashire Business School Placement Unit and UNITE (both at UCLan), and two Association of Graduate Careers Advisory Services task groups (Employer Liaison Specialist Group and Product and Services Advisory Group) all notified their employer contacts of the survey. The undergraduate survey was piloted with 140 undergraduate students at UCLan, between April and July 2008.

Preliminary data from the employer survey and the student pilot survey were summarised using the BOS statistics. Data from BOS were then exported into SPSS for further statistical analyses.

3. Results

3.1 Profile of employer respondents

By August 2008, 154 employers from a range of employment sectors had completed the survey, although consulting, and banking/accountancy firms had a proportionately higher representation than other sectors (Figure 1).

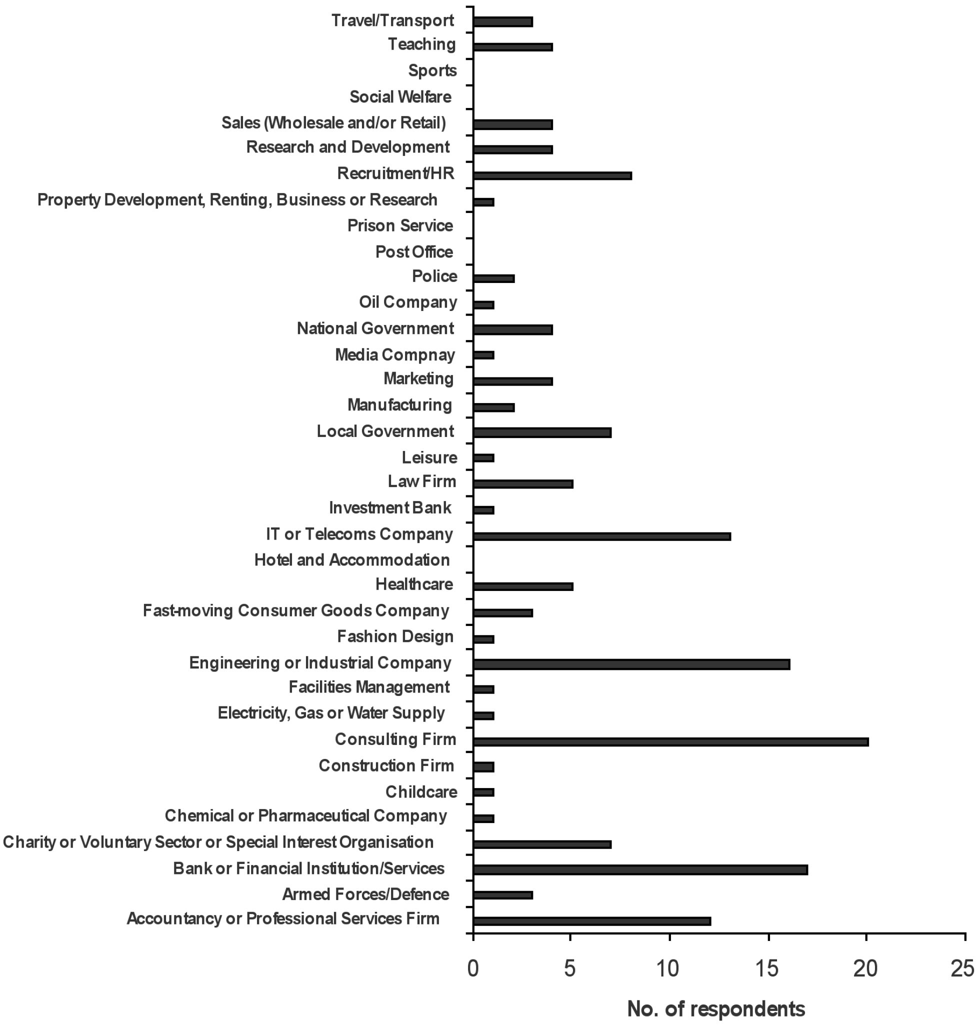
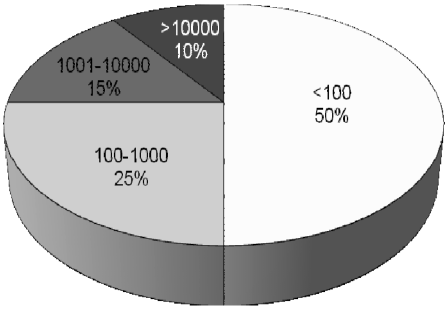


Figure 1: Responses by employment sector (N = 154)



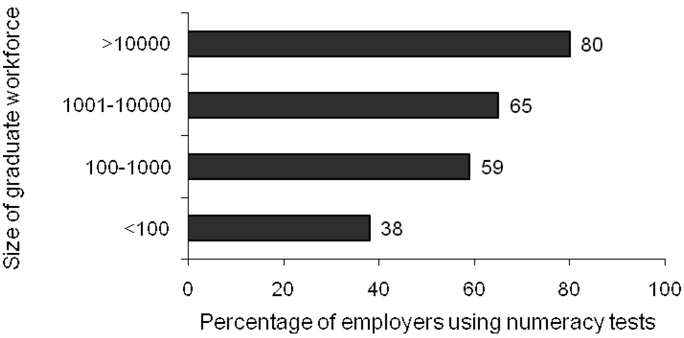
Of those responding, 56% represented multinational organisations based in the UK, while 31% and 13% represented companies operating at national (UK) and local levels respectively. Responding organisations also varied in terms of the size of their graduate workforce (Figure 2).

Figure 2: Percentage of employer respondents by size of graduate workforce (N = 154)

3.2 Profile of undergraduate respondents

Of the 140 undergraduate respondents, 52% were studying nursing; 31% biological/biomedical sciences; 14% physiotherapy, and 3% history. Full-time students constituted 94% of the sample, and 94% were primarily face-to-face learners (as opposed to distance/online learners); respondents were pre-dominantly female (81%). Fifteen percent were in foundation year, 80% were in year 1, 1% in year 2, and 4% in year 3. With regard to age distribution, 53% were aged 18-22, 22% were aged 23-30, 19% were aged 31-40, and 6% were aged 40 or above. In terms of respondents' highest mathematics qualification, 69% possessed GCSE (or O-level) Mathematics; only 17% possessed a higher Mathematics qualification (i.e. AS, A2, Irish Leaving Certificate or HND). Thirteen percent of students (predominantly studying physiotherapy and history) indicated that they were not provided with any opportunities to practise and further develop their numerical skills as part of their undergraduate studies at UCLan.

3.3 Use of numeracy tests in graduate recruitment



Approximately half (51%) of the employer respondents use a numeracy test as part of their graduate recruitment procedures. In general, the greater the size of the graduate workforce, the more likely that applicants' numeracy skills will be tested (Figure 3). In addition, a greater proportion (58%) of national (UK) organisations used a numeracy test compared to multinational (49%) and local (45%) businesses.

Figure 3: Use of numeracy tests in relation to size of graduate workforce (N = 154)

Some employment sectors (e.g. accountancy or professional services, banking or financial services, sales organisations, research and development sector, armed forces) make greater use of numeracy tests than others (e.g. law firms, recruitment and HR, charity or voluntary sector, marketing, IT or telecoms companies). On the one hand, this may reflect the extent to which employee's numeracy skills are important to the success of the sector. Alternatively, it may indicate that some sectors require a high level of formal mathematics qualifications from their applicants and are, therefore, less reliant on numeracy tests.

- *"As a retailer it is important that candidates understand basic maths as they will work closely with budgets, profit and loss statements etc."* (Sales)
- *"Our company desires graduates to be numerate and comfortable with the analysis of large databases, most of which have a mathematical or numerical base."* (Consulting firm)
- *"We have found that high mathematical competence is both a necessity in itself in our software development, and is a good proxy in pre-employment testing for general programming ability."* (IT or telecoms company)

- *"Other than basic numerical ability, having a strong numeric ability is not relevant to the roles our graduates undertake."* (Recruitment and HR)

Many (62%) graduate employers use commercially available tests, such as those available from SHL, PSYTECH, ASE and GMA, with SHL proving to be the most popular provider (used by 34% of respondents). Bespoke tests were used by the remaining 38% of employer respondents. While larger companies predominantly use commercially available tests (e.g. 92% of employers with a graduate workforce of more than 10,000), many smaller companies rely upon bespoke numeracy tests (e.g. 52% of employers with a graduate workforce of less than 100 employees).

Numeracy tests are used in the recruitment of employees in all the Standard Occupational Classification 2000 categories used by the Higher Education Statistical Agency [11], but are predominantly used in the types of jobs and occupations associated with graduates' aspirations, e.g. professional, managerial, administrative, and associate professional and technical occupations (Figure 4).

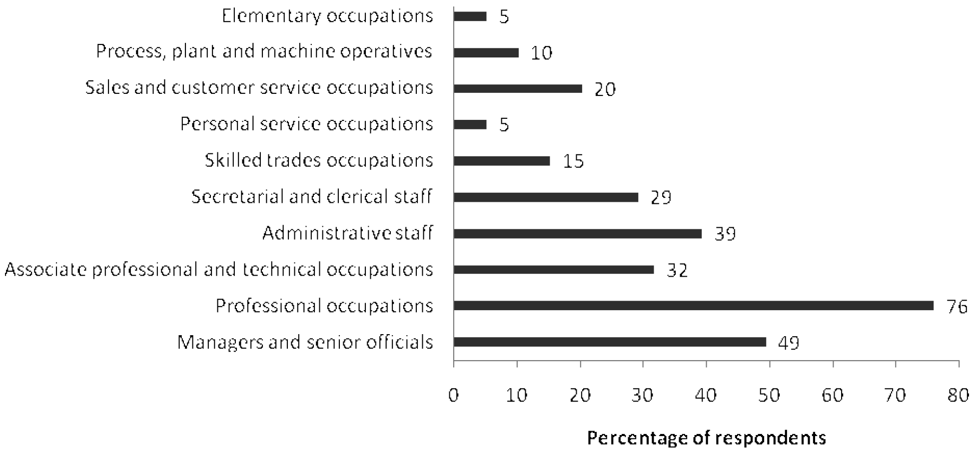


Figure 4: Types of occupations in which numeracy tests are used (N = 79)

Poor numeracy skills can seriously limit the prospects of obtaining a graduate job. Seventy percent of employers indicated that it was a requirement that applicants 'pass' the numeracy test in order to proceed to the next stage of the recruitment process, although the 'pass' threshold varied across the employment sectors and depended largely upon the graduate position. In the remaining 30% of cases, although 'desirable', it was not essential to pass the test; it was the overall performance of the applicant at the assessment centre that was more important.

- *"Many graduates are rejected without interview because of poor maths skills."* (Banking or financial services)

Graduate employers also consider the subject and classification of an applicant's first degree in their selection procedures. While 55% of companies considered the subject of an applicant's first degree important, 74% of employers considered the classification of an applicant's first degree important (of which 49% required a 2:1 degree). These findings contrast with those of a recent CBI survey in which employers ranked degree subject (56%) higher in importance than degree classification (32%) in the selection of graduate recruits [12]. However, the 55% of employers who considered the degree subject important were primarily those requiring applicants to have a mathematics-related degree, e.g. 30% required an engineering degree, 30% a mathematics or other 'hard quantitative' subject, 8% an accountancy or business studies degree, and 8% a computer/IT degree.

3.4 Undergraduates' views

Students clearly recognised the value of numeracy skills to their graduate job prospects, with 62% agreeing that they would need to be numerically competent if they were to gain future employment. However, about 40% of respondents were not aware that employers are increasingly using numerical tests as part of their graduate recruitment procedures. Additionally, few students (about 30%) were confident they could pass a numeracy test, while almost 50% were anxious about attempting such a test; the remaining 20% were indifferent.

- *"I feel quite nervous regarding mathematics, and although I have passed tests in the past, still feel anxious, and know I need to learn more as I find a lot of it quite difficult."* (female nursing student, aged 23-30)
- *"I think my problem lies with the fact that it's been a long time since I did maths at school, so my confidence is low on the subject."* (female biological science student, aged 23-30)

A perceived lack of numerical competence may have underpinned the fact that only 27% of respondents wanted to have a job that involved the use of numeracy skills.

3.5 Generic numerical skills: employers' vs. student's perspectives

Employers were presented with a list of generic numerical skills and asked in which of these skills they required their graduate recruits to be competent. The only numerical skills for which the percentage of responding employers fell below 50% were: representative sampling, using database software, using statistical software, and, somewhat surprisingly, understanding the language of maths (Figure 5). Interestingly, 44% of companies/organisations (predominantly law firms, marketing, recruitment and HR) indicated they would be satisfied if their recruits were technically competent in carrying out mathematical computations (e.g. using calculators or computers) without actually understanding the mathematical concepts underpinning them, perhaps indicating the significance of the application of modern technologies and software to workplace numeracy [13]. Only forty percent of respondents claimed to provide opportunities for training in numerical skills for their graduate recruits; such training takes many forms, with 'on-the-job-training' proving to be the most popular (55%).

Students were asked to self-evaluate their competence in the same skills set, on a 5-point Likert scale (1 = not at all competent, to 5 = highly competent). Fewer than 50% of students rated themselves as 'competent' or 'highly competent' on twelve of the fourteen skills listed, with the exception of 'calculating percentages' (53%) and 'data interpretation' (51%), suggesting a lack of confidence and/or competence and a numerical skills deficit when compared with employers' requirements. It is important to note that, since students were asked to self-evaluate their competency, they may have over-estimated their level of competence.

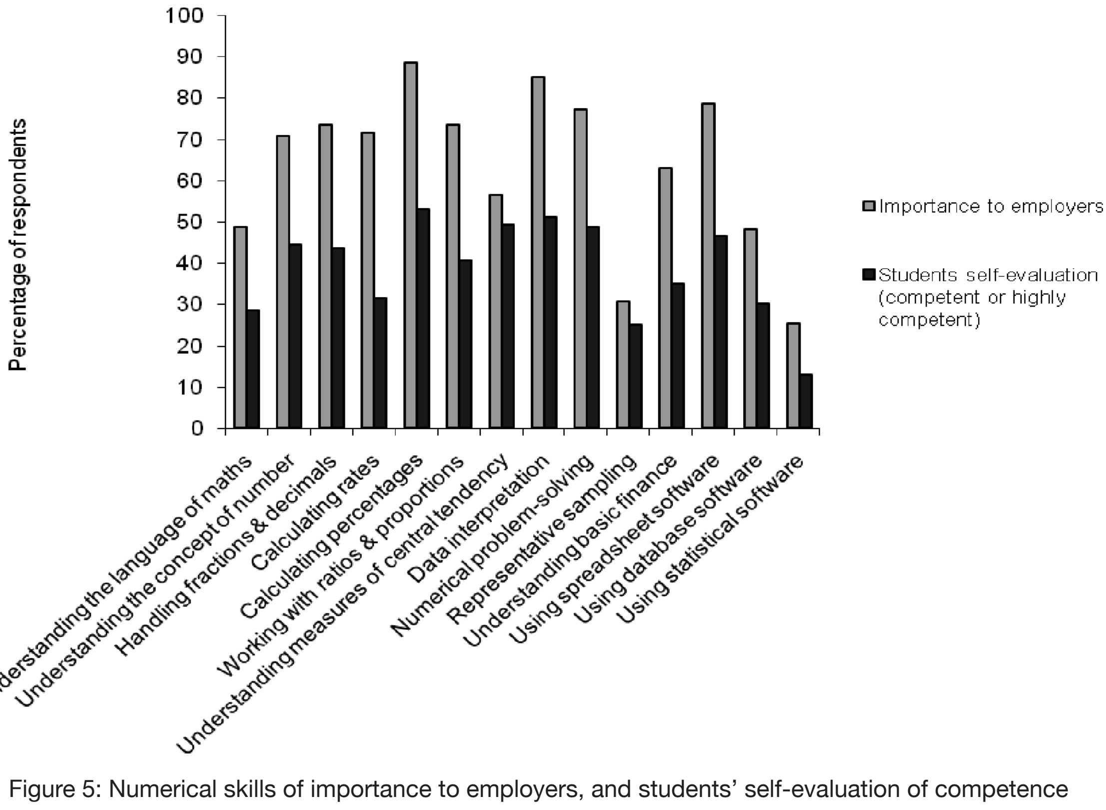


Figure 5: Numerical skills of importance to employers, and students' self-evaluation of competence

Conclusions

The preliminary results of this project suggest that competency in a range of numerical skills is important to students in obtaining employment associated with their graduate aspirations, particularly in large organisations. With the exception of STEM graduates, many may enter jobs not directly related to their academic discipline, but may still need to be numerically competent in order to operate effectively in the workplace.

Students recognise that numeracy skills are essential for their future graduate employment, but lack confidence and competence in many of the generic numerical skills employers consider essential. In order to enhance students' employability, universities need to promote undergraduates' numerical competence by offering them sufficient support and opportunities to practise and further develop the numeracy skills required in the workplace – through curricula and/or centrally provided resources/facilities. This is particularly important in the case of those undergraduates enrolled in disciplines which do not explicitly accommodate the development of numeracy skills within the curriculum, and who thus may have had little or no opportunity to practise and further develop these skills since their compulsory (pre-16) education [14, 15]. In addition, greater access to the types of tests used by employers would benefit undergraduates, since greater familiarity and practice could help improve students' test performance.

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Notes

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Maths Café – an initiative to help non-mathematicians

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Abstract

This paper describes the implementation, running and evaluation of a Maths Café run at Brunel University during a two-week revision period in 2008. Extensive advertising and proper resourcing ensured the Café's success in terms of the number of students helped and the quality of help provided. Feedback from students was overwhelmingly positive. The effect on students' marks, especially moving them from a fail to a pass in their quantitative methods modules, is harder to ascertain; this is examined for categories of students with diverse entry qualifications in mathematics. To plan future provision, a breakdown of requested topic areas is presented and commented on.

1. Introduction

In Higher Education (HE) there is a pressing need to support students in developing their mathematical skills. Changes to A-level syllabuses and a long-term decline in the number of students opting to study post-16 mathematics have no doubt contributed to the lack of mathematical preparedness of students entering HE [1] [2]. Students either engage with the "unexpected" quantitative aspects of their courses or simply ignore them for as long as possible [3]. In courses such as Economics, Psychology, etc, students often question the need for and relevance of mathematics [3] and therefore find it difficult to learn the basics, especially if they have not done any mathematics since GCSE. Moreover, in many subject areas there is diversity in students' mathematical qualifications [4] ranging from good A-level to weak GCSE grades. This means that students' analytical and manipulative skills will generally be extremely diverse [5]. The teacher must then attempt to ensure that weaker students are able to engage, whilst stronger students are still challenged and do not get bored [6].

To respond to these issues, a maths support tutor was employed within Brunel University's Effective Learning Advice Service (ELAS) to offer all students one-to-one sessions and group workshops. The demand throughout the year is constant and manageable for the one tutor, except during the revision period when demand soars. Moreover, "at risk" students, who might benefit from additional support, are not necessarily accessing it [7] [8]. It was therefore felt important to extend the one-to-one provision during the revision period and provide an environment in which students would feel comfortable and motivated to ask for help [6]. Our solution was the Café.

2. The Café

The Café was a joint initiative between Brunel University and the Mathematics Working Group of the West London Lifelong Learning Network (WLLLN). The WLLLN-funded project had the principal aim of improving the retention of non-traditional (often "at risk") students, although it was open to all-comers. The two-week revision period drop-in service was based on that of the University of Portsmouth [9] and comprised:

- buying-in hourly paid lecturers and support tutors. At least two members of staff were always available for one-to-one sessions,
- providing paper-based resources to students, produced by the maths support tutor herself and material from the (national) mathcentre [10],
- offering free refreshments as an incentive to attend the Café and keep them (and the tutors) going!
- advertising by producing and distributing leaflets, posters, notepaper with Café logo etc.
- decorating the room in a café style (see Figure 1a).

Figure 1: Photos taken during the Café
(a) Room dressed in a café style (b) Students and staff working together

The Café was open every day from 10am – 4pm and was located in a highly-visible room, funded by the LearnHigher CETL [11]. The room is at the front of the central Lecture Centre and has glass walls, so the Café activity could hardly be missed by students.

This project was the first of its kind to take place at Brunel University and was a learning process for everybody involved. So, apart from its intrinsic value to students, we put in place mechanisms to identify:

- numbers and make-up (gender and degree course) of students making use of the Café,
- their perceptions of it,
- the main mathematical problem areas.

As described below, the Café was very successful and is planned to run again in April 2009. However, this might have the perverse effect of encouraging students to leave revision until the end of the year, knowing that extra support will be available! The information collected will therefore be used to design and implement a more integrated approach to supporting students in the future.

3. Evaluation

To collect the relevant data to answer the above points and evaluate the Café, all students were asked to complete a self-registration form asking their name, gender, academic school, course and level of study. After students had seen a tutor they were asked to complete a feedback form. By day two of the Café it was seen that only about half of the students were submitting the forms so then all tutors kept a tally. Although this gave a fair record of student/tutor sessions, students also accessed the Café to make use of the room as a learning space, working with peers. Students stated that they wanted to work in the room since they knew there was help on hand if they needed it. Additionally, students accessed the Café just to make use of the freely-available paper-based resources. By the end of the first day, all the leaflets on the shelves had been taken so 200 additional copies of each were made.

3.1 Results

The results are analysed and discussed in four sub-sections:

3.1.1 Student demographic

Approximately 350 students accessed one-to-one support during the two-week period. This high level of demand was unexpected and indicates that there was a pressing need for support during the revision period. Moreover, the figure does not include students who came to the Café to access the paper-based resources or who came to use the Café as a learning space.

Of the 350 students, only 6% had received support from the maths tutor prior to the Café. This indicates that the Café was accessible and approachable to a wider body of students, which may be due to the casual drop-in nature of the Café and its relaxed ambience.

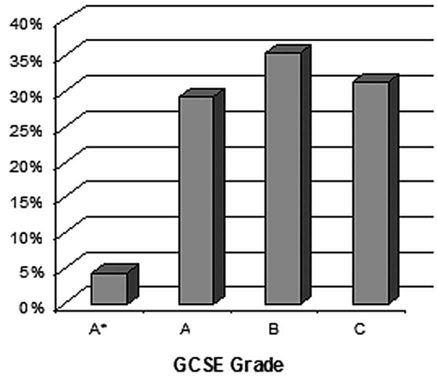
56% (198 students) returned the self-registration form. Given the almost exact 50-50 gender split at Brunel University as a whole, we were initially surprised at the high percentage (74%) of male students attending. However, from the gender split of the 156 students who registered their attendance at the Cafe who were drawn from the four main courses that attended, three of which are strongly male dominated (see Table 1), we should have a weighted split of 77% male / 23% female which is very close to the overall 74% male / 26% female for these four student cohorts. So it is clear that male students were in no way put off attending by any significant aspect of the Café, a claim supported by their comments, see section 3.1.2. All students appear to benefit from the casual drop-in nature of the Café. This contrasts with the reported 37% male / 63% female split for students attending Brunel's Counselling Service [12] where males are much less likely to seek help.

Course	Students registered on the Course		Students registered at the Maths Café	
	Total Number	Percentage Male	Total Number	Percentage Male
FC - Financial Computing	78	82%	43	77%
FoE - Foundations of Engineering	137	93%	40	88%
FoIT - Foundations of Information Technology	113	77%	27	96%
EF - Economics	225	59%	46	52%
Total	**553**	**74%**	**156**	**77%**
Other	-	-	42	66%
Grand Total	**-**	**-**	**198**	**74%**

Table 1: Gender split of students enrolled on the four main courses, and of those registered at the Café

One of the aims of the Café was to support non-traditional students, especially those students enrolled on highly-quantitative modules and without A-level mathematics. It is therefore important to find out students' GCSE and A-level grades in mathematics. From the 198 students who completed a Café registration form, 141 (71%) disclosed their previous exam results. Figure 2a (overleaf) shows that students' GCSE grades were split relatively equally between grades A, B and C, with a small percentage achieving an A*. Figure 2b (overleaf) shows that the majority of the students who accessed the Café had not completed an AS-level or A-level in mathematics (61% and 65%

respectively). Such students clearly felt they needed support to bridge the gap between GCSE mathematics and undergraduate mathematics, without which they may struggle [1] and leave or change courses.



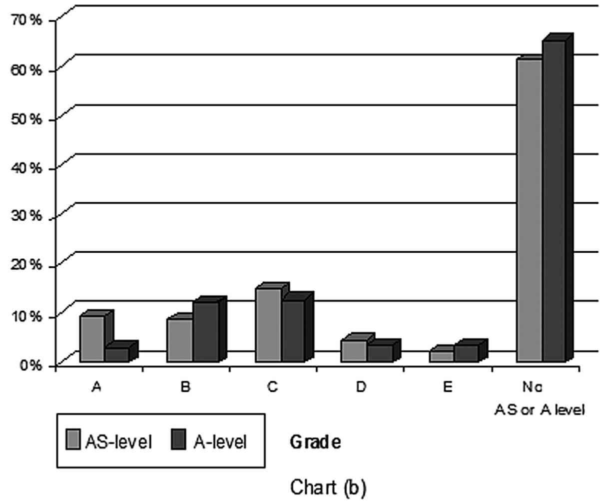


Figure 2: Distribution of the mathematics qualifications of students attending the Café
(a) GCSE grades (b) AS-level and/or A-level mathematics grades

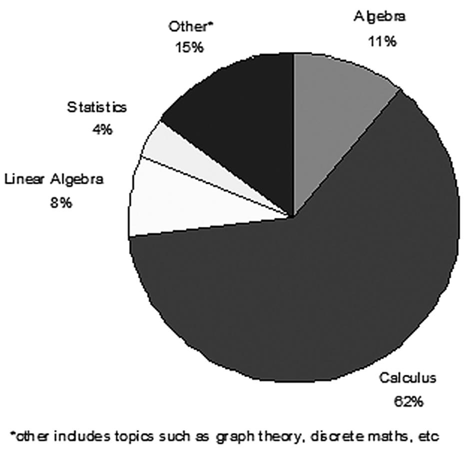


Figure 3: Chart showing the percentage of students who needed help with each topic area.

As expected, the majority of students who accessed the Café were from the foundation level (34%) and level 1 (56%). In terms of retention, they were the target groups; hence we may infer that the Café was set up successfully and advertised in an appropriate way.

As part of the Café registration, students had to state what topic area they needed help with. This was done both to collect useful data and so that students thought about the topic(s) they actually need help with, rather than just saying maths in general. Students requested help with 38 topics, grouped into 5 categories, see Figure 3.

62% of students requested help with calculus. However, often their real difficulty was not being competent with basic algebra. In most cases, students could apply the rules of differentiation and integration but were unable to simplify their answers. Also, by revision period, most students may have felt they were confident with the algebra aspect of their module or that they were "less interested" in the foundations of their course and focused on what might be explicitly examined. This was certainly the feeling of the Café tutors.

3.1.2 Feedback received from students

Students were asked to complete a brief feedback form after they had seen a Café tutor and 48% of the 350 students did so. Students found the one-to-one tutoring either 'very useful' (74%) or 'useful' (25%).

45% of students returning feedback forms made at least one suggestion, of which the most common suggestion (43%) was to have more tutors present. During the project two tutors were present at all times, but quite frequently the room was filled to maximum capacity and there was very little standing room available. During these peak periods, tutors kept to an absolute maximum 20-minute limit per student so that more students could be helped and so that students were not waiting long. This was a reasonable adjustment and worked well, but it would have been better to have a "back-up" tutor on hand. The second most common suggestion (27%) was to extend the duration and opening times. Both suggestions would require more funding.

Other suggestions were more general or were one-off comments, such as having more food available and running the Café more times during the year.

The last section of the feedback form asked students for any general comments. 48% of students made comments; all were messages of appreciation such as:

"Thank you for your support." "I was amazed at the level of support that was given to me." "Very knowledgeable and understanding teachers." "Explanations given were very good."

Evidently the Café setting promoted an environment that was friendly and open, where students seemed to be less afraid to disclose what they did not know or understand. This, of itself, was a significant help to the tutors who were then able to address the roots of most problems.

3.1.3 Evidence of Impact

Although student feedback and perceptions of the Café are important, this does not provide direct information of the actual impact the Café had on students' learning. This is difficult to ascertain, primarily because the Café was designed to be a student resource, not an educational experiment with, for example, control groups. Moreover, the students at the Café were self-selected for (unknown) reasons of their own. Nevertheless, it is pertinent to compare their subsequent performances with others in their cohort that did not attend the Café, and with previous years when no Café was available.

As noted in Table 1, the Café students were drawn from four main courses. Mathematics (or quantitative methods) examination results and overall module results from the quantitative module for all four courses have been collected. It is certainly not expected that all Café students would achieve high marks, but we hoped to attract and help students who were struggling with mathematics and move them from a failure mark (below 40%) to a pass.

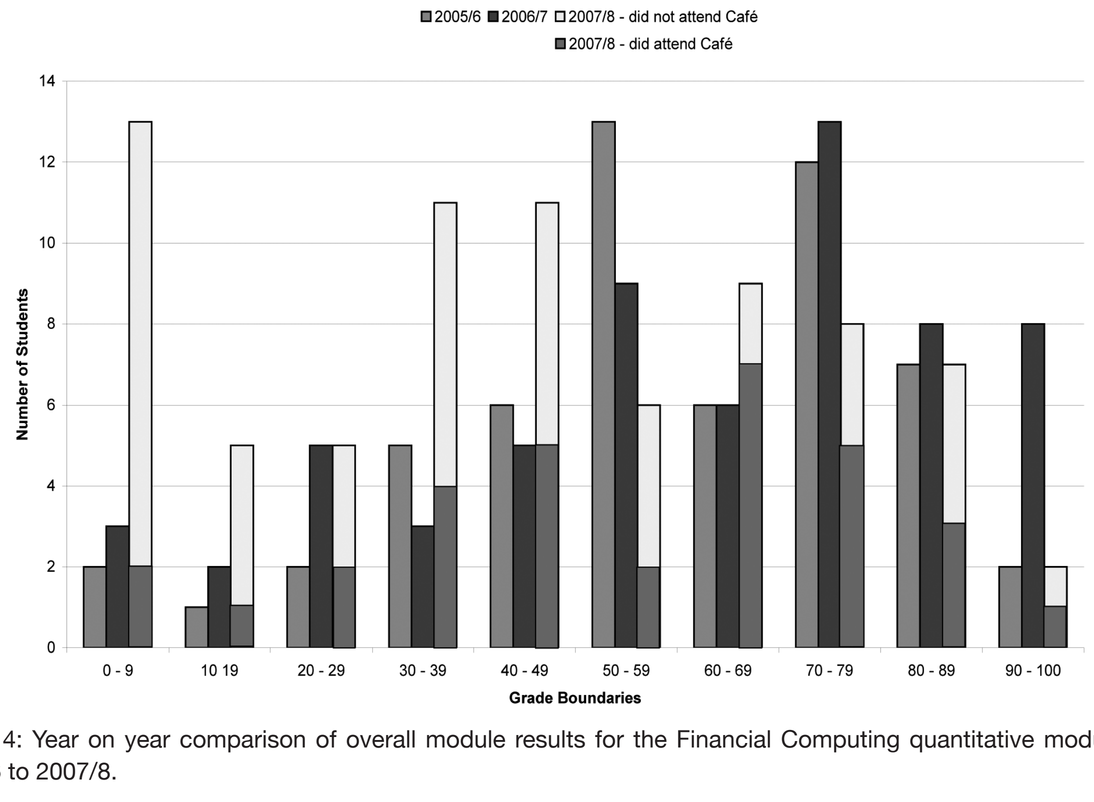


Figure 4: Year on year comparison of overall module results for the Financial Computing quantitative module from 2005/6 to 2007/8.

The results from the FC module are the most pertinent since 55% of students enrolled on this module attended the Café, which is much higher than any other group. For this group, the Café tutors advised students on completing their last assignment and helped them to prepare for the exam, which was worth only 40% of the overall module. Because both coursework and exam could have been affected by the Café, we consider their overall module marks here. From Figure 4 (previous page) it can be seen that 25 of the 34 students who failed (0% - 39%), had not attended the Café. This has (at least) two possible interpretations; either students at risk of failing who attended the Café managed to pass, or that "failing" students did not make use of the Café. What is interesting is that 7 out of the 9 students in the boundary 60% - 69% attended the Café, with a similar situation for the 70% - 79% grade boundary. Thus the Café appeared to attract stronger students who simply wanted to improve.

To establish possible effects of the Café on this cohort, a study was made of the cohorts for the two previous years. Their grade distributions are shown in Figure 4 and overall statistics are given in Table 2.

Academic Year	Number of students	Overall Module Statistics			Exam Statistics		
		Mean	St Dev.	Pass Rate	Mean	St Dev.	Pass Rate
2005/06	55	61%	19%	85%	52%	28%	66%
2006/07	62	62%	23%	81%	56%	32%	69%
2007/08	78	55%	23%	77%	43%	27%	56%

Table 2: Statistics for the Financial Computing quantitative module for academic years 2005/06 to 2007/08.

It is clear that the 2007/08 cohort did substantially worse that the previous two cohorts. We do not know if there are any confounding influences acting, such as a change in teaching, assessment or admissions policy (although the group did grow in number). Although we cannot isolate cause and effect, it is our opinion that these students knew they were poorly prepared for their assessments and sought help in the Café.

It is also difficult to draw any firm conclusions for the FoE, FoIT and EF courses from their subsequent maths exam performances since only 40 (of 137 students), 27 (of 113 students) and 46 (of 225 students) respectively attended the Café. However, what is apparent is that the majority of FoIT students that attended were the "at risk" since many still failed. A small proportion of students achieved a mark between 40% - 49% and so may have been 'saved'. This idea is supported to some extent by comparing the exam pass rates for the two previous years: 2005/06 32%, 2006/07 26% and 2007/08 46%. (N.B. (i) these are pass rates for the exam component, not the overall module marks. (ii) the foundation programmes, FoIT and FoE, attract students lacking the qualifications for direct entry into level 1 courses and hence have comparatively high failure rates in the foundation year). The corresponding FoE figures are: 2005/06 – 50%, 2006/07 – 33% and 2007/08 – 48%.

EF students that attended the Café achieved module marks spread from 20% - 79% with a similar pass rate to those that did not attend. It is noteworthy that the modal category for the whole cohort was 30% - 39%, indicating that a large proportion of students are in need of help. This is not surprising, given that GCSE mathematics only is required for entry and about half of the cohort have not studied mathematics beyond that level prior to university. One of the authors taught that group and the vast majority of the EF students that attended the Café were his students; hence this group achieving as well as those with A-level mathematics can be seen as a success, and may, in part, be due to the Café. However, a year-on-year comparison is not possible since marks from previous years were not made available.

4. Conclusions and Recommendations

On the basis of numbers attending and students' perceptions of the help given, the Café was very successful. Unfortunately, we cannot make such a strong claim on the basis of students' subsequent performances in their remaining coursework or exams. Isolating cause and effect is problematic, but there is some evidence that the

Café saved students from failure. Clearly, further evidence from future years will be needed for a proper study, although the effects of changes in student cohort, teaching and assessment will generally make comparisons open to challenges.

Despite this lack of hard evidence, the Café was very popular and much useful learning took place in a supportive environment. In short, there was a real buzz to the Café which everyone, including the tutors, enjoyed!

We recommend similar provision being available in other universities; indeed the idea has been taken up in at least two others, one with the modification that tutors are replaced by student mentors. The Café idea may also be applicable to other disciplines, e.g. statistics and programming. Proper funding is needed to cover the teaching, resources, advertising, setting up and evaluation costs.

Whilst there is a need to support students on an ongoing basis, it is our experience that additional support is especially needed during the crucial revision period. The Café provides an excellent vehicle for delivering it.

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Head Start Mathematics. Report on a programmme for adult learners of mathematics returning to higher education

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The Mathematics Learning Centre in the University of Limerick deals with large numbers of adult learners of mathematics. These students have different learning issues/requirements compared to traditional age learners who tend to be much more homogeneous as regards age, mathematical background and knowledge. 'Front-end' tutorials are organised and taught in the first two weeks of the academic year to help adult learners catch up on mathematics fundamentals they will need in their courses. The author has found that these students find it tremendously difficult to catch up *and* keep up with other studies at the same time. An intervention *before* they start their studies would be more beneficial and a lot less stressful. The author has been seconded to work with sigma to create a teaching and learning package consisting of a book of notes/manual that students and teachers of mathematics can take home and keep. This programme can then be taught to mature students in any third level institution over a period of a week *before* the students enter college. In this paper the author gives an account of her work with sigma and the resulting programme designed. Feedback from the students who participated on the course in August, 2008, is also provided.

1. Introduction

The Mathematics Learning Centre (MLC) provides support for all students participating in mathematics intensive courses at the University of Limerick (UL). A fully supervised drop-in centre opens for 20 hours a week, where students can attend and receive one-to-one attention with any mathematics queries they may have. In addition, support tutorials are provided on a weekly basis which run parallel to regular tutorials and cover the same material but at a slower, more student-led pace. Support tutorials are provided for adult learners and traditional age students separately as it is believed that adult learners have different learning issues/requirements compared to traditional age learners who tend to be much more homogeneous as regards age, mathematical background and knowledge. In addition to these support tutorials, 'Front-End' tutorials, directed mainly at adult learners of mathematics, are offered during the first two weeks of the first semester of the academic year in a bid to revise essential mathematics skills that students will need upon embarking on any mathematics intensive course. As manager of the MLC, the author has witnessed the fact that many adult learners find it tremendously difficult to revise these fundamentals, whilst attempting to keep abreast of new material simultaneously. In an attempt to alleviate some of this stress and anxiety, she believed it necessary to implement some form of intervention before these adult learners start their higher education. It was for this reason that the author and her colleagues at UL decided upon *Head Start Mathematics*.

In this paper, the author reports on the design of the resulting programme which has run at UL for the past two years. The paper will provide feedback from the students who participated on the course and recommendations for improvement. The author has been seconded to work with **sigma** to create a teaching and learning package for use by any individuals who wish to execute a similar type intervention in their own institution. Progress on this work will also be detailed. Finally, the author wanted to provide some empirical evidence on the efficacy of the course. Students' mathematical self-concept was measured before and after to investigate if the programme had any impact (positive or negative) on students who participated. Results from this study are detailed also.

2. Motivation behind Head Start Mathematics

Adult learners of mathematics present a welcome, significant and growing minority at UL. There were 474 adult learners registered in 2004/05. Currently (September, 2008) the number stands at approximately 600 which represents 8% of the student body. Adult Learners (or Mature students) are classified as students who are 23 years of age or over on the 1st of January on the year of enrolment. Adult learners do not always enter Irish third level education via traditional entry routes i.e. through the Central Applications Office (CAO) having completed the Irish school Leaving Certificate Examination. Many are accepted onto degree programmes via an interview process. Some have completed the Leaving Certificate examination, some have not. Most degree programmes in UL (with the exception of humanities) contain some mathematical element so most students will have to study mathematics to some extent for at least one semester in their 4 years of study. For many students, this presents an unwelcome and often unpleasant experience, particularly adult learners, many of whom have not studied mathematics in any academic sense for quite a number of years.

2.1. Aims, Objectives and Course Design

It was the author's intention to create a course which would ease the transition to third level education for adult learners who are intending starting or returning to college, by:

- revising essential mathematics skills they will need,
- revising essential study skills by being part of a lecture/tutorial group,
- meeting other Adult learners who are 'in the same boat',
- giving the learners an induction to life at third level before crowds of students arrive back i.e. lectures, tutorials, finding their way around campus etc.

The course content is based on the mathematics syllabus of the Access programme which runs at UL. The access course is a one year pre-degree programme offered by UL to mature students who wish to continue their studies and pursue a degree there. A number of places on certain degree programmes are reserved and offered to students who complete this course. The course covers a number of subjects, mathematics included, so the mathematics material and level was deemed appropriate for *Head Start Mathematics*. The topics chosen were: Number Systems (Natural Numbers and Integers followed by Rational Numbers), Algebra, Equations, Factorising, Graphing lines, Problem Solving, Quadratics and Other Special Functions, Logs and Indices. A set of hand written notes was provided to all students. The author is currently working with **sigma** to design a comprehensive set of notes/workbooks for *Head Start Mathematics*. (This project is near completion and the package will be available from **sigma** in June 2009 for use by anyone interested in implementing a similar type of intervention in their own institutions).

The programme was scheduled to run over a one week period. It was designed so that there would be a one hour lecture followed by a one hour workshop each morning and afternoon. The lecture was given by a teacher from the MLC and in each workshop there were 4 teachers who could circulate and provide students with one-to-one help for any queries they had. The final session on the Friday afternoon was reserved for a discussion with students on the programme and distribution of questionnaires. The course was advertised via the mature student office in UL and in three other regional third level institutions in the region. It was free of charge to participants. In August, 2007, 33 students from around the region took part and in 2008 it was held in UL (27 students) and in Tralee Institute of Technology (18 students).

3. Head Start Mathematics 2008

3.1 Student Profiles

22 males and 5 females took part in *Head Start Mathematics* in UL in August 2008. All were adult learners (i.e. over 23 years of age) and had been accepted on degree programmes either in UL and Mary Immaculate College of Education (also in Limerick), due to start on September 8th. There were no participants pursuing mathematics degrees. 23 out of 27 spoke English as a first language. 4 students had dropped out of school before completing the Leaving Certificate examination, 17 had completed the Leaving Certificate examination and 6 had other qualifications (diplomas or qualifications outside Ireland). The length of time since they had last studied mathematics varied greatly within the group. The breakdown is given in Table 1.

No. of years since last studied maths	N	%
< 3 years	1	4
3-5 years	8	30
6-10 years	12	44
11-20 years	3	11
> 20 years	3	11
Total	27	100

Table 1: Length of time since last studied mathematics

3.2 Mathematical Self-Concept

"Mathematical self-concept is defined as beliefs, feelings or attitudes regarding one's ability to understand or perform in situations involving mathematics" [1].

The author wanted to ascertain if participating in the *Head Start Mathematics* programme impacted (positively or negatively) on students' mathematical self-concept. Mathematical self-concept was chosen as it has been shown that there is a correlation between it and student achievement [2]. It was anticipated therefore that an improvement in students' mathematical self-concept would potentially lead to better performance in mathematics at third level. (While informal feedback was received from the 2007 cohort, their Mathematical Self-Concept was not measured).

A subset of Gourgey's Mathematical Self-Concept scale [1] was used in the study (see Table 2). This scale which consisted of 6 positively worded statements and 6 negatively worded statements was used by Miller-Reilly [3] to measure affective change in adult learners of mathematics in second chance courses in New Zealand. It was also used by Liston [2] on Service Mathematics undergraduates at UL to measure affective variables and their impact on mathematics performance so was deemed appropriate for this small scale study. The value of Cronbach's Alpha was calculated to ensure reliability of the scale. The value was 0.81 which indicated high reliability.

The participants were asked to indicate their level of agreement with the statements in the questionnaire on a scale of 1 to 5. The scores on the positive worded statements were as follows: 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree and 5 = Strongly Agree. The scoring on the negatively worded statements was reversed (i.e. if you strongly disagreed with a negatively worded statement you got a score of 5 etc.) The maximum score achievable therefore would be 60. The higher the score, the higher the students' mathematical self-concept. The students were given the scale at the start of the programme and again at the end of the week to see if there was a significant difference in students' mathematical self-concept.

In order to gain deeper insight into the students' concerns and anxieties about studying mathematics and also in an attempt to further measure the effectiveness of the course without giving a formal assessment, the students were given some open ended questions in addition to the mathematical self-concept scale. The students were asked to state any concerns or anxieties they had regarding the *Head Start Mathematics* course and their main concerns regarding mathematics in college. At the end of the course, they were asked to describe their experience of the week, what was most difficult about undertaking a course like this, to list the things they felt were good about *Head Start Mathematics* and possible ways in which they thought we could improve the course for subsequent years.

3.3 Results

Nine out of the 27 students had to leave early and were absent on the last session of the programme. Only students who completed the entire programme were considered for the analysis.

Paired sample t - tests were carried out to investigate if there was a difference in the mathematical self-concept of students before the *Head Start Mathematics* programme compared to after. Table 2 gives the mean scores of each question on the scale, before and after the course. 6 of the statements show an increase after the week although in only one instance (statement 1) was the difference significant. This could be because of the small sample size i.e. a larger sample showing the same trend might have given significant results.

	Pre Mean (SD)	Post Mean (SD)
1. It takes me much longer to understand mathematical concepts than the average person.	3.3 (.67)	3.7 (.57)*
2. If I can understand a maths problem, then it must be an easy one.	3.3 (.97)	3.5 (.79)
3. I don't ask questions in maths classes because mine sound so stupid.	3.7 (.96)	3.8 (.99)
4. I have never been able to think mathematically.	3.8 (.79)	3.7 (.89)
5. I don't have a good enough memory to learn maths.	3.9 (.54)	3.8 (.79)
6. Whenever I do a maths problem, I am sure that I have made a mistake.	3.4 (.98)	3.6 (.86)
7. I have never felt myself incapable of learning maths.	3.5 (.92)	3.4 (.98)
8. I have a good mind for maths.	3.3 (.77)	3.4 (.70)
9. I can understand maths better than most people.	2.6 (.70)	2.8 (.71)
10. I have no more trouble understanding maths than any other subject.	2.9 (.87)	2.9 (.99)
11. When I have difficulties with maths, I know I can handle them if I try.	3.8 (.62)	4.1 (.24)
12. When I do maths, I feel confident that I have done it correctly.	3.0 (.69)	2.9 (.80)

* Significant difference $p < 0.05$

Table 2: Pre and Post Mean Scores of Mathematical Self-Concept (N= 18)

Liston [2] measured the mathematical self-concept of approximately 600 undergraduate (91% traditional age, 9% adult) students in UL Service Mathematics courses to be 40.6 (SD=7.04) out of 60. The mathematical self-concept of the students in this study was measured at 40.7 (SD = 5.16) at the start of the programme which was surprisingly high. After the week it was measured at 41.8 (SD = 5.39). The difference was not significant. However the results suggest that the *Head Start Mathematics* course did not impact negatively on the students' mathematical self-concept.

3.4 Qualitative Feedback from Students

The students were invited to divulge their anxieties regarding the study of mathematics and were encouraged to give feedback on the *Head Start Mathematics* programme so as to help facilitators improve on the intervention for other years to come.

Some of the concerns voiced before the course began were:

- '(I have a) general fear not having done maths for a while'
- 'I'm nervous to be back in class with other people doing a subject I am very weak in.
- I'm worried that I will be unable to keep up'
- 'That I might not be able for it'
- '(I have)forgotten what I (have) learned in secondary school'

After the course, the comments were more positive, for example:

- "I made large progress with maths during this week'
- 'I feel more confident about maths having done this course'
- 'Definite improvement – performing a problem in steps rather than panicking at the sight of a problem'
- 'Very glad I did the head start course, shook off a lot of cob-webs'
- 'There was a lot to take in in one week but it was grand'
- A fantastic week. I learned a huge amount. Mind put at ease. It helped greatly in facing into September'

The following comments were very encouraging, displaying the fact that the aims of the course as outlined by the author had been achieved:

- 'It gave a chance to meet the mature students in my course'
- 'It was a gentle introduction to college life'
- 'The willingness of fellow students to help and advise was great'

As regards improving the course, the students gave some constructive feedback suggesting we provide answers to the questions given, provide guidance on the use of calculators and lengthen the sessions to provide more time to work on tasks.

4. Summary

This study endorses the *Head Start Mathematics* programme or similar type interventions for adult learners of mathematics. A statistical enquiry into the mathematical self-concept of students did not reveal any statistically significant improvements, possibly due in part to the small sample size involved. However, the feedback received from participants on the UL programme run in 2008 was enormously affirmative and made for a positive experience for all involved.

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DEWIS - a computer aided assessment system for mathematics and statistics

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Abstract

This paper describes DEWIS which is a web-based computer aided assessment (CAA) system specifically designed for the assessment of mathematics and statistics. The design and development of the system was motivated by difficulties encountered in using other CAA systems at the Department of Mathematics and Statistics at the University of the West of England. DEWIS provides a web based CAA system that allows for a wide range of question types (numerical, string, algebraic and selection). It is a robust and secure server-side system with extensive data collection and reporting, and uses programmed questions and programmed feedback. The system is designed to provide instantaneous marking but also contains a delayed-marking option.

1. Motivation

Web-based computer aided assessment (CAA) has been used widely for formative and summative assessments by the Department of Mathematics and Statistics at the University of the West of England (UWE) for over 10 years.

The most common web-based CAA system used for Mathematics at UWE has been QuestionMark Perception, in particular version 3 (QMP3). Using this system, a typical assessment comprises a set of questions. Two methods exist for setting an assessment, *random selection* and *random generation*, which are illustrated in Figure 1.

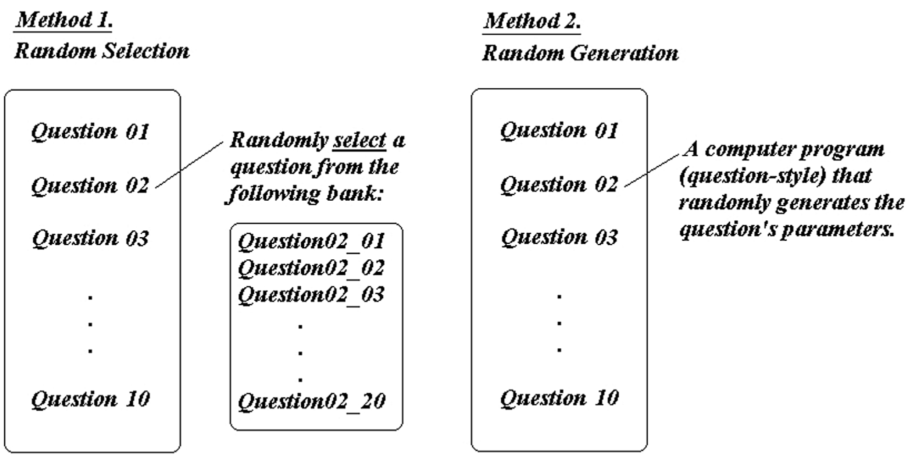

Figure 1: Schematic diagram of the random selection and random generation methods for creating an assessment with ten questions. The events shown occur when the student accesses the assessment.

The difference between the two methods lies in the mechanism for obtaining each question. In the random selection method, a question is selected at random from a bank of pre-prepared questions that are of the same *question-style*. These are questions which, for example, differ only in their numerical parameters. This is the standard approach with QMP3 and many other CAA systems.

At UWE, as at many other institutions, a significant collection of banks of questions have been created covering a diverse range of questions in Mathematics and Statistics. In addition, use has been made of the *Helping Engineers Learn Mathematics* (HELM) question banks [1]. Some disadvantages to this method are:

- It is time-consuming to create and test banks of questions. To create each question in the bank, a text file is manually created which contains the text of the question, the solutions and the marking scheme. There exists the possibility of errors in the creation of such files and making alterations to questions is time consuming.
- For a given question-style, the number of different questions is limited to the number of questions in the associated bank. This number is typically 20-30 questions and, therefore, if a student is allowed more than one attempt at the test, there is a chance that they get asked the same question.

In the random generation method, each question is associated with a question-style. In this method a question-style is a computer program which provides an algorithm for generating the numerical parameters for the question, as well as algorithms for obtaining the solution, to provide a marking scheme and to provide feedback based on the generated parameters. Each time a student attempts an assessment, the algorithm for each question-style is triggered to provide a question.

This method is not available in the standard QMP3 but is made possible by *Mathletics* [2,3] which is a system that runs as an add-on to the QMP3 system and provides a mechanism for random parameter generators within question-styles. The *Mathletics* system is the creation of Martin Greenhow (Brunel University).

The key advantages of this method over the random selection method are:

- For each question-style only one question file is required. Provided the programming is correct, there is a guarantee that the calculated solutions are correct.
- The marking and feedback algorithms are computer programs that treat the student's input as a variable within the programming environment. As such the system provides a mechanism for the tutor to:
  - » generate feedback specific to the student's input,
  - » mark the student's answer against questions that have non-unique solutions, such as a fraction.
  - » award continuation marks.
- The number of potential questions generated per question-style is typically large – limited only by the range of the question parameters.
- Questions can be reverse engineered to enforce, for example, integer solutions if required.

Mathletics is a suite of 1800 question-styles, where each one is a javascript program. On starting an assessment using the *Mathletics*/QMP3 combination, the web browser on the client (student's) computer runs the appropriate *Mathletics* javascript programs. Hence the question parameters supplied to the student are created *on the fly*, as are the correct solution(s) to the question(s).

When the student submits their answers, the javascript program marks their answers and provides the students with feedback based on the question parameters presented and the student's input. The javascript program passes the marks awarded for each question back to the QMP3 system.

Unfortunately, generating the question parameters on the client machine does have its disadvantages which are:

- QMP3 does not easily allow random question parameters generated by the client's machine to be passed back to the QMP3 server. Therefore, the tutor does not readily have access to the specific questions that the students were asked.
- The large overhead on the student's internet browser to download the question algorithms can result in significant time delays.

- Programs that run on client machines could potentially be modified by the student to provide a stand-alone algorithm to evaluate the solutions.

In 2005, QuestionMark launched version 4 (QMP4) and with it, withdrew the open coding facility. Having bought licences to QMP4 at UWE, and no longer having support for QMP3, we therefore lost the option to use Mathletics as a web-based CAA system.

This provided the motivation for creating DEWIS, which is a stand-alone web-based CAA system developed at UWE. The aim was to employ the random generation method which runs its algorithms on the web server, instead of the client computer, and which was not dependent upon third party software.

2. The DEWIS System

2.1. Introduction

The DEWIS system is a web-based CAA system that operates as a suite of Computer Gateway Interface (CGI) scripts that run on a web-server. A CGI script is a computer program that is called from an internet browser. However, unlike javascript files, CGI scripts are executed on the web-server and not on the client (student's) computer. The CGI script dynamically creates HTML output which is displayed on the client computer. Advantages of using server-based programming, over client-side (javascript) programming include:

- Significant reduction in the computing overhead on the client computer.
- Settings on the client computer do not affect the running of the CGI scripts.
- Improved security – the student cannot access the CGI scripts and hence has no access to the solution algorithm.
- Data collection – since the web-server generates the questions, solutions, feedback and marking scheme, it can store all this information in its own filespace.
- Continuation – if a student accidently or deliberately closes their browser they can continue the same assessment by logging back into the DEWIS system.
- Question parameters can be dependent on the attempt number.

In addition, the DEWIS system uses the random generation method, the advantages of which are listed in section 1.

2.2. Question Types

The DEWIS system supports a number of different question types. These include numerical input (integer and floating-point), multiple choice, multiple response, text input and algebraic input (string recognition and function evaluations). A given question can contain a mixture of such types. A selection of these different question types is available at the DEWIS web-site [4]. In all questions, the input by the student can be checked by the system for validity prior to submission of the answers. Hence, for example, the input of text where a numerical input is expected can be flagged to the student.

In this paper we present two questions (see Figures 2 and 3) which have been used to assess 1000 students studying Business Statistics at UWE and at Taylor's University College in Malaysia. The assessment appears to the student as a single static HTML file with no evidence that the parameters in the questions have been generated randomly. The size of this file on the client computer is less than 8 Kbytes. In these two figures we highlight which parameters have been generated randomly by the CGI script.

Question 1.

The number of errors discovered during an audit of 15 sets of invoices were as follows:

5	7	13	2	7	18	11	2	12	13	8	9	11	12	17

all values randomly generated

Calculate the following:

a) The mean (give your answer correct to <u>two</u> decimal places):

b) The median:

c) The standard deviation using the $n - 1$ divisor (give your answer correct to <u>two</u> decimal places):

d) The range:

Suppose that the number 21 is added to each value of the data in the series.
<u>Using only your answers to parts (a) and (c)</u>, calculate the following:

e) The new value of the mean (give your answer correct to <u>two</u> decimal places):

f) The new value of the standard deviation (give your answer correct to <u>two</u> decimal places):

Figure 2: Example of a data analysis question in DEWIS.

Question 2.

The following table contains details of all the activities involved in a marketing project.

randomly generated values

activity	preceding activities	estimated duration in weeks	no. of staff required per week
A	-	4	4
B	-	1	5
C	B	5	4
D	A,C	6	2
E	D	3	4
F	E	2	3
G	-	5	4
H	D,G	6	1
I	H	2	4
J	E	2	6
K	I,J	5	6
L	D	6	3

chosen as a function of student attempt number

- Ignoring any possible shortage of workers, calculate the minimum project duration.
- Calculate the critical path.
- Under the assumption that all tasks start at their earliest times, calculate the number of workers required during the busiest week.

The minimum project duration, in weeks, is :

The critical path is :

The number of workers required during the busiest week(s) is :

Figure 3: Example of a critical path analysis question in DEWIS.

Question 1 involves an analysis of a data-set and requires a mixture of integer and floating-point inputs. The fifteen data values in the data-set as well as the increment value for parts (e) and (f) are generated randomly by the system.

On the student submitting their answers, the "marking and reporting" CGI script is executed on the server. This CGI script immediately sends to the student's browser the results of the marking together with a link to the feedback. This feedback is specific to the questions the student was given and the answers the student supplied. An example of such feedback for Question 1 is given in Figure 4 (overleaf) in response to the student's answers of (a) 4.703 (b) 11 (c) 4.75394 (d) 15 (e) 25.7 and (f) 4.75. Normally, the feedback includes a copy of the original question but lack of space prevents us from showing this here. Figure 4 shows the flexibility of the system in marking floating-point answers required to a specific precision, and also displays the ability to award continuation marks in parts (e) and (f).

The DEWIS system provides a mechanism for the academic to choose the extent of feedback given to the student, ranging from extensive to simply supplying the solution and marks awarded.

Question 1.

The solutions are as follows (bracketed values show the values to higher precision):

Mean	9.80 (9.80000..)
Median	11
Standard Deviation	4.75 (4.75394..)
Range	16
New Mean	30.80
New Standard Deviation	4.75

computed from the solution algorithm

a) Your answer (4.703) for the mean is incorrect.

b) Your answer (11) for the median is correct.

c) Your answer (4.75394) for the standard deviation is not expressed to the required number of decimal places. However, your answer is numerically correct when it is evaluated to 2 decimal places.

d) Your answer (15) for the range is incorrect.

The marking for parts (e) and (f) will be using your answers to parts (a) and (c), respectively.

e) Your answer (25.7) for the new mean is not expressed to the required number of decimal places. However, your answer is numerically correct.

f) Your answer (4.75) for the new standard deviation is correct.

You scored 8 marks for this question.

Figure 4: Example of feedback for Question 1 in DEWIS.

Question 2 (Figure 3) considers a critical path analysis and requires both integer and text input as answers. The "preceding activities list" in this question is not generated randomly but selected based on the student's assessment attempt number. In this particular question-style, students experience an increasingly challenging question in subsequent attempts. The random generator in this example is programmed to create a question that has a unique critical path.

The feedback for this question is shown in Figure 5 in response to the student not supplying answers. Note that there is the option in the DEWIS system of feedback not being supplied if the question is not attempted. The feedback for this question is more extensive and also contains a link to a graphic of the activity network.

Question 2.

Following are the calculations of the earliest/latest start/finish times for each task, together with the floats:

Activity	Preceding Activities	Estimated Duration (weeks)	Staff (per week)	EST	EFT	LST	LFT	Float
A	-	4	4	0	4	2	6	2
B	-	1	5	0	1	0	1	0
C	B	5	4	1	6	1	6	0
D	A,C	6	2	6	12	6	12	0
E	D	3	4	12	15	15	18	3
F	E	2	3	15	17	23	25	8
G	-	5	4	0	5	7	12	7
H	D,G	6	1	12	18	12	18	0
I	H	2	4	18	20	18	20	0
J	E	2	6	15	17	18	20	3
K	I,J	5	6	20	25	20	25	0
L	D	6	3	12	18	19	25	7

computed from the solution algorithm

The network diagram for this project is available here (popup).

The activities on the critical path are determined by those activities that have zero float. From the above table we note, keeping to the order specified by the *preceding activities*, that the critical path is given by:
BCDHIK.

By summing the durations of the activities on the critical path, we obtain the minimum project duration:
1 + 5 + 6 + 6 + 2 + 5 = **25.**

Following is a table showing the number of workers required each week, under the assumption that all tasks start at their earliest start times.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
13	12	12	12	8	4	2	2	2	2	2	2	8	8	8	13	13	4	4	4	6	6	6	6	6

Thus, the number of people required for the busiest week is **13.**

a) You did not supply an answer for the minimum project duration.

b) You did not supply an answer for the critical path.

c) You did not supply an answer for the number of people on the busiest week.

You scored 0 marks for this question.

Figure 5: Example of feedback for Question 2 in DEWIS.

2.3. Additional Features

DEWIS has the following additional features:

- The student may access the feedback pages for all of their previous attempts. This is possible since the DEWIS file system contains all the data of every student attempt.
- The programming code for each question-style is kept separate from the programming code for the DEWIS system. This significantly reduces the programming complexity of the question-styles.
- The system employs a flag based marking scheme, whereby every answer inputted by a student is associated with a flag which is allocated an integer value during the marking. The function that allocates the marks awarded for different flag values is kept separate from the marking scheme and thus significantly simplifies the process of altering the allocation and weighting of marks for a particular question. This approach also facilitates delaying the awarding of marks if so required.
- An academic wanting to set up a DEWIS assessment using existing questions can do so without programming knowledge. All that is required is for them to select the question-styles from the catalogue and to decide on the marking scheme. This involves a straightforward edit of a text file.
- The DEWIS system has an extensive reporting mechanism for academics to track the progress of the assessment. Included in the reporter is information about every assessment attempt, containing the question parameters and corresponding solutions, the answers submitted and the result of the marking process. The reporter shows all marks awarded to a student and also highlights the maximum mark for each student over multiple attempts. All log-ins to the system are recorded, including the client machine's IP address. Instances of continuation runs are recorded as are detections by the system of attempted security breaches (which the system has been designed to withstand).

2.4. Results and Student Views

In the 2007-08 academic year, the DEWIS system was used to assess 120 students studying *Discrete Mathematics for Computing*. Each student was allowed a maximum of three attempts at the test. The students were asked to supply a critical review of the system and we are grateful for their valuable feedback. Examples of suggestions made were: to include a timer button on the assessment so that students do not need to keep account of time; to supply a confirmation box on submission of the test; to supply pop-up boxes that contain a "calculator" specific to the question – for example, a question on normal distribution can have a pop-up box that contains the normal distribution table. All of these suggestions and others were taken on board and incorporated into DEWIS.

In the 2008-09 academic year, the DEWIS system is being used in a number of modules at UWE involving, at level 1: Discrete Mathematics for Computing, Business Statistics, Calculus and, at level 2, Engineering Mathematics. In total more than 1000 students are registered to take assessments with the system with over 2500 assessment attempts to date. The system has proved to be extremely robust. Particularly noticeable is the almost complete absence of students requiring additional attempts due to problems with the client (student's) machine. This is attributed in part to the DEWIS system supporting the "continuation of attempt" feature. This is in sharp contrast to our previous experience with QMP3.

The reporter feature is popular with the academics. In the case of student queries about particular assessments, the academic can, through the reporter, view the actual question given to the student, their answers, the marks and feedback that were supplied. Some students took advantage to discuss their assessment attempts in *espressoMaths* [5] (UWE's Mathematics drop-in service) where tutors could refer to the reporter to assist them in helping the student.

2.5. Future Direction

Currently the DEWIS system has a relatively small number of question-styles. We are currently working on increasing this number and expanding the subject range. In collaboration with Martin Greenhow (Brunel University) we are investigating the feasibility of converting the *Mathletics* question-styles (written in javascript, running on the client machine) to be compatible with the DEWIS system (written in Perl, running on the web-server).

Another aim is to enable the setting of assessments and the creation of questions through a web-based interface. This interface would allow academics from outside UWE to:

- set assessments on the DEWIS system, including setting up their own student database for an assessment,
- select the DEWIS question-styles to be assessed from a catalogue of question-styles or, alternatively, write their own DEWIS question-styles which could be incorporated into the DEWIS catalogue,
- have full functionality of the reporter.

With this feature in place, members of the MSOR community would be able to use DEWIS for CAA at their institutions.

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Using R with Acrotex to generate unique self-marking problem sheets

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Abstract

This article outlines the potential to use freely available tools to produce unique (student specific) datasets to a common template along with corresponding self-marking worksheets. This has potential in terms of plagiarism where each student is required to complete essentially the same data analysis, but with subtly different numerical results. We also highlight the potential to use these worksheets to support the learning of concepts around sampling theory.

1. Outline

The R software [1] is now established as a major tool for statistical education as well as research. LaTeX is also very widely used in the Mathematics, Statistics and OR (MSOR) community and it can be noted that there is extensive support around R for the generation of LaTeX. One of the most remarkable tools in this regard is Sweave [2], which realises many of the ambitions set out by Knuth [3] in terms of "literate programming". In essence, it is possible to combine R code as well as LaTeX markup to create a "live" analysis document. There are R packages which make use of this functionality in a teaching context, such as `exams` [4] which can automatically generate exams with multiple choice as well as arithmetic questions and `ProfessR` [5] which can also help with the creation of randomly shuffled multiple choice questions drawn from question banks as well as assisting with their grading.

In this article, rather than drawing questions from a bank, we consider using R to generate a unique set of data for each student, along with a number of associated questions in a self-marking worksheet. Unique here is taken to mean that each dataset is a sample from the same population, and that it is envisaged that each student will complete the same learning tasks, but that the numerical results will vary slightly. The materials described here have been used within a final year multivariate methods course (mainstream Mathematics and Statistics module) as well as a post-graduate medical module dealing with critical appraisal. Both courses were taught at the University of Plymouth and feedback from both sets of students was collected during October and November 2008.

This article will outline the possible construction of a self marking worksheet in section 2 by briefly summarising the use of Sweave in section 2.1 and the use of a LaTeX package, Acrotex, in section 2.2 before giving a simple illustration (multiple choice assessment of the calculation of the sample mean) in section 2.3. Some thoughts on the use of these tools in a whole class setting is given in section 3 in relation to elements of sampling theory.

2. Student specific worksheets

Once a question template is available, the facility to randomly generate exercises in that general pattern is clearly useful. There is a wide variety of tools that can help with this. We consider here the potential to generate student specific datasets and corresponding self-marking problem sheets in a statistical context. We assume that we wish the student to carry out a data analysis and that either the student or the instructor will check the results. In order to do this, we make use of the Sweave facility within R to generate data and solutions, and the Acrotex package within LaTeX to create self-marking problem sheets.

2.1 Use of Sweave

`Sweave()` is an R function which reads in a source file, processes any R code within that file and produces a `.tex` file. This output file is a mixture of the original LaTeX in the source file and the output of the R code, either as instructions to include figures, additional LaTeX formatted results, or simple "verbatim" output from the R program. The output file can be simply processed by LaTeX. Within the source file, R code blocks are denoted with:

```
<<>>=
```

and the subsequent LaTeX section is denoted by:

```
@
```

This is a longstanding format, referred to as noweb [6], which was envisaged for "literate analysis" combining a document with the instructions required to perform an analysis. When working with R, it is conventional to give such source files the suffix `.Rnw`. Whilst choices of editors for working with LaTeX and R vary widely, some popular editors such as emacs [7] contain modes for these noweb files assist with feature syntax markup, chunk evaluation and so on.

When using the `Sweave()` function, the intervening R code is evaluated and processed as indicated within the file. For example, with opening tags `<<fig = TRUE>>=`, a plot is produced as both pdf and postscript, and the output .tex file contains an appropriate `\includegraphics` directive. Also, the R output can be hidden (`<<output=hide>>=`), printed verbatim (`<<output=verbatim>>=`) or the code chunk may contain R functions which generate LaTeX intended to be handled as such (`<<output=tex>>=`). In addition to such block output, it is also possible to contain scalars in-line in the LaTeX sections of the document within a `\Sexpr{}` construction (R code goes within the braces). More details are available within the Sweave manual, but clearly this is a powerful tool for a wide variety of applications.

2.2 Use of Acrotex

Acrotex is an extremely powerful LaTeX package written by David Story and available from the Comprehensive Tex Archive Network (CTAN) or from its own website [8]. Applications of this package have been considered in MSOR Connections [9]. It provides the ability to make interactive pdf documents given some LaTeX markup. Internally this happens by means of javascript. Javascript knowledge is not needed in any way by the LaTeX author, but it does mean that, at the time of writing, only Adobe Reader can render the interactive pdfs correctly.

2.3 Illustration

In terms of generating a unique dataset for each student, one could anticipate producing a synthetic dataset by randomly generating data to a pre-determined pattern. Alternatively, as per the Dynamic Resources Using Interesting Datasets (DRUID) project of the Royal Statistical Society Centre for Statistical Education, one could use carefully constructed random samples from a real dataset.

In order to illustrate this application, we shall sub-sample from a real dataset. The following code snippet is from a Sweave document which loads the `MASS` package [10] and randomly samples 50 rows from a 114 row dataset concerning beaver body temperatures (`beav1`). These data are written to a csv file for subsequent use by a student. By repeatedly applying this step, for example by re-running the source file through Sweave and LaTeXing, different samples are drawn and matched pairs of datasets and solution sheets generated.

```
<<GenData, fig = FALSE, echo = FALSE, results = hide>>=
library(MASS)
data(beav1)
idx <- sample(c(1:114), 50)
MyData <- beav1[idx,]
write.csv(MyData, "mydata.csv")

@
```

R can be used to carry out any necessary calculations on the retained data (`MyData`), such as calculating the sample means, and hence is used to help construct the answers environment within Acrotex.

Whilst numeric input is possible, we shall illustrate the construction of multiple choice questions. Clearly it is also necessary to randomise the order of answers from student to student. To achieve this, a marking vector markmu has been created, which has elements 1 for the correct answer and 0 for the wrong answer. The appropriate element of this vector is concatenated with \Ans to give the Acrotex commands `\Ans1` for a correct answer and `\Ans0` for an incorrect answer. A corresponding vector of possible answers will also be created called `answersmu`, this contains the correct answer in the same position as the 1 in the `markmu` vector. In order to randomise the order in which the answers are presented to the student, an indexing vector random is randomly drawn from the integers 1, ... , 4.

```
\begin{questions}
\item What is the sample mean for the body temperature in \emph{your} data?
\begin{answers}[samplemean]{4}
\Ans\Sexpr{marksmu[random[1]]} \Sexpr{answersmu[random[1]]} &
\Ans\Sexpr{marksmu[random[2]]} \Sexpr{answersmu[random[2]]} &
\Ans\Sexpr{marksmu[random[3]]} \Sexpr{answersmu[random[3]]} &
\Ans\Sexpr{marksmu[random[4]]} \Sexpr{answersmu[random[4]]}
\end{answers}
```

In the snippet above, `random[1]` selects the integer in the first position of this shuffled vector. Therefore, `marksmu[random[1]]` and `answersmu[randommu[1]]` select the corresponding entries in the marking vector and the answer vector. After the source file has been processed through `Sweave()`, the resultant `tex` file may look like:

```
\item What is the sample mean for the body temperature in \emph{your} data?
\begin{answers}[samplemean]{4}
\Ans0 42.48 &
\Ans1 36.82 &
\Ans0 20.5
\Ans0 0.54
\end{answers}
```

although the ordering of the correct and incorrect answers will vary each time the source file is "Sweaved" in R. The correct answer will also vary according to the data provided to the student.

In this example, the question is contained within the quiz environment in Acrotex, Figure 1 provides a screenshot of the question generated by this code snippet. Here, the pdf has been arranged to provide instant feedback.

It is also possible to make students complete and email results (as a .fdf file) to the instructor, see the Acrotex documentation for further details.

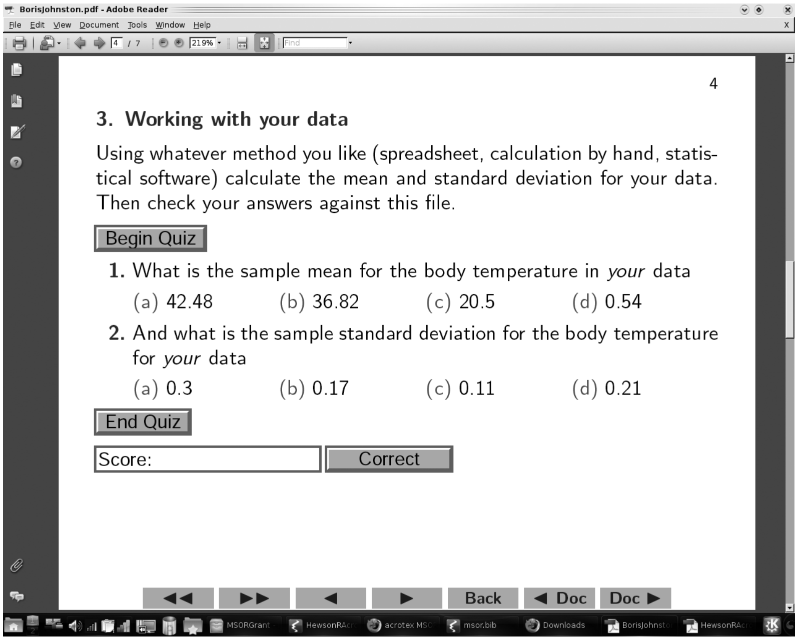

Figure 1: Screenshot of interactive pdf generated to offer multiple choice assessment on calculation of mean

In order to generate a test for each student, all that remains is to write a short script that will run the `.Rnw` file through R sufficient times to generate the required number of datasets and worksheets, and to rename these appropriately. This can be done in any number of scripting languages, one example is shown below using R, where the class list has been contained in a csv file containing the students' first name (`Forename`) and surname (`Familyname`). This script processes a template file `myex.Rnw`, runs pdflatex on the output three times (necessary for Acrotex), and then uses the unix command `cp` to rename both the data file and the pdf after the student before creating the next pair of files.

```
classnames <- read.csv(names.csv)
namelist <- paste(classnames$Forename,
 classnames$Familyname, sep = "")
for (i in 1:length(namelist)){
 Sweave("myex.Rnw")
 system("pdflatex myex")
 system("pdflatex myex")
 system("pdflatex myex")
eval(parse(text = paste("system(\"cp mydata.csv ", namelist[i], ".csv\")",
sep= "")))
eval(parse(text = paste("system(\"cp mydata.pdf ", namelist[i], ".pdf\")",
sep= "")))
}
```

3. Evaluation

Based on the two classes in which these tools have been used, it certainly appears that interactive pdfs are as popular as any other approach to learning the more mechanical aspects of data analysis:

> *"Able to repeat it and digest the contents. The game and quiz like feel."*

> *"Interactive stuff helps with the understanding of the material."*

Hopefully the potential for this kind of approach to generating learning objects while mitigating the risk of plagiarism is clear. We therefore consider another aspect of these tools. Schwarz provides a review of electronic resources that deserves careful reading for anyone interested in computer aided learning [11]. Specifically, in the context of sampling distributions he suggests that it may be useful to "step (a little) back from the computer and engage the entire class". It is in precisely this situation where these learner specific data and solution files may be useful. Whether using simulated or sampled data, each learner is working form the same population. Once engaged with the mechanics of summary statistics (means, odds ratios, confidence intervals) the end result is a class full of students with unique sample estimates from the same population. As suggested, the most "low tech" method of collation was used, i.e. dots and lines on a whiteboard for the point and interval estimates were used to illustrate the underlying concept. Because of the link with assessment, feedback such as:

> *"Interactive worksheets were excellent and gave a good practice for the test."*

was typical, and highlighted the focus on mechanical aspects. But bearing in mind that these were used on postgraduate courses aimed at healthcare professionals who has seen this before, there was some evidence that the collation of individual sample results was valued:

> *"I have found these the most instructive way of learning this and I even think for the first time ever I might just have got to grips with this subject."*

Despite the limitations of this evaluation, this work takes place in an environment where the mechanical aspects can be self-marked and the instructor can concentrate on key concepts. It is suggested that topics in sampling theory can indeed be well covered by pooling results from a set of samples.

4. Conclusion

Given that R and LaTeX skills are relatively widespread in the MSOR community, this approach is accessible to many. Tools within both systems (Sweave and Acrotex) provide a convenient mechanism for the generation of unique student specific data sets and self-marking problem sheets. This has potential for mitigating plagiarism, but also deeper learning in areas such as sample theory. If one agrees that more effort in learning should be directed towards concepts and less to the mechanics of data analysis [12], these worksheets provide a useful resource to aid in that effort.

5. Acknowledgements

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Developing numeracy in criminology students through crime data

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Abstract

Criminology students at Lancaster, as elsewhere, do not expect quantitative ideas to play a role in their undergraduate degree. Many have poor mathematical skills and have difficulty with the interpretation of data in numerical form. In parallel with this, the Economic and Social Research Council has recognised that many social science undergraduates are not exposed to mathematics and statistics in their degree courses, and this will lead to a lack of quantitative social science researchers for the future. The Council are thus funding the development of innovative undergraduate courses to tackle this problem.

This paper describes the characteristics of an innovative course in criminology "Measuring Crime" which introduces second-year students to basic concepts of numeracy, graphics and reading and understanding tables, as well as the various sources of crime data and their similarities and contradictions. It introduces students to the idea of crime data as quantitative information rather than case studies or interviews. It encourages students to plot data and to understand and question the source of commonly voiced research statements. Statistical concepts such as trend lines are also introduced quietly through graphics. Although a shock for many students, the course is in general well received.

1. Introduction

Studying statistics is not traditionally popular within social sciences. Students often choose academic routes which deliberately avoid anything numerical, while others are numerically competent but dislike anything quantitative. However, there is an increasing move to ensure that all students develop the skills of dealing both with number and with data. Adrian Smith's report "Making Mathematics Count" [1] recommended that all post-14 students should acquire skills in numeracy. Some university disciplines indeed need little in the way of numerical skills, and numeracy training would be for them an acquisition of life skills in topics such as spreadsheets and tax calculations. However, most social science disciplines use quantitative methods, and such students will need exposure to the ideas of gaining knowledge through data exploration and handling.

The Economic and Social Research Council (ESRC) has two specific concerns about the lack of engagement with social science methods. The first relates to demographics. The Commission on the Social Sciences reported a deficit of quantitative skills in UK social science [2] and this was echoed by a 2005 report from the Higher Education Funding Council for England [3]. Both reports fed in to a comprehensive review by the ESRC on the demographic review of the UK social sciences [4] which was published in 2006, and concluded that

> *"Quantitative social science is a particular concern to the ESRC, as supply is seen as insufficient, particularly as this subject underpins other disciplines. As the report implies, there are two different issues to be explored. One is the survival of quantitative disciplines like Social Statistics and Demography, given the decreasing numbers of students choosing to study these disciplines at undergraduate and postgraduate level. The other is the supply of*

> *staff with advanced quantitative skills across the social sciences more generally, be it in Social Policy, Sociology, Politics or Geography."*

The shortage of staff in UK social science research is a major concern for the health of social science generally. The second concern is academic. There are a large number of papers published every year with quantitative social science analyses, originating mainly from countries such as the United States and the Netherlands, and there is an increasing recognition that properly trained social scientists need to engage with *all* the literature, and not just the literature they feel able to approach.

The ESRC response is to develop a life course approach to developing quantitative skills, with, unusually for a research council, initiatives taking place in schools and at the undergraduate level, with the aim of improving the supply of quantitatively literate social scientists for later postgraduate study. There has also been a recognition that research methods courses are often taught by staff hostile to quantitative methods; and also a reappraisal about what quantitative methods can contribute to social science by groups that are traditionally hostile. For example, Oakley [5] identified the hostility against quantitative methods and stated:

> *"…the most sustained war on the quantitative paradigm was undoubtedly waged by feminist social scientists, who, from the early 1970s on, identified pervasive masculine biases across the different disciplinary traditions of social science."*

She identifies good aspects in both qualitative and quantitative methods, and suggests that it is time to move on from the dialectics of the earlier debate.

2. Criminology and quantitative methods

Quantitative methods are used extensively in criminology, yet few UK criminology courses teach any form of quantitative methods – so research posts in the Home Office tend to be filled by psychologists rather than criminologists.

Our approach has been to design a course which will counter the hostility to and avoidance of numbers and data. The programme allows students access to crime datasets and the debates surrounding them, but in such a way that students who are nervous of statistics are not put off. The course, a half unit (10 week) course, given in the second term of the second year, follows on from a traditional course in research methods that runs in the first term of the second year. The 'Measuring Crime' course aims to:

- Revise basic ideas of numeracy – percentages, proportions.
- Begin to use spreadsheet software.
- Provide skills that allow students to turn numerical data into graphs.
- Provide skills that allow students to produce well labelled and informative graphs.
- Get students to think about trends and how to interpret them.
- Get students to think about relationships between phenomena and within datasets.

The course structure includes formal lectures (to cover concepts of how and why crime is measured); lab computer sessions to develop data handling skills and interpretation of crime data; and assessment is through worksheets, one essay plus an exam. The overall aim of the lectures is to allow students to assess the strengths and weaknesses of various sources of crime data and to make effective comparisons between these sources. The lectures cover issues surrounding the reliability and validity of (victim and offender) sample surveys, as well as providing a framework within which to critique the main sources of quantitative crime data e.g. the British Crime Survey, police recorded crime, court statistics, the Offending Crime and Justice Survey. This involves discussing the methodology of the self-report surveys. In addition students are provided with an explanation of how offences are dealt with at various stages of the Criminal Justice System. This provides an understanding of why some crimes are included in police recorded crime figures and some are not, and why some receive a sanction and some do not. In doing so, students understand why it is necessary to be cautious when comparing, for example, police recorded crime figures with court statistics. Other topics covered in the lectures include prediction and risk using quantitative crime data, and methods of evaluation (of crime reduction programmes) using quantitative data. The practical work includes the use of real datasets (e.g. British Crime Survey, Offenders Index & Criminal Statistics drawn from the courts) and we show that they are real by getting students to access them from official websites. Practical sessions include use of Excel and SPSS but no formal statistics.

A major component of the course is to get students to think about issues of measurement. The course begins with a seminar where students are asked to consider how they might estimate the number of robberies in Lancaster in the last year. The aim of the discussion is to introduce the students to the idea that there is no one source of data which can measure the totality of crime. Police recorded statistics miss out the individuals who do not report; crime surveys will not have sufficient numbers of respondents in Lancaster; and insurance data will also be unreliable. The discussion of the various data sources and their strengths and weaknesses leads to a discussion of why police recorded crime and the British Crime survey (a victimisation survey) have shown changing trends over time in recent years.

3. The practical component of the course

We highlight two aspects of the practical work which challenge the student to think about data and information in a critical way.

3.1 100 years of homicide

Students are asked to download the dataset "100 years of crime" [6] from the Home Office Website.

The coursework changes every year, but each year students are asked to compare the trends for two different offences, and to use Excel to graph these trends. For example, in 2008 students had to graph the yearly number of homicides in England and Wales since 1899 to the latest year. They were also asked to do the same with "attempted homicide" and to compare the two graphs (Figure 1).

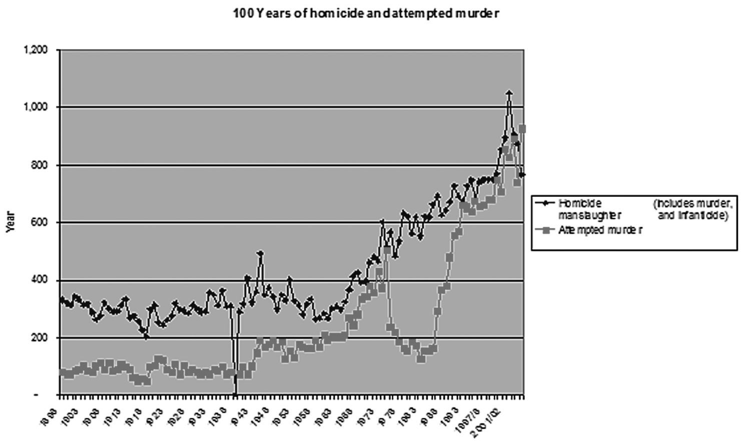

Figure 1: 100 years of recorded homicide and attempted murder

The first issue they confronted was definitional – they needed to understand what the word "homicide" means in criminology, and to understand the distinction between murder, manslaughter and infanticide. They were then asked to describe the trend lines. Most students identified the relatively flat trend line up to 1960, and contrast that with increasing numbers after 1960. Some students were able to delve more deeply and identify volatility during the two world wars and declining trends following the wars. Some also identified the 2001 peak as being related to the Shipman homicides. Most however did not appreciate that data was missing in 1939, and report instead that there were no homicides at all in that year. This leads into a discussion of data and interpretation, the need to read carefully the documentation relating to the collection of the data, and which killings are recorded as homicide and which not.

More complex question can then be addressed. What for example does it mean that more homicides are recorded in the 21st Century compared to the late 1800s? Why does the direction of the attempted murder trend line differ from the homicide trend line between the early 1970s and late 1980s? Would this be an artefact of measurement, or does this reflect changes in behaviour?

3.2 Verifying criminal facts

Students are encouraged to question crime "facts" by engaging in numerical detective work. We take the example of domestic violence.

Some facts about domestic violence

- One in four women will experience domestic violence at some time in their lives.
- Two women are killed by their partner or former partner every week.
- A woman is raped, stabbed or beaten every six seconds.
- There are more animal sanctuaries in Britain than refuges for women fleeing domestic violence.

Figure 2: Four statements about domestic violence – can they be verified?

Figure 2 represents four facts often used on domestic violence websites. Can we identify where such statements come from? By investigating data sources and Home Office reports, we can show that the first uses the British Crime Survey, the second the Homicide Index, the third a London survey of calls logged to Police stations in London. The fourth statement has so far not been verified.

4. Feedback and Evaluation

Now that the course has been running for a number of years (the first course ran in 2005), students are almost all positive about the course. The average number of students on the course is about 60 and each year the module evaluation returns similar findings. On the whole the students find the course intellectually stimulating. In fact, in the module evaluation for the 2009 course, 67% of respondents rated the course as 'Very Good' or 'Good' and 80% of respondents said that they either 'Strongly Agreed' or 'Agreed' that they had learnt a lot from the course. When asked to identify which parts of the course are found to be most valuable, students consistently identify two areas in particular.

Firstly, students remark on the practical skills they develop in the computer workshops. They appreciate the fact that not only do they learn how to use Excel and SPSS, but that more generally they become more proficient with computers. Students recognise the benefits that these transferable skills will give them in their academic pursuits as well as in the job market. As one student remarks:

> *The module has taught me how to use the Excel package and has enabled me to become more confident with computers.* (2008 student)

Secondly, students identify as valuable the development of their criminological skills and their ability to critically analyse crime data by thinking about crime in a different way. That is, they learn to appreciate that both legal and *ad hominem* definitions of crime and particular criminal acts are not constant and universally understood. In turn, they improve their understanding of criminological statistics and what they really mean. Students finish the course feeling that they have the practical and intellectual skills to offer a competent critique of any literature or comment relating to crime data:

> *I loved that we were genuinely building skills in proper statistical applications; it really felt like "doing" criminology. It was also interesting to see criminality calculated in such a quantitative way, especially in terms of prediction.* (2009 student)

In giving their feedback students often remark on their initial resistance to working with quantitative information and new technology. In addition, many students remark on how challenging they find the course, and how the content of both the lectures and (in particular) the computer workshops at first seems daunting but as the course progresses they begin to appreciate the value of these sessions and many come to really enjoy the learning experience.

There are always a small number of students who struggle to get to grips with computer technology, and some (not necessarily the same students) who struggle with the academic challenges that the course presents. We are aware of the needs and concerns of our students and provide appropriate support. Consequently, those students that do find the material and tasks difficult to tackle still make progress in these areas and this is reflected in their feedback:

> *Gaining experience with computer software was challenging, however I now have the confidence to tackle it on my own.* (2006 student)

When developing the course an area of concern was to ensure that the links between the lectures and the workshops were made clear and that the course was seen as a coherent whole. For example, one of the lectures on the course discusses the social processes that lead to crimes being recorded (or not being recorded) by the police. The associated workshop gets students to investigate crime figures in one particular year and encourages them to think about why more crimes are committed than are prosecuted and why at each stage of the Criminal Justice System (e.g. crimes reported to the police, crimes recorded by the police, offences heard in court, etc.) these figures gradually reduce. Each year students comment that they are appreciative of these connections. We feel this is important as it means that students are more likely to engage with the workshops and will get more from each component part of the course.

In summary, each year the feedback from students makes clear that they understand how the skills picked up in this course provide them with the basic building blocks that assist their overall academic and working performance. The work that is produced by the students shows that not only are they capable of working with quantitative data and understanding quantitative criminology but, with the correct approach to teaching and learning, many of them are extremely competent. The feedback the course receives provides convincing evidence that for many students the barriers to obtaining quantitative social science skills are perceived and not real. In other words, students often feel that taking a quantitative route is something that they are not cut out for but when they are faced with the challenges of such a course they realise their own abilities and potential.

5. Conclusions

Throughout, we try to focus on substantive areas of criminology that students find interesting, rather than teaching statistical techniques in isolation from the context of study. We want students to think critically and constructively about the data and apply what they know from criminology to make sense of it.

One of the major aims of the course is to develop students' capacity to critically evaluate crime knowledge by being able to understand and read official information, to interpret data intelligently and apply what they know about criminology to draw useful inferences. Students start the course nervously but most engage positively and successfully with the course (hence, it is important that it is a compulsory module), and feedback has been encouragingly positive in spite of the challenges this course presents to students.

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Views of engineering students on the use of electronic voting systems in mathematics

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Abstract

Some of the concerns that have been expressed about university education in the UK include large classes with attendant low student-to-staff interaction, student passivity and non-responsiveness in class, low student motivation and participation rates, and pedantic teaching style. To address these concerns, some academic staff members at Loughborough University began using electronic voting systems (EVS) in the 2007/2008 academic year to teach Mathematics to undergraduate Engineering students. This study was designed to investigate the views of affected students about the use of EVS in Mathematics classes, and to probe the impact of their use on student in-class participation rates. The findings show that 80% of students have favourable perceptions of the usefulness of EVS. The results also show that compared to standard student response solicitation methods, EVS use promotes higher student in-class participation rates. However, students expressed concerns about technical and other issues associated with EVS use. The contributions of this research include focus on EVS use in the formative assessment mode, an empirical study of the impact of EVS use on student participation rates, and the impact of EVS drawbacks on perceived usefulness.

1. Introduction

In this section, the background for the current study and the literature review are presented.

1.1 Background

Across university campuses in the UK and elsewhere around the world, academic staff share similar concerns about the nature of contemporary student teaching and learning. These concerns include the fact that classes are bigger, with sometimes upwards of 100 students; students seem distracted and unmotivated in class, and for subjects like Mathematics which can sometimes be abstract, student passivity is perceived to be high. The larger class sizes have made it easier for students to become 'anonymous', and it is a challenge for most students to participate in class by, for instance, responding verbally to a question. In a bid to address some of these concerns, a number of student-focused learning approaches including Peer Instruction [1], Just-in-time Teaching [2], and Classwide Discussion [3] are being implemented. At the heart of these learning approaches is often a technology known as electronic voting systems (EVS), classroom communication systems, student response systems or simply, handsets (US: clickers).

EVS is a technology that affords a lecturer the means to give students, even in a large class, the chance to engage with course material by having them answer questions in class - with immediate feedback provided. At the Mathematics Education Centre (MEC) at Loughborough University, TurningPoint EVS [4] supplied the EVS systems being used by staff, with the enabling TurningPoint (TP) software embedded in Microsoft PowerPoint. So a lecturer can prepare multiple choice questions (MCQ's) as a series of PowerPoint slides for, for example, formative assessment purposes. The students respond by clicking the corresponding alphanumeric answer choice on their EVS handsets (Figure 1). Student responses are then displayed on the PowerPoint slide in the form of a suitable chart (Figure 2). The lecturer may then decide to elaborate on any relevant issues arising out of the question-and-answer display session. For instance, a lecturer should address why options (1) and (2) in Figure 2, which nearly 45% of the students in a class had selected as the correct option, are in fact incorrect.

Figure 1: Students using TurningPoint (EVS) handsets to register their responses to a question in class. (Used with permission of Turning Technologies.)

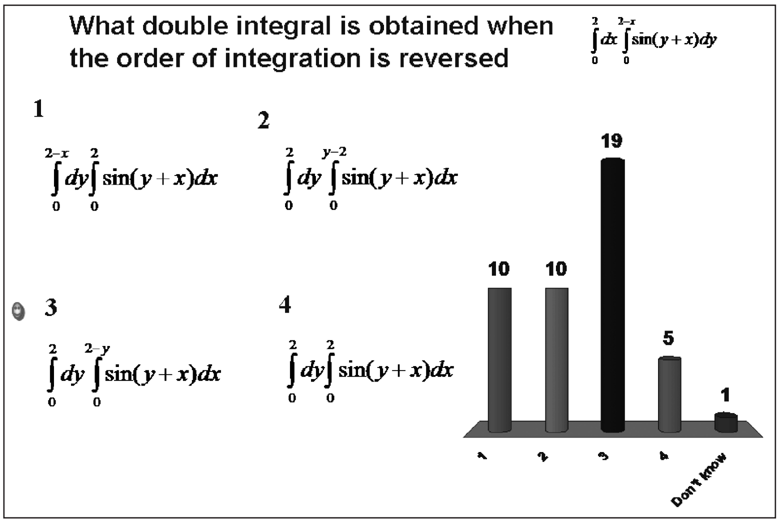

Figure 2: Chart showing student response to a question on integration – with two of the options (1 and 2) representing common student misconceptions about double integrals

This study is about the use of EVS by MEC staff in teaching Mathematics to undergraduate Engineering students. There are two research objectives for this study:

1. To obtain student views about the usefulness (or otherwise) and impact of EVS use on learning.
2. To probe the impact of EVS use on student engagement (as measured by in-class student participation rates).

1.2 Literature Review

Publications focussing on student perceptions of EVS use include Zhu [5], which was based on a study of the use of EVS at the University of Michigan. In contrast to the Simpson and Oliver study [6], Zhu identified seven ways in which faculty use EVS and also proffered a list of 14 recommendations on how to use EVS. The MacGeorge et al. [7] study on the other hand adopted a "multi-survey" design that tracked student responses over the course of a semester while the effect of student diversity on perceptions of handset use was also measured. The authors also stressed that the impact of instructor approach to the use of EVS requires further research. Similarly, Kaleta & Joosten [8] sought to measure student attitudes as well as the impact of handset use on grades and retention at the University of Wisconsin. The reported findings are consistent with those reported elsewhere in that student attitudes were generally positive, with slight improvements in grades and reductions in retention.

Papers with specific focus on the use of EVS in mathematics include McCabe, Heal & White [9], Lomen & Robinson [10], and Cline, Zullo & Parker [11] in which the authors describe the use of coloured cards to stimulate engagement and 'peer discussion' in their classes and then contrast this approach with the greater functionality afforded by the use of EVS. Further, electronic resources with comprehensive information on the use of EVS include the Vanderbilt University portal [12] and the repository created by Draper [13] of Glasgow University.

2. Methodology

This section describes the methodology adopted in the design and execution of this study.

2.1 Sample

One hundred and forty-five second-year undergraduate students (out of a total class size of 250 students) studying Automotive, Aeronautical and Mechanical Engineering participated in this study. These students were chosen because they are a group of students who have been taught Mathematics with the aid of EVS. These 145 students (representing 58% of the total student population of 250 students in engineering mathematics classes being taught using EVS) completed a main questionnaire on the use of EVS. In addition, 120 students, drawn from the same 250 students, completed a one-minute questionnaire (see section 2.2). (Some of these 120 students were also part of the cohort of 145 students who completed the main questionnaire). Both questionnaires were administered in the first semester of the 2007/2008 UK academic year.

2.2 Methods

This study adopted the mixed-methods research protocol, which consists of the following methods:

2.2.1 Main Questionnaire: 145 students completed a detailed, 13-item questionnaire which was created using the service provided by Bristol University [14]. The data presented in this study is based on student responses to this questionnaire, supplemented with data from observations, a one-minute questionnaire and informal feedback. This questionnaire was piloted with 35 students (drawn from the base class of 250 students) before the final version, which incorporated feedback from the trial version, was administered to the cohort of 145 students cited above.

2.2.2 One-Minute Questionnaire (OMQ): Based on the one-minute paper concept, Angelo & Cross [15], this questionnaire was administered to students with one purpose in mind: To get them to list what they perceived to be the pros and cons of handset usage. Further, students were given less than 120 seconds to complete the open-ended questionnaire, so as to get them to write down the issues that were uppermost in their minds, without giving it too much thought.

2.2.3 Observations: One of the authors sat in on classes and observed the influence or otherwise of the use of EVS on teaching and learning in the classes where EVS was being used. The observations were initially open-ended, with the aim of going into classes simply to learn, and record observations; and therefore not pre-empting findings or introducing preconceptions about handset use into the observation process. From the initial open observations, the author was able to collect data that informed later class observations. So subsequent observations included watching out for the quantity, time and purpose of the questions used, student response and/or enthusiasm, TP equipment setup and functionality.

2.2.4 Informal Feedback: There were informal discussions with individuals and groups of students, usually after classes where EVS had been used, soliciting their opinions on the benefits or otherwise of handset usage. For instance, a common question students were asked during the informal exchanges is, What's your opinion on the use of EVS in lectures?

3. Results, Analysis and Discussion

The analysis of the data from the main questionnaire is presented in this section. The data from the OMQ, class observations and informal feedback from students are not included in this article due to space constraints.

3.1 EVS Usefulness

In response to a question on how useful students found the EVS, 57.9% of students said they found EVS 'useful' while 22.8% found them 'very useful' (Figure 3). So 80.7% or 4 out of 5 students found the EVS generally useful. Only 4.8% of students found the EVS either 'not at all useful' or 'not very useful'. However, 14.5% of the respondents responded to this question by selecting the 'neutral' option provided.

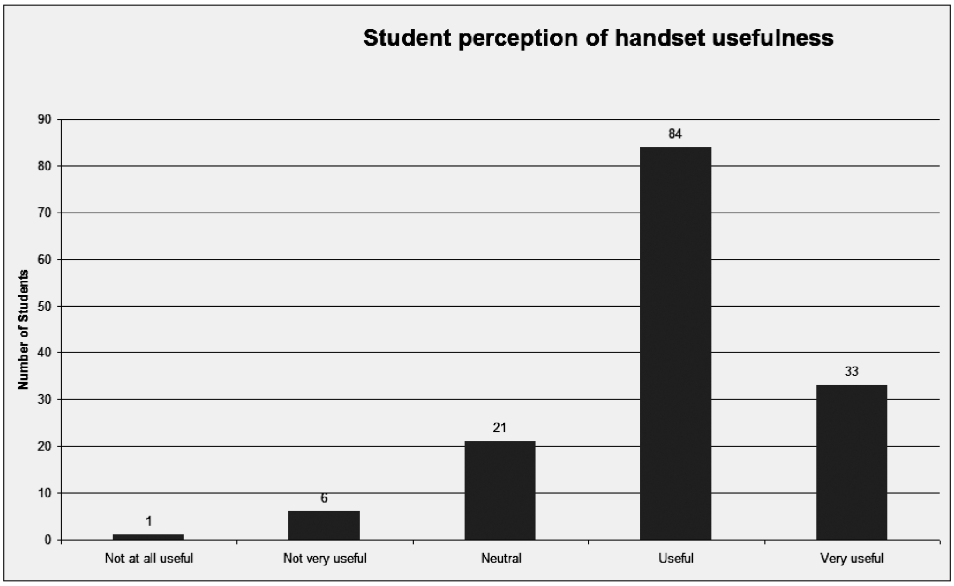

Figure 3: 80% of students said EVS (i.e. handsets) is 'useful' or 'very useful'

3.2 Impact of EVS on Participation Rates

To evaluate whether EVS use had significant advantages over other methods that are usually used to solicit student response in class, students were asked to specify how likely they were to respond when EVS is used compared to **raising of hands** or giving a **verbal response**, with 0% representing no response at all, and 76-100% representing maximum response rate (Figure 4 overleaf). By focusing on the maximum response rate possible (i.e. the 76-100% column), it is evident that the use of EVS, compared to the other two methods, clearly has a much greater effect on the likelihood of students responding to a question in class.

3.3 EVS Drawbacks

Responses to a main questionnaire item on the perceived disadvantages of handset use shows that two main drawbacks were identified – EVS sometimes do not work (78 students) and it takes time to set up the systems for

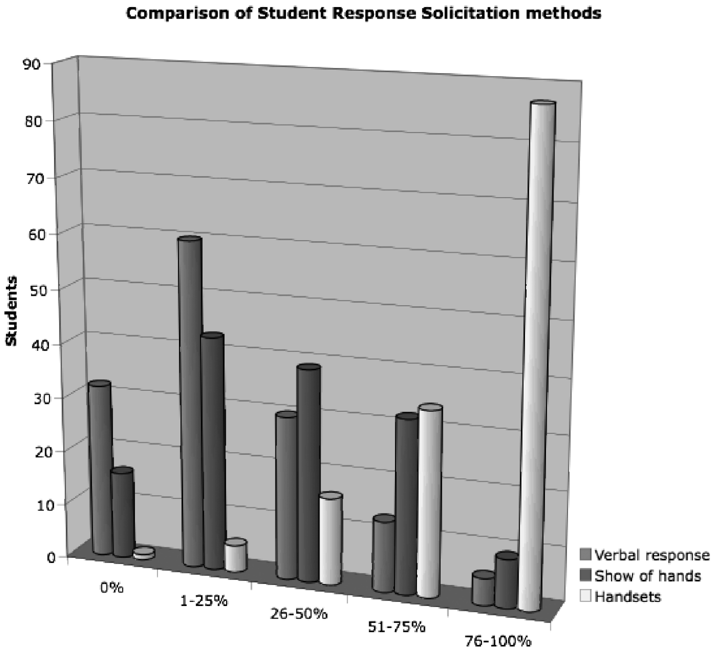

Figure 4: Comparison of two other student response solicitation methods with EVS

use in class (42 students). These drawbacks have to do with setup and operational issues which can be more readily overcome as staff competence and confidence in using EVS increase with time. To determine the impact of these two drawbacks on the perceived usefulness of EVS, the responses of students who had identified these drawbacks were correlated with their responses to the item on usefulness of EVS (Figure 5). The results show that 35 students or 83% of those 42 students who said EVS 'take time to set up' also said that they are 'useful' or 'very useful', while 65 students or 83% of those 78 students who complained that EVS sometimes 'don't work' also said they found EVS 'useful' or 'very useful'. These results further support the notion that the identified drawbacks were not considered sufficient by most of the participating students for them to significantly alter their positive perceptions of handset usefulness.

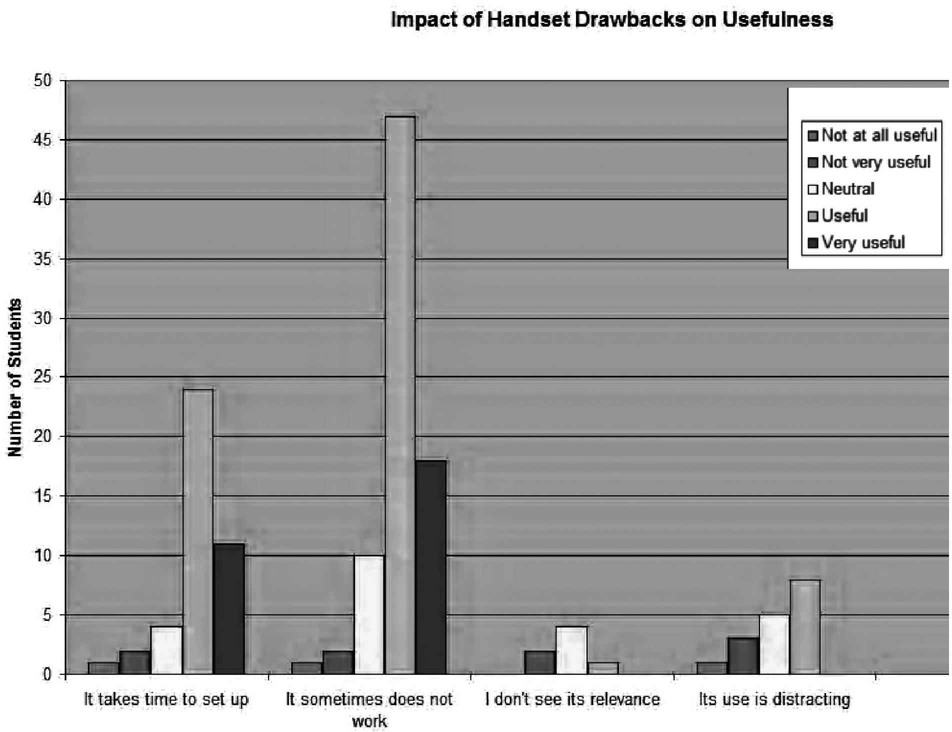

Figure 5: Impact of handset drawbacks on its perceived usefulness

4. Conclusion

This study was focused on investigating the views of the affected students about the use of EVS by the MEC staff at Loughborough University to teach Mathematics, with a view to highlighting:

- The usefulness (or otherwise) and impact of EVS use on learning
- The impact of EVS use on student participation rates or engagement in class.

The results show that the majority of students are mainly positive about the usefulness of EVS in their engineering mathematics classes. Results also show that EVS is seen as a more effective tool in getting students to engage or participate in class, compared to other commonly used student response solicitation methods. Moreover, the identified drawbacks of EVS use were not considered sufficient by most of the participating students for them to significantly alter their positive perceptions of EVS usefulness.

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Introducing the history of mathematics to third level students with weak mathematical backgrounds: a case study

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Abstract

Many students who traditionally struggle with basic aspects of Mathematics have little or no concept of Mathematics as a living and growing subject area. They appear not to appreciate the background of the day-to-day Mathematics that they study, and which some of them may one day teach. These students generally have no exposure to this material and are unlikely to investigate the History of Mathematics independently. In this paper we will discuss the incidents that lead us to consider how to introduce students with weak mathematical backgrounds to the History of Mathematics. We will briefly mention the reasons why there are such significant numbers of students with these issues. We will also provide some detail on the first steps taken by the Mathematics Support Centre in the National University of Ireland Maynooth to try to introduce the background and context of Mathematics to these students. Based on the feedback we have received to date, we will discuss if these initiatives have had a positive impact in terms of students' attitudes and results.

1. Origins of this approach

The idea of introducing students with weak mathematical skills to the History of Mathematics arose as a result of some particular incidents in the Mathematics Support Centre (MSC) at the National University of Ireland Maynooth (NUIM). On one occasion, while discussing aspects of Calculus, a student asked if '…*Calculus was just made up to torture students?*' On another occasion, while addressing issues with zero and infinity, a student asked '*Why are there all these crazy rules?*' It is a common occurrence during weaker students' initial visits that they think they are '*really stupid or slow*'. They get frustrated because they are struggling with basic concepts, whilst in the middle of a higher level Mathematics course.

As we started to explain the historical background to these mathematical topics, we discovered that these students had rarely thought of this before. Subsequently these students have little or no concept of Mathematics as a continuous and growing subject. They see little of its development and few recognize the connections between the different areas of Mathematics. They generally have no idea why they are studying their course material. They try to apply the rules and hope to get close enough to the answer. This lack of understanding is well documented; see [1], [2] and [3].

We find that explaining that some mathematical concepts have taken thousands of years to develop into their current form actually reassures the students. They see the bigger picture and realize that mathematical understanding is not automatic, it involves success and failure. These are an essential part of the process of understanding. Students who realize this can overcome the 'fear' of tackling new mathematical material.

As a result of these observations, we wanted to regularly expose students with weak mathematical backgrounds to the origins of the relevant mathematical material.

2. Why is this approach needed?

There is widespread concern about the numbers of students who have basic mathematical problems. Recent reports, [2] and [3], contain detailed analysis of these issues in the teaching and learning of Mathematics at second level in Ireland. Some of the main factors listed include: bad publicity for Mathematics, negative attitudes towards the subject, little understanding of the context or background of Mathematics, rote learning. [2], [4] and [5] have highlighted possible impacts of these problems. Low attainment in Mathematics is cited as a contributing factor in low enrolment and retention rates in science and technology courses, [6] and [7]. There is also significant international research on these issues [8].

Introducing new teaching methods to address these issues should be a priority. Using the History of Mathematics is one approach that should help with basic understanding of the material. We believe that this can help alter the students' image of Mathematics and show that there is much more to Mathematics than memorization.

3. Existing resources and similar ideas

3.1 History of Mathematics Material

There is extensive material available on the History of Mathematics, for example [9], [10] and [11]. There are also a number of websites containing extensive information, for example [12]. However, we believe that students with weak mathematical backgrounds are unlikely to use these resources independently. At the very least, they will not use these resources until they are made aware of the role that the History of Mathematics can play in their mathematical education. It is safe to assume that a student struggling with fractions will find a text on the History of Mathematics very daunting.

3.2 History of Mathematics Courses

Many universities offer the History of Mathematics as a standard undergraduate course. However, in general these courses are available for specialist Mathematics students only. For example, in NUIM, the History of Mathematics is provided to final year Mathematical Studies students only [13]. These are the students who are most likely to become Mathematics teachers. They can introduce and use some of this material when they are teachers of Mathematics, thus tackling the problem from the start.

In NUIM, it is first year students who have the most common basic problems with Mathematics; 41% of the visits to the MSC in 2007-2008 were from first years. These students get little or no exposure to the background and origins of Mathematics. Only those continuing on into third year Arts will see the material at all. This is too late for the weaker students, so it is important that we try to introduce the material earlier by other means.

3.3 Using the History of Mathematics in Mathematics Education

The role of the History of Mathematics in Mathematics Education is not under scrutiny. Extensive material is available which discusses this issue, see [14], [15] and [16]. [15] contains several interesting papers, for example Grugetti [pp. 29-35] states that '*An historical… analysis allows teachers to understand why a certain concept is difficult for the student…*' and '*In observing the historical evolution of a concept, pupils will find that mathematics is not fixed and definitive*'. Student teachers who are being trained to use the History of Mathematics in their teaching are interviewed by Isaacs, Mohan Ram and Richards [pp. 123-133]. One student commented '*I have never been taught maths in this way before, rather I have always been given a set of problems and been told to solve them, which has made maths a boring subject. Yet, when faced with a question to answer, and the history behind a particular thing, it makes further questions easier to handle and I found it stays ingrained in the memory better.*'

These are issues we would like to address. However, almost without exception, the articles and material are geared towards specialist mathematical students. This gives us valuable insight into the process of introducing the History of Mathematics to students in general. However, how do we address this issue with the weaker students?

4. First steps towards implementation

We want to introduce the History of Mathematics to weaker students, students who are unlikely to attend History of Mathematics courses, read the textbooks or be involved in similar initiatives. Simply pointing the students towards the available resources would not have any significant impact. If they are already having difficulties with Mathematics, why would they research the background of the material that is already confusing them?

We decided to develop resources which would supplement the normal mathematical material available.

4.1 Mature Students Mathematics Refresher Course

4.1.1 Implementation

In 2007 the author was asked to design a Mathematics Refresher Course for incoming Foundation students to NUIM. These students are typically mature students who have not completed the Leaving Certificate (A Level). The five day course is run prior to the start of the academic year. Students then proceed to a Foundation Certificate Course in Science, Economics or Engineering. When they complete the Certificate, they are qualified to enter into the first year of an equivalent degree.

The students are mathematically very weak so the topics covered include: counting, addition, subtraction, multiplication, division, zero, fractions, decimals, percentages, algebra, functions etc. The author designed the course from a historical point of view. Each of the topics are discussed and developed from their origins, and then explained with examples. The topics also overlap to reflect the natural development of Mathematics.

4.1.2 Feedback

In 2007 and 2008, 40 Foundation Course students completed basic evaluation forms which were distributed by the Mature Students' Office. They were asked to grade their answers from 1 to 10, where 1 indicated poor and 10 indicated excellent.

- Question one gauged the students' evaluation of course content. The average mark was 9.18.
- Question two gauged the students' evaluation of course presentation. The average mark was 9.40.
- Question three gauged the students' evaluation of how well the course met their expectations. The average mark was 9.25.

One student commented '*I've done Maths at secondary school and I learned more at this foundation week of Maths*'.

The Mature Student Officer stated that a greater percentage of students exposed to this Refresher Course completed the Foundation Certificate Course and continued on to degree level. The Mature Students Office is introducing a Mathematics Refresher Course for mature students entering degrees in 2009-2010. They have requested that the author design a similar course aimed to a slightly higher level. The Adult Education Office in NUIM provides 'Outreach' Certificate Programmes in Finance and Economics. They have requested permission to use the Mathematics Refresher Course.

The feedback and subsequent decisions to use the course in other projects is very positive. A complete evaluation process is underway to determine the best methods to update the course to the students' benefit and how to include more mathematical topics.

4.2 Mathematics Support Centre (MSC)

The MSC was set up in NUIM in October 2007. A complete analysis of the services the MSC provides and the impact it has had is available [17]. The MSC aims to help students who are struggling with any aspect of Mathematics. A significant number of these students struggle with basic concepts.

4.2.1 Implementation

One of the principal objectives of the MSC is to try to use context and background to explain basic mathematical concepts. Due to the huge numbers who attend the MSC, it has been difficult to implement an exact program to date. However, the tutors do their utmost to maintain this objective at all stages.

4.2.2 Feedback

Though there is no conclusive evidence on the use of the History of Mathematics in the MSC, there is evidence to suggest the MSC is having impact on students' grades and their attitudes towards Mathematics. In particular, the MSC appears to have a significant impact on the weaker students, see [17, pp. 30-31]. This is encouraging, as these are the students who we target with our approach.

Students who attended the MSC quoted the ability of tutors to give context and background to the problems they were having, as a major source of influence and motivation.

As the MSC develops, we hope to implement a more exact program for our approach. Consequently, we can conduct a more precise investigation into the students' attitudes towards the use of context and history in the drop-in sessions.

4.3 Secondment with Coventry University

The author was offered a secondment opportunity by **sigma** (Centre for Excellence in Mathematics and Statistics Support) in 2008. This offer was based on his interest in using the History of Mathematics and it was agreed that he could work on methods to introduce it to weaker students.

4.3.1 Implementation

The secondment involved a week of collaboration with Dr. John Goodband, Coventry University. We decided that the most effective approach was to provide a single double sided A4 page to supplement certain sections of the Engineering Mathematics First Aid Kit (EMFAK) [18]. The EMFAK is a comprehensive resource, it is widely available and used in most Mathematics Support Centres.

The author worked specifically on the History of Mathematics. Material on Complex Numbers and Linear Algebra was produced. The content of these pages includes an initial summary of the origins of that area of Mathematics. It also addresses common misconceptions and contains a description of the progression of the topic. Finally there is a timeline of major developments in the subject area until modern times. The descriptions are brief and designed for students who would otherwise know little about this material. The pages are available in the Mathematics Support Centres in Loughborough, Coventry and Maynooth. They are attached to the related pages in the EMFAK. They will also be available on-line in the near future.

4.3.2 Feedback

The pages were completed in September 2008, so there has been little opportunity to gauge exact student reactions. However, initial comments from staff and students have been very positive. The co-ordinator of the on-line Mathematics Proficiency Course in NUIM has requested additional history pages on other topics. Funds are also available from **sigma** to continue with this project and the author aims to complete a comprehensive set to accompany the EMFAK.

These reactions are encouraging and we will have a clear indication of the appeal of these handouts at the end of the 2008-2009.

5. Conclusions

As a result of our experiences in the MSC, we have started these three connected projects to help promote the use of the History of Mathematics when helping students with mathematical weaknesses. The projects are relatively new, so there is little statistically significant data to date. However, we believe we have sufficient evidence to argue that using the History of Mathematics can have a significant and lasting influence on weaker students' attitudes and grades. This has wider repercussions and should impact Mathematics poor public image.

We hope to continue with these projects and provide comprehensive programs to introduce this material to the weaker students. Continuing this work will also give us more data, which will help determine the exact impact of this approach.

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Teaching mathematics at a distance – trialling a wiki community to focus reflection and share resources

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Abstract

Professional development for academic staff in Higher Education is always more interesting and inspiring if good practice can be embedded in a way which is meaningful and relevant to the individual. The current project focuses on raising awareness of significant or difficult parts of a course, and promoting the exchange of good practice using a wiki environment. Our findings suggest that this methodology has promise, and is particularly valuable to new tutors, or at the start of a new course. The wiki can be used to host a repository of teaching materials and we illustrate a number of examples. We have also learnt a number of useful lessons on the ways in which a wiki might be used to support a staff community in the future, and offer a list of recommendations.

1. Introduction

Professional development for academic staff in Higher Education is always more useful if good practice can be embedded in a way which is meaningful and relevant to the individual. There is scope for the sharing of good practice between staff at the point of need, or between new and experienced staff, and communities of practice can enhance practice through contact with peers. Using online media the community can operate regardless of time and place, of particular relevance to part-time teachers, or for any group of staff who are not regularly co-located [1].

We describe a project which assesses the potential for enhancing the teaching practice of part-time mathematics tutors in the Open University, using a wiki to support an online community and to allow the sharing and development of resources.

2. Professional development at the Open University

Professional development is challenging in a distance environment, where face to face events are expensive and difficult to organise. Opportunities for the exchange of good practice on course teaching commonly take place in an initial face-to-face briefing for tutors at the outset of a new course; on some courses a debriefing happens after the first year. Tutors are also encouraged to attend professional development events which provide both subject specific and generic sessions. Such events are supported by a range of online resources for distance study.

Online communities using forums are already enthusiastically embraced by tutors on some courses. These forums are particularly useful during assignment marking, when tutors may use the online group to discuss their understanding of question requirements, or of marking criteria. Not surprisingly, such groups are particularly successful where forums are in habitual use for core tutoring duties [2]. The mathematics course involved in this study is an example: it has enjoyed an active online tutor community for several years. The current project builds on this work with its focus on raising awareness of significant or difficult parts of a course, and promoting the exchange of good practice in teaching, using a wiki.

3. Methodology

Open Mathematics (MU120) is a 30-credit point level 1 course which runs over nine months, starting twice a year. The course provides an introduction to studying mathematics within real world contexts and typically attracts around 3000 students a year, supported by around 150 tutors.

Ten tutors (labelled M1-M10) were recruited for the project, ranging from tutors newly appointed to tutors who have taught the course since its first presentation in 1996. The tutors are scattered throughout Scotland. In terms of other commitments: 3 tutors are employed with other HE/FE providers; 3 have retired from their day job; for 3 tutors the OU is their main source of income and one is a freelance science communicator.

In a full day workshop tutors discussed significant or difficult points of the course and then activities which could help students with these parts of the course. They were introduced to current thinking on Threshold Concepts and Troublesome Knowledge [3] in the hope that these ideas might help them to talk about their subject and the difficulties they encounter in teaching.

A wiki "book of course teaching" was set up for the project, in which the workshop output was included. The wiki used is a new tool which has been introduced as part of the University's Moodle VLE. It has as yet fairly basic functionality, including the ability to create and edit new web pages, but no facility to attach files or to alert subscribers to new entries. Tutors were asked to visit the wiki monthly during the course to reflect on current experiences and to share teaching material with fellow tutors. A wiki moderator reminded participants once a month that their contributions were due, and organised the wiki as it grew.

The project concluded with a reflective exercise, in which participants were asked to visit the wiki and assess the extent to which they agreed with the significant or problem areas identified, and to consider whether the material deposited there could be relevant to their tutoring practice. A questionnaire was circulated by email.

The following account draws on two sets of notes from different participants on the initial workshop together with examples from the wiki and short qualitative responses from the questionnaire.

4. Issues in the teaching of mathematics

In identifying significant or problematic areas in the course there was much discussion on algebra and the difficulties experienced by students in working with algebraic ideas and seeing the relationship between geometry and algebra.

> *"..the difficulty that students have in understanding what is meant by solving an equation...: many students confuse this with rearranging an equation." M7*
>
> *"multiplication of brackets of form (ax+b)(cx+d), $(ax+b)^2$ and even a(b+c) where some of values are negative." M8*

Tutors also discussed the issue of communicating mathematics effectively. They noted that students often do not realise that communicating mathematics involves more than simply writing down the answer or writing only in symbolic language and that a combination of words and mathematical notation expressing their reasoning process is required. It was also noted that students need support and encouragement to appreciate why using notation and terminology correctly is important.

> *"Lack of experience of writing for other people to read. Not understanding that a mathematical solution is a form of communication from one person to another... Writing their solutions out properly." M2*

Other discussion focussed on conceptually difficult areas for novice mathematicians such as percentages, ratios, negative numbers or scientific notation.

> *"Conversion of units: I think that students concentrate too much on the numbers, instead of trying to visualise the situation." M7*
>
> *"...if students perceive that something is difficult then they will lose themselves in the detail and not see the big picture. If something is difficult then it must take a complicated process to solve it." M4*

Finally, tutors discussed how students' difficulties might not be absolutely tied to an identifiable part of the course, year after year. For example knowledge might be troublesome as a result of students' varied backgrounds (e.g. previous courses, school). Alternative notation in use, for example for writing numbers in scientific notation, can also be an obstacle for new learners in mathematics. Moreover, the approach in the course teaching and assessment material may suit some learners more than others.

5. Wiki contributions

The wiki contains some excellent new material of interest for current tutors and for staff designing future courses. This account concentrates on: developing communication skills in mathematics, relating mathematics to everyday life, and helping students to understand difficult concepts.

As noted, learning to communicate mathematics effectively was a major issue: the following handout (Figure 1) makes use of a model answer to illustrate good practice.

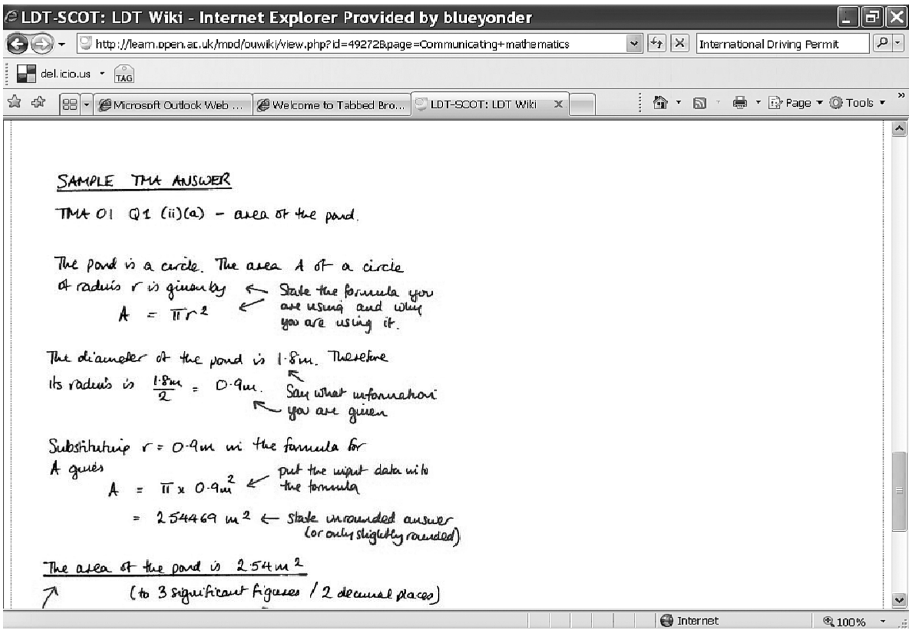
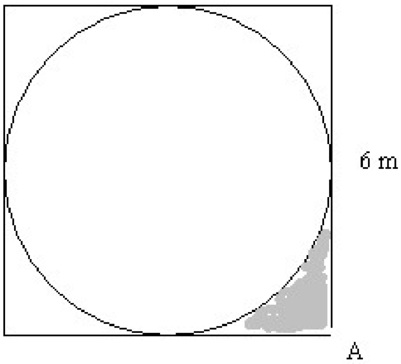


Figure 1: A screenshot from the wiki showing part of a 'communicating mathematics' worksheet

Figure 2 (overleaf) is another example of encouraging good communication in mathematics, by engaging students in a dialogue with an exercise.

Relating mathematics to everyday knowledge was another popular theme, important for helping students to understand abstract concepts, and also applicability. Quirky and interesting examples, such as in Figure 3 (overleaf), were added to address the age-old question of WHY we study mathematics – to enable us to solve problems and answer questions.

A flowerbed in a park is a square with sides 6m long. A circle is set inside, as shown in the diagram.



(i) Find the area of the square flowerbed.

(ii) Find the area of the circular bed in the centre. Give your answer correct to one decimal place.

(iii) Find the area of the shaded area at corner A.

Here is a student's answer to this question. How could it be improved?

(i) 36

(ii) Area = π r2 = 3.14 ×9 = 28 m2

(iii) Area = 36 – 28 = 8 / 4 = 2 m2

[...]
Notes:
Add some words to explain what you are calculating;
Be careful not to misuse the equals sign. The student wrote 36 – 28 = 8 / 4 = 2 which just isn't true! Can you see why? The expressions on either side of the equals sign must be equal and 36 – 28 is not equal to 8 / 4.
Remember appropriate units.
[...]

(M3)

Figure 2: An example that engages students in a dialogue with an exercise.

What have an elephant's ears got to do with mathematics?

Students are calculating volumes and areas at an early stage in MU120. As a group exercise I ask them to calculate areas and volumes of cubes of side 1, 2, 4, and 8 metres, and see if they can spot a pattern in the results.

With each doubling of the side of the cube, the area goes up fourfold but the volume goes up eightfold. I assure the students that this applies to any shape, elephants included.

An elephant's body generates heat, which it mostly loses through its skin. The amount of heat that it generates is going to be (roughly) in proportion to the amount of elephant (its volume), but its heat-losing capacity is going to be roughly in proportion to its surface area.

If you have two elephants, one twice as tall as the other, the taller elephant will generate about 8 times as much heat but will only have four times as much skin to lose it through. As a general rule, large animals therefore have a heat-loss problem.

An elephant's huge ear flaps are richly supplied with blood and are used as radiators - extra surface area to make up for its relative shortage of area compared with smaller animals.

Figure 3: A real life example on the wiki of mathematics in action.

5.1 Reflections on the wiki community

Most participants were positive about the benefits of sharing experience and resources; it was of particular value to those who were less experienced.

> *"Sharing difficulties, teaching practice and resources is very helpful, especially to new and perhaps inexperienced [tutors]. I fit into this category ..." M6*
>
> *"Good to get reassurance that other tutors encounter the same kind of problems that I experience and how these are tackled by them." M8*

Participants were asked to visit the wiki and identify an entry which was of particular relevance to them. It was clear that the benefit was marginal for some: three out of seven said there was nothing of particular use to them, possibly because the course has been running for some years, and many staff have considerable experience.

> *"Many of the examples were interesting, but mostly just described what I have been trying to do for years ..." M5*

Others appreciated the sharing of resources and techniques, and identified specific examples:

> *"I found this very useful as it gave a different approach to those I have used – it was a very full, detailed and cohesive explanation of the teaching technique used." M6*
>
> *"I like this idea: but haven't quite got around to preparing one myself. To have the prepared resources already available is great." M4*

However, the wiki contributions were irregular and somewhat reluctant. There may be several reasons, providing useful lessons for future good practice.

Since the wiki was an unfamiliar tool, the tutors struggled to remember how to use it each time they joined. They were not just coping with new functionality, but also with navigating and deciding where to post contributions, or whether they should be posted as comments or main text, or indeed posted at all.

> *"Is this a useful place to share resources? I have a worksheet on mathematical communication, but if I copy it in, the wiki could become unmanageable ..." M7*

As shown in Figure 4, in order to distinguish their input from earlier contributions, some participants wanted to use coloured text, while others wanted to identify themselves as the author.

Ideas from the workshop

** Sally here again**

A very sticky area is the notion of 'two minuses make a plus' when multiplying numbers. The **real** reason for this is that it has to be so - otherwise all fundamental notions fall down.(Russell et al). I have seen many different motivations for this, however none seem to work terribly well for students.

(I'm not sure if I'm writing this in the correct place – if someone can advise me how to write in a different colour, then that would be great.)

Sally's comment: can anyone think of a real life need for negative numbers other than debt and temperature, (both of which I feel acutely after dog walking and in process of moving house.)

Bill says: Perhaps we could introduce the concept of deviations as in deviations from the mean in a statistical sense .... also the concept of variance or variation from a target or plan

Figure 4: Deciding how to use the wiki

This may be related to more familiar practice with forums and email. There are also particular difficulties in communicating mathematics using print media.

> *"Explaining in print can be time consuming, especially if mathematical formulae etc need to be inserted. The wiki also appears to get messy as comments are added, making it difficult to follow just one entry...I hadn't used a wiki before and sometimes felt hesitant that I may 'spoil' the page. Although this worry has lessened somewhat during the year, perhaps the different skill levels throughout the group have hindered participation." M6*

There were usability issues, for example files could not be attached and there was no notification of changes to participants' email boxes, so it was effectively out of sight and mind until participants were reminded of its existence every month. The wiki was not in a place which tutors would pass on their way to core duties; they required to follow a separate link, so serendipitous visits were unlikely. These comments are reminiscent of the lessons we have observed from participation in other online groups, particularly online forums [4].

The wiki was chosen because of the potential to organise contributions and make them available for easy searching and retrieval. However these objectives were not realised in this pilot. A lack of consistency in the places where new entries were posted and a proliferation of new pages required moderator input to link them to the home page. There was no obvious distinction between entries posted as comments and those posted on the main part of the page. Future wiki communities need better guidance on good wiki practice, and a protocol for identifying new material.

Finally, the small group size (10) combined with the fact that activity was expected only monthly meant that the wiki did not have much "buzz". This was coupled with tutors' lack of time, demands from other online groups and a certain lack of motivation to contribute.

> *"Why don't people contribute? I suspect that the basic issue is: what's in it for them? To act in a spirit of reciprocal altruism requires that a contributor expects to get something useful out of the wiki. However there is a fairly well established body of ways of explaining maths, that tutors are going to be largely familiar with. The odds of seeing something really new are quite small." M2*

It is difficult to write material for teaching mathematics at this level which is truly innovative and useful. A few contributors did provide such material; however, we should not have expected everyone to do this and perhaps asking more specific questions for tutors to answer might have provoked a higher level of participation. This said, the issues associated with teaching these ticklish topics in mathematics remain vibrant and open.

6. Discussion

Our findings suggest that this methodology for professional development has potential, and is particularly valuable for new tutors, or at the start of a new course. The workshop was effective in identifying 'troublesome' areas for the teaching of this course, and stimulated some fascinating discussion into the nature of mathematics and its teaching.

The wiki potentially provided a repository of teaching materials, which some tutors found helpful. However for various reasons it was not particularly successful as an online community; the following useful lessons have been learnt for further practice.

Contributing to a wiki

- Participants need guidance on where to post, and which types of material are appropriate.
- They need a protocol for amending or commenting on the work of other contributors, and how to acknowledge authorship if that is considered important.

- The moderator needs to move and organise content to improve usability.

Participation

- There has to be a good reason for tutors to participate!
- An initial face to face meeting can help to initiate the community and allows discussion of its focus and purpose.
- The use of near-synchronous or synchronous sessions can revive interest.
- Introducing structured tasks may encourage participation.
- If participation is optional, then a large group is preferable, allowing for contributions by an active minority and passive access by others.
- Membership of the wiki community should be integrated into the workload of tutors.

Usability

- The tool should alert participants to new material.
- Use of the tool should be integrated with the use of other communication tools by the group.
- If the tool is used in other contexts then this is likely to increase its acceptability.

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Developing employability skills in the mathematics HE curriculum through personal development planning

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Abstract

The QAA Benchmark Statement for Mathematics, Statistics and Operational Research lists a range of employability skills that graduates of degree programmes in Mathematics are expected to have. Personal Development Planning (PDP) provides one important technique which can assist with the development of these skills. In particular, it can encourage a more reflective approach to learning and result in the improvement of key skills for employability.

In this paper, we describe our aims and objectives when embedding PDP into the curriculum, briefly explain how we have attempted to do this and refer to some of the alternative approaches used elsewhere. We also discuss the benefits and challenges of our approaches, when considered from the perspective of staff, students and employers. These views are informed by recent student feedback, examples of which will be presented.

If PDP is to be a successful component of a course, it is of vital importance that it is seen to be supported and valued by staff, and that it is properly embedded into the curriculum. This in turn raises the issues of resourcing and whether a coherent strategy for assessment and feedback exists. Strategies for addressing these issues will be presented. We will conclude with some general ideas about what we consider to be the important elements of a well-founded PDP system.

1. Background

It has been known for some time that there is a shortage of mathematically competent candidates for graduate-level jobs in the UK, both in education and in industry [1-8]. In addition, many of these candidates lack important employability skills, such as communication, teamworking, leadership and autonomy [9].

In these circumstances, it is important to make all stakeholders aware of the need to create a curriculum in HE Mathematics which, in addition to delivering the mathematical competencies stipulated in the benchmarking statements, also ensures that graduates are adequately prepared for employment. This means that ways need to be found to encourage the development of both employability skills and mathematical skills as part of course provision.

There are three principal challenges: one is to convince colleagues that this can be done both within the existing curriculum and without loss of course content; the second is to make students understand the purposes of general skills development so that they take it seriously and the third is to embed this within institutional practice, so that skills development is seen to be valued.

The first challenge can be addressed by using examples of how learning, teaching and assessment activities can be tailored to develop the required skills. For example group work can be used to encourage teamworking while peer mentoring can develop leadership and autonomy. The second requires a degree of openness and transparency between staff and students, providing clear explanations of the purposes of various activities. Central to this is the need to make students appreciate the need to take advantage of the many opportunities that a university course offers to develop important skills, both within and outside the curriculum. The document published by the Association of Graduate Recruiters [10] is very helpful in this respect. To address the third challenge, many universities (e.g. [11]-[13]) have been developing Employability Awards, which provide explicit recognition and reward for the additional skills students can develop at university. Other such schemes are also under development.

In this paper, we discuss the role of PDP as a means of developing important employability skills, and provide examples of how it has been used in two Mathematics degree programmes.

1.1. Employability and PDP

If we hope to encourage the development of Employability skills, it is first necessary to define the meaning of Employability. In Yorke [14] employability is defined as:

> *'a set of skills, knowledge and personal attributes that make an individual more likely to [be] secure and [to] be successful in their chosen occupation(s) to the benefit of themselves, the workforce, the community and the economy'.*

A key point here is that a requirement to 'be successful' introduces the idea of **sustainable** employability. It is not just about getting a first job, but also about keeping it, and developing it as part of a long term career plan. The relationship between employability and PDP has been widely explored, and summarised by Ward *et al*. [15]:

> *'There is a strong relationship between PDP and student employability, and this relationship is central to the development of learners' ability to identify, articulate and evidence their learning and overall development'.*

The development of policy in respect of PDP in UK Higher Education dates from the Dearing Report [16], which led to the idea of student Progress Files. The Quality Assurance Agency in [17 p2] defined the PDP element of Progress Files as a:

> *'structured and supported process to develop the capacity of individuals to reflect upon their own learning and achievement, and to plan for their own personal educational and career development'*

The QAA Progress File guidelines on PDP [17, p2] also state that

> *'the primary objective for PDP is to improve the capacity of individuals to understand what and how they are learning, and to review, plan and take responsibility for their own learning, helping students:*
>
> *• become more effective, independent and confident self-directed learners;*
>
> *• understand how they are learning and relate their learning to a wider context;*
>
> *• improve their general skills for study and career management;*
>
> *• articulate personal goals and evaluate progress towards their achievement;*
>
> *• and encourage a positive attitude to learning throughout life'*

Potentially, therefore, PDP can help develop skills in communication, planning, time-management, organisation, reflection, self awareness/self efficacy, problem identification, target setting and action planning, and autonomy.

We will describe how we have implemented PDP in the mathematics curricula in our institutions, and evaluate its success in delivering these employability skills.

1.2. Embedding PDP in the curriculum

There are three specific models for embedding PDP in the curriculum that can be identified, each with its own advantages and disadvantages.

- Add-on (the inclusion of a separate 'skills' module)
- One module (partial embedding)
- All modules (fully embedded - skills development permeates the programme)

Other constraints are likely to dictate which of these may be possible to employ, but the fully-embedded approach will meet with most success since in this case students will see skills development as a key part of the programme of studies, and as something valued by staff and the institution. It will also place the skills development firmly in the subject context. Case studies of ways in which each of these models has been used can be found in [15] and [18]-[20].

A common variation on the Personal Development Plan (and a variant of the acronym) is the Personal Development Portfolio. This generally incorporates an element of reflective planning, but also contains examples of student work, together with a commentary putting the work into context. It is often referred to as an e-Portfolio, and a current JISC InfoNet initiative [21] is aimed at encouraging the further development of these at UK HE institutions.

2. PDP at Oxford Brookes University

At Oxford Brookes University (OBU), PDP is incorporated into a final year Mathematics module which runs over the full academic year. The PDP contributes 10% to the overall module assessment and to date the number of students taking the module has been small. Students are required to complete specific activities and write short reflective statements based on these. The actual activities included have varied with experience in using the scheme. General areas which have so far been included can be categorised under the following headings (i) library skills for Mathematics, (ii) careers preparation and awareness, (iii) presentation skills, (iv) time management and (v) evidencing of transferable skills. Work is submitted in the form of small logbooks. Full marks are awarded when the activities are completed exactly as stipulated in the assessment requirements. The reflective statements are then graded using an assessment matrix. Further details of the assessment method can be found in [22].

Due to the nature of the assessment mechanism described above, the pass rate gives a reasonable measure of the level of serious student engagement with the scheme. The figures shown in Table 1 are encouraging.

Year	Number of Students	Number of Submissions	Pass Rate
2005/2006	10	10	70% (7/10)
2006/2007	11	10	82% (9/11)
2007/2008	14	14	93% (13/14)

Table 1: Student participation in PDP at OBU between September 2005 and May 2008

3. PDP at Sheffield Hallam University

At Sheffield Hallam University (SHU), PDP is part of a web-based electronic Progress File, fully embedded but assessed in just one module at each level [23]. In year 1 students make logbook entries, which are assessed, weekly for all modules. In year 2 students are expected to make entries weekly, but are assessed every two weeks. For final year students, PDP is part of the Project module, and contributes 5% towards its assessment. The level of participation so far this year is illustrated in Table 2.

Students are provided with guidance that entries should summarise progress, be reflective, identify strengths, weaknesses and problems, and develop a strategy for dealing with them.

The system that manages this process can provide a variety of live summaries of the data from the database. Student comments are not visible to each other, but staff can view the entries and respond immediately by email from the system, helping resolve any problems and issues rapidly. Students also see this as a valuable means of contact, and feel supported both as individuals and as part of a mathematical community.

Students can save summaries of their reflective logs as PDF files for review purposes. This helps them to become aware of their own progress and development through the course.

	Number of Entries (per person)	**Number of Words** (per entry)	**Participation**
Year 1	8130 (98)	401918 (49)	83/88 (84%)
Year 2	3143 (73)	252793 (80)	43/60 (72%)
Year 3	976 (26)	95763 (98)	37/50 (74%)

Table 2: Participation in PDP at SHU between September 2008 and May 2009 for students on each year of the BSc Mathematics course

4. General Skills Development

4.1 Skills identified in the Benchmark Statement

The QAA Benchmark Statement for Mathematics, Statistics and Operational Research (MSOR) [24] refers to a number of key skills. PDP can help deliver some of these skills. However it is very difficult to come up with a metric or performance indicator which will measure the degree to which this is succeeding. We are therefore using student feedback to gauge the extent to which students themselves feel that they are acquiring these skills.

The MSOR Benchmark statement [24, section 3.27, 5.15], states that a graduate will typically have, amongst other things:

a) 'the ability to work .. with a degree of independence' and 'the ability to learn independently'

b) 'the opportunity to develop general skills of time management and organisation'

c) 'general communication skills .. write coherently and to communicate results clearly'.

The independent working skills referred to in (a) are being developed by students, as the following comments illustrate.

> *"When you are entering a comment.. you have to think about it carefully and if it is something that you have been struggling with then I sometimes find that by thinking about it I have solved my problem that I was going to write in the first place."*

> *"This was very helpful, as it allowed me to break down problems and deal with them swiftly and effectively"*

Students openly recognise that their engagement with PDP has assisted them with the personal management skills identified in (b).

> *[the Progress file] "made me completely alert on what work I had done and what work was left outstanding."*

> *"It has helped me keep a track of the activities that I have and haven't completed during the week. This has helped me work out what things are next in priority."*

> *"It has helped me to condense my thoughts about what work I am doing, what I have done, and more importantly what I still needed to do. This kept me on track."*

The communication skills mentioned in (c) are necessarily essential components of both the PDP schemes described in this paper. Once again students have identified how their skills are developing in this area.

> *"From the usage of Progress File I gain lots of things like better apprehension in lessons, self-criticism and the most important helps me to improve better my English."*

> *"The progress file has helped me to develop my communication skills and to become more confident in talking about my own work and feelings on the course."*

The above comments are indicative of those received, and suggest that students do perceive the intended benefits.

4.2. Summary of benefits

In the following two tables (Tables 3 and 4), student comments made as part of their PDP reflection have been reviewed, and common themes identified. These have been sorted by frequency and presented below:

Year:	**2006**	**2007**	**2008**	**All yrs**	
Number of students:	**27**	**28**	**19**	**74**	
Benefits					
Planning and meeting deadlines; being organised	19	5	10	**34**	46%
Assessing understanding and reflecting on it	14	6	12	**32**	43%
Communicating with lecturers	11	12	7	**30**	41%
Gaining a view of progression over the year	9	6	7	**22**	30%
Prioritising work	9		3	**12**	16%
Staff can see progress, understand student viewpoint		6	5	**11**	15%
Recognise own strengths and weaknesses		4	1	**5**	7%
Identify development needs		3	2	**5**	7%
Helps me gain confidence		4		**4**	5%
Encourages competition, motivation			4	**4**	5%
Improves use of English		4		**4**	5%
Target setting		1	3	**4**	5%

Table 3: Results of student survey from Sheffield Hallam University (year 1)

Year:	**2006**	**2007**	**2008**	**All yrs**	
Number of students:	**8**	**10**	**14**	**32**	
Students thought PDP					
was well organised	7	9	12	**28**	88%
was useful	7	8	13	**28**	88%
had a clear purpose	7	8	13	**28**	88%
encouraged reflection	8	7	12	**27**	84%
was worthwhile	5	8	13	**26**	81%
had a heavy workload	1	8	7	**16**	50%
had excessive contact	2	4	6	**12**	38%
was intellectually demanding	2	5	4	**11**	34%

Table 4: Results of student survey from Oxford Brookes University (year 3)

It is noticeable that without prompting, student perception of the benefits of the PDP process closely reflects that intended, as described at the beginning of this section.

4.3. Additional Perceived Benefits

Students have identified other benefits in their PDP entries, such as improved staff-student communication, the rapid resolution of problems, improved module delivery and the encouragement of reflective learning. Evidence for this is presented below in the form of a selection of student comments.

> *"It is a great place for communication and helped strengthen the bond between teacher and student because it allows the lecturers to understand more about what we the students want"*
>
> *"I have definitely used it for reflection and taken the appropriate action from it as I have often listed problems that I have had then I have had a response and taken appropriate action from there on"*
>
> *"The most useful thing about it is that the tutors read what I have put and sometimes have contacted me by email and the problem that I have had has been sorted before the next tutorial, which has meant I have been able to continue with my work and get the maximum from the tutorial questions"*
>
> *"It has given me the ability to provide weekly feedback on how the lectures went and thus given the lecturers the opportunity to read my comments and consider making improvements to their lectures"*
>
> *"It helped me to ... engage in self-evaluation and objective reflection"*
>
> *"It provides you with, what in my course, feels like a substantial piece of reflective work".*

At OBU a key element of the PDP scheme is careers preparation and awareness. The following comments from the final year students show clear evidence of a greater focus on future career prospects. The comments illustrate clearly that students have recognised that PDP has helped them to develop their employability skills.

> *"I found the PDP component very useful as beforehand I had no idea of possible future career paths"*
>
> *"I have been alerted to the usefulness of the careers centre"*
>
> *"As I went on I realised the importance of it in preparing myself for a master's application or a job interview"*
>
> *"Very useful in the sense of providing space/time to think about careers, the future and how what we are doing on the course can help to further our goals"*
>
> *"It helped in developing my skills and in thinking about a future career"*
>
> *"It gave me very good professional experience to enable me to take responsibility for my own development."*

5. Conclusions

The experience at SHU and OBU suggests that key factors in the successful implementation of PDP are as follows.

- **PDP needs to be a core part of academic activity**. This is necessary to show that staff value and support the benefits of PDP, and that it is part and parcel of the complex mix of skills that the course aims to develop in its graduates. It also ensures that the PDP activities are contextualised as part of the Mathematics curriculum.
- **The reasons for PDP need to be clearly explained to students.** Students are much more likely to engage in an activity if they can see its purpose (either short or long term). One approach is to use input from employers or alumni to emphasise the importance and relevance of the skills in a particular career area.
- **The *process* is more important to student learning than the *bureaucracy*.** The recording mechanism used to support PDP should not supplant the staff role, leaving students to manage on their own. The value of PDP is in student engagement with the process and it should not become a tick-box activity.

- **All staff involved need to be engaged.** Staff should support the intentions and purpose of the PDP activity, and ensure that students receive a consistent message. Student feedback reported here demonstrates their desire for staff to take a more active role in the process.
- **Collect and use feedback.** The PDP process will be most effective if it meets student needs, therefore regular feedback should be sought and acted upon.
- **Identify a staff 'champion'.** A PDP process will be more effective if someone takes responsibility for driving it forward, soliciting feedback, acting upon it, and 'selling' it to all stakeholders.
- **PDP should provide academic credit.** Students have many other demands upon their time and will prioritise their time strategically to get the best academic results.

These principles are in line both with the recommendations in [15], and with the needs of employers identified by Edwards in [25].

In this paper we have described how we have implemented PDP in different ways in our two institutions. From the QAA Progress File guidelines [17] given in 1.1 and the extracts from the MSOR Benchmark statement [24], given in 4.1, it can be identified that that some of the key attributes for employability are skills in communication, self-management, independent learning, the development of a reflective approach to learning and responsibility for careers development. As staff, our aim is to integrate these skills into the Mathematics curriculum by means of our work on PDP. The comments received from students show that they have recognised that they are developing these employability skills through their engagement with PDP. Their comments have also provided evidence of additional benefits of using our PDP schemes.

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Understanding student usage of mathematics support – who, why and how?

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Abstract

The Mathematics Learning Support Centre at Loughborough University was established in 1996 to provide assistance to engineering undergraduates with mathematics learning needs. However, recent usage data indicates that many students who need mathematics support are not using the Centre. This paper reports some findings from interview research carried out with regular users of the Centre in an attempt to better understand the types of students who use the support and, in addition, how the Centre is being used. In-depth interviews were carried out with regular users of the support. In particular, this paper considers the extent to which the students themselves felt they were motivated and engaged with mathematics and their University courses. It also examines the way in which the students used the Centre to support their learning of mathematics. These findings will be used to discuss the extent to which mathematics support is effectively being used.

1. Introduction

It is widely accepted that there has been a decline in the mathematical preparedness of students on entry to universities in the UK and that many students embarking on a degree course lack some basic mathematical skills [1, 2]. A popular strategy of supporting students is in the form of a mathematics support centre, whereby learning support is offered to students, which is additional to that provided by their normal teaching. In 2004, Perkin and Croft [3] found that 66 out of 106 UK universities questioned provided mathematics support.

At Loughborough University (LU) mathematics support is offered by the Mathematics Learning Support Centre (MLSC). It provides a wide range of support mechanisms including one-to-one support on a drop-in basis, paper-based handouts and computer-based material. Due to the MLSC's success in supporting students and similar work at Coventry University, both LU and Coventry University were jointly awarded Centre for Excellence in Teaching and Learning (CETL) status in 2005. A new centre, sigma, was established jointly between the two universities and the funding that the CETL award brings is being used to expand and enhance the provision of mathematics and statistics support.

The MLSC at LU is highly valued by staff and students and recognised as an integral part of the University [4]. The success of the MLSC is evident through its popularity amongst students, with a recorded 4617 visits in 2006/7 [5]. However, support provided by the MLSC requires students to be *proactive* and take the initiative in accessing the support available. Consequently, if students are unaware of their weaknesses or lack motivation to seek support, then the support will remain unused. Therefore, the success of the MLSC partly depends on who access the support and, perhaps more importantly, how that support is used.

This paper will describe a study conducted in the academic year 2007/8 which sought to identify which students regularly engage with the support, what had motivated them to engage with it, and how they had used it. Data from in-depth interviews will be analysed and the results of these will be discussed in detail. The paper will then use these findings to discuss the extent to which mathematics support is effectively being used.

2. Methodology

For this stage of the research, Science, Technology, Engineering and Mathematics (STEM) students and non-STEM students were targeted who had used the MLSC ten or more times in 2006/7, and hence were classified as 'regular' users. 105 students met these requirements, although 27 of these students were no longer studying at LU. The remaining 78 students were contacted via e-mail, on two separate occasions, in November 2007 (Semester 1 of the academic year 2007/8). Eleven students responded and were subsequently interviewed. A further eighteen participants were recruited by approaching students in the MLSC. Recruiting additional participants in this manner ensured that such students were familiar with the support facilities since they were actively engaging with the support at that time. However, since participants were recruited 'on the spot', not all students met the initial requirements, namely that they had used the support ten times or more in the academic year 2006/7. Out of the 29 students interviewed, 15 were identified as regular users during the academic year of 2006/7; the remaining 14 students were identified as regular users in 2005/6 or 2007/8.

Each participant was interviewed using a semi-structured method incorporating an interview guide. All sessions were led by one of the authors of this paper, Symonds, and the discussions were recorded using a digital voice recorder.

3. Results

3.1 Who?

Analysis of MLSC usage data for the academic year 2006/7 shows that students were not accessing the available mathematics support on a regular basis. Indeed, the data indicate that very few students (104 out of 1249 or 8%) could be classed as a 'regular' user of the support (defined as visiting the MLSC 10 or more times), of which half of those were taking a Mathematics degree. Engineering students account for the majority of the remaining regular users (28 out of 104 or 27%) with only 10 students from the remaining users taking a non-STEM courses.

It is possible that the students who were regular/occasional users of the MLSC were students in need of mathematics support, and those who had never used the Centre may not have needed the support. However, further analysis by comparing mathematics module grades against MLSC usage, indicates that students achieving higher grades were more likely to have accessed the support on a regular basis, as can be seen in Table 1. Indeed, from a sample of 744 first year STEM students (from 2006/7) 78 students had failed a mathematics

Visits	Grade						
	A* > 79%	A 70-79%	B 60-69%	C 50-59%	D 40-49%	E 30-39%	F < 30%
0	69%	60%	68%	74%	72%	89%	83%
1	11%	13%	10%	14%	9%	5%	10%
2-9	12%	23%	19%	10%	18%	3%	7%
10+	8%	4%	3%	2%	1%	3%	0%
Total	100%	100%	100%	100%	100%	100%	100%

Table 1: Frequency of visits to the MLSC in 2006/7 by mathematics module grade.

module of which 86% had never visited the MLSC. These students were clearly in need of mathematics support but they had failed to avail themselves of such services. Unfortunately this means that the MLSC is not being used to its full potential, since students who really do need the support are not engaging with it. It appears that better students seeking excellence are using the MLSC more than students looking to avoid failure.

3.2 Why?

Regular users of the support were interviewed to understand what had motivated them to use the support. Analysis of the interview data reveals that there were a number of reasons that had encouraged the regular users to first access the support. In particular, four students stated that they had anticipated that before arrival they would need help with mathematics at university due to a perceived lack of ability and, consequently, had visited the Centre in the first few weeks of term. An additional four students stated that they had made their first visit after encountering difficulties with a problem sheet associated with a mathematics module. Other reasons included collecting a workbook and curiosity to find out more about the MLSC. Generally, the regular users' responses indicated that these students were engaged with their mathematics module from the outset. The students were consequently aware of their problems immediately and they had sought the relevant help when needed.

In addition, for some students their motivation to succeed compelled them to actively engage strongly with mathematics and their course. Consequently, such students engaged regularly with the MLSC since they believed this would help them succeed further. For other regular users of the Centre a fear of failure had motivated them to engage with the support. Such students were aware of their weaknesses and, consequently, this had motivated them to monitor and direct their learning accordingly. In terms of these students, it appears that they will avail themselves of as much help as possible in order to avoid failure.

Although making the initial visit to the MLSC is undoubtedly important in introducing students to the support, return visits are equally important. Not only does this indicate that the student feels sufficient benefit from the first visit to warrant a further visit but, moreover, it is possible that the student may need to make regular visits to be effectively supported. Regular users of the support were therefore asked specifically what had motivated them to make a return visit and why they had continued to use the support. From the interviews it was found that students returned for two main reasons. The first was that students were satisfied with the support they had required initially and this had motivated them to obtain help when they had encountered further difficulties. The second was that students liked the atmosphere of the MLSC and continued to use this as a convenient (quiet) place to work, rather than merely a 'drop-in' facility (this will be discussed further below).

Analysis of the interview data also indicates that regular users are generally motivated students who are engaged with their university courses. Students indicated that they regularly attended their lecture and tutorial sessions and would complete problem sheets on a weekly basis. They would also ensure that revision was not left until the 'last minute'. Consequently, regular users are monitoring their own learning and, hence, are aware of any mathematics difficulties and the need of support.

3.3 How?

Analysis of the interview data indicates that the regular users of the MLSC essentially used the support as a way to scaffold their learning. The MLSC has become more than a support service and is generally used as a 'learning space' by such students. For the regular users of the MLSC, the support centre is a convenient and effective place to engage with mathematics. In particular, students associate the space with learning and are motivated by the 'working environment'. Since students are motivated to engage with mathematics, they are able to focus on specific learning goals and effectively monitor and direct their own learning to achieve those goals. This, in turn, builds confidence since many students felt that they had 'achieved' something during their visit to the MLSC and that they had spent their time 'productively'. Consequently, this motivates them to return to the MLSC and to generally engage with the mathematics on their courses.

In addition, further analysis of the responses from the regular users suggests that such students will engage with the support on a 'Deep' level (as opposed to a 'Surface' level). For example, rather than using the support to merely obtain 'answers' or a method to solve a specific mathematics problem that could be taken away and replicated, students stated that they required a 'deeper understanding' to the problem at hand. In particular, the regular users would clarify ideas with the lecturers on duty and ask questions that would help them understand the problem in a broader context.

Regular users appear to be motivated individuals who are engaged with mathematics and their courses. In particular, such students are motivated to work on their mathematics outside timetabled sessions and feel much more confident in trying to solve problems on their own. Consequently, the MLSC is used as a learning space to help scaffold their learning and enhance their motivation and personal performance in mathematics.

4. Summary and Conclusions

This paper has discussed how support provided by the MLSC is used by regular users. In particular, it has examined which students regularly engage with the support, the reasons that had motivated them to engage with the support, and how they had used this support. Analysis of MLSC usage data indicates that regular users are more likely to be better students seeking excellence rather than less able students avoiding failure.

A common theme that emerged from the analysis of the regular users' responses was that of motivation and engagement. Such students are motivated to seek help by a desire to improve their performance. These students are aware that they must work hard to achieve their goals; indeed, many aspire to the top grades. Similarly, Brown & Rodd [6] in their study investigating successful undergraduate mathematicians found that successful students were motivated by the prospect of achieving excellence. In particular, their data suggests that for some students, enjoyment of the subject is correlated with success. Hence, this internal desire motivates them further.

Generally, students who use the Centre regularly tend to be frequently attending timetabled lecture and tutorial sessions and regularly monitoring their own learning by completing problem sheets. Indeed, the MLSC has become a 'learning space' for the regular users, where by students are motivated and engaged with mathematics due to the 'working environment'. Consequently, the students are active participants in their own learning. Since students are regularly completing the work they are able to identify their weaknesses and obtain the support immediately. It appears that using the MLSC as a learning space creates a heightened sense of emotional security amongst students in which students use the support to reinforce a belief in their ability. This in turn builds confidence, which encourages students to engage further with the mathematics and the support.

Our findings suggest that the nature of mathematics support is changing from that of remedial support for the conventionally less able students, to that of enhancement for the more motivated students. It is possible that weaker students are alienated by the working environment of the MLSC and hence do not feel comfortable in regularly engaging with the support. As such, mathematics support has now evolved into a learning space for students who are motivated by excellence and who wish to enhance their grades.

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Teaching university mathematics: what mathematicians have said

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Abstract

This paper focuses on research into the teaching of mathematics at university level. It is part of a socioculturally-based research programme to characterise mathematics teaching in a university. It reports from a survey of staff teaching mathematics in one UK university department to mathematics students and to engineering students. A questionnaire in three parts was used, addressing mathematicians' views about teaching, about their students, and about developing their teaching. Findings indicated that mathematicians are highly positive about teaching and are personally committed to supporting their students. There was disagreement on the purpose of teaching mathematics at university and on the role of the lecture. Little difference in views was found between those teaching mathematics students and those teaching engineering students. Overwhelmingly mathematicians stated that they would not replace their teaching with increased research time. The paper ends with questions for further research.

1. Introduction

There have been several reports, in the years 1995 to 2000 in particular, that have addressed the issue of the mathematical decline in students' preparedness for university (for example, *Tackling the Mathematics Problem* by The London Mathematical Society [1]; *The Changing Mathematical Background of Undergraduate Engineers* by Sutherland and Pozzi [2]). The research reported in this paper has been motivated by a desire to understand this trend better and to investigate the processes of teaching that promote students' learning of university mathematics.

How do members of staff in a university mathematics department see *the teaching of mathematics*? What does it mean for them to teach mathematics? We have begun to address these questions through a short survey of members of staff in a UK university School of Mathematics on a range of issues surrounding *the teaching and learning of mathematics at university*. How do mathematicians see their role as teachers of mathematics, what are their views on their students' learning needs and what contributes to the development of their practices as teachers of mathematics? The research is rooted in a sociocultural frame; it explores teachers' perspectives in order to learn more about the aspects and issues in learning and teaching mathematics in a university. The survey was supported by 82% of staff (31 individuals). The degree of awareness and willingness among respondents to address issues relating to the teaching of mathematics in higher education can be seen as reflected in this dimension alone. This paper describes some of the findings, suggests how such findings can be illuminative in understanding the mathematics environment in a university, and identifies areas for further research activity.

2. Theoretical and Methodological Perspectives

Processes and practices in mathematics teaching and learning in a university have developed over centuries. We can think of such practices in any university as constituting a community of practice with its own participants, norms, expectations and ways of being [3], [4]. The ways in which participants, mathematicians and students, act and interact are rooted in established forms of activity including mathematics as a discipline, approaches to learning and teaching mathematics, expectations of what should be taught and learned, and the sociocultural milieu in which activity takes place. We follow Vygotsky [5] in seeing learning as taking place first in the social domain and only later as internalisation to the mental plane. Thus, the process of students' learning mathematics is seen as one of enculturation into established practices from which they develop their own mathematical perspectives.

Burton [6] explored the role of community for mathematicians and how belonging to a community shaped a person's identity. A shift was acknowledged in research activity from individual to more collaborative research. This was expressed in Burton [7]:

> *"Many of the mathematicians who contributed to this picture themselves pointed to a substantial cultural shift in mathematics from a discipline dominated by individualism to one where team work is highly valued."* [7, p. 131]

Here we focus on teaching activity rather than research. Pring [8] acknowledges that the purpose of teaching is to support learning, the teacher providing the link between the 'public world of knowledge', the subject matter, and the personal world of the learner. Our theoretical focus is therefore to locate characteristics of teaching within the sociocultural milieu of mathematics and the growth of the mathematical community within the university as a whole. The University in the study prides itself on student well-being, and the School of Mathematics has in place well-developed forms of mathematical support for students [9]. Mathematics teaching, therefore, is closely associated with such norms.

In the study we are using a range of qualitative and quantitative methods to explore research questions. Here we draw on data collected in a questionnaire designed to capture mathematicians' perspectives.

The Questionnaire

In this survey questionnaires were handed out to all academic staff in one UK School of Mathematics. All academic staff who were either permanently employed at the university or had teaching commitments on undergraduate modules were included. Some permanent staff taught only a post-graduate module at the time of the survey and some staff teaching large groups of undergraduates were employed on 'teaching-only' contracts. All were regarded as contributing to the teaching and learning environment at the university.

The questionnaire was divided into three parts, each part addressing a different aspect of teaching. The focus of the first part was on what mathematicians said 'about teaching', the second what they said 'about students' and the third what they said 'about training' (to teach). In the sections that follow we give an account of ***what the mathematicians have said***.

The questionnaire was anonymous and responses, for the most part, were requested on a 4-point Likert scale: *'strongly agree', 'agree', 'disagree'* and *'strongly disagree'.* An option *'not applicable'* was also included. A typical statement read:

The undergraduate lecture fulfils the same role that it did twenty years ago.	SA	A	D	SD	N/A

Some questions included an open response 'box' which could be used, in addition to the Likert scale, if the respondent wished; for example:

Teaching mathematics at University is about preparing students….					
to develop skills to solve a mathematical problem	SA	A	D	SD	N/A
to gain insights into the nature of mathematics	SA	A	D	SD	N/A
for a career that involves using mathematics	SA	A	D	SD	N/A
other (please specify):					

One question was entirely in open form, requesting the respondent's own words. Thus, both quantitative and qualitative data were obtained. Analysis of all quantitative data was carried out using SPSS and Excel.

3. Outcomes

3.1 About Teaching

The first question on the survey asked mathematicians how they *felt* about teaching. Various adjectives were listed from which the respondents were asked to circle all those that they felt applied to them. The five most frequently selected adjectives were, in order, *'part of the job'* (17), *'challenging'* (16), *'important'* (16), *'enjoyable'* (15) and *'worthwhile'* (12). Each adjective was assigned a positive, negative or neutral attribute with the following results:

Positive	58	enjoyable, important, worthwhile, interesting, fun, sociable, rewarding
Neutral	20	part of the job, useful, essential to growth, like problem solving
Negative	38	stressful, challenging, pointless, tiring, frustrating, unrewarding

58 words (50%) were selected that describe 'positive' feelings such as *enjoyable, important, worthwhile*. 38 words (33%) were selected that describe 'negative' feelings associated with teaching, for example *stressful, tiring, frustrating*. A further 20 words (17%) described 'neutral' feelings, e.g. *part of the job, useful.* Many respondents chose 'teaching is challenging' (16). Initially, this statement was interpreted as having negative associations. However, the word 'challenging' could be considered a positive attribute which would increase the percentage of words describing 'positive' feelings to 64% and decrease the corresponding percentage for 'negative' feelings to 19%. If 'challenging' were considered a neutral attribute the figures would be 42%, 22% and 33% respectively.

The second question asked lecturers to estimate how much time they *felt* that they spent on the various aspects of their job including teaching and planning teaching activities. The first column of figures in Table 1 shows their responses.

	All academic staff	All academic staff except those employed only to teach
Teaching and teaching related activities	43%	38%
Research and research related activities	33%	35%
University administrative duties	17%	18%
Services to the profession (e.g. journal editor)	5%	6%
Other	2%	2%

Table 1: Estimated percentages of time spent on various work-related activities.

If we remove from the calculation individuals who were employed solely to teach, then the amount of time that lecturers said that they spent on the various activities is shown in the second column in Table 1. That is, all those who were employed for both their research and teaching activities, spent an almost equal amount of time on teaching and research and quite a substantial amount (one fifth) of their time on administration.

Questions about the role of the lecture caused most disagreement. One quarter of all respondents said that '*the undergraduate lecture fulfilled the same role that it did twenty years ago*' while just over two thirds said it did not. The remainder indicated N/A. Asked how lecturers used the lecture, nearly 80% agreed with the statement *'to explain in more detail'* while around 50% agreed with *'to add (further) examples'.* In addition, an open response 'box' was given for completing the sentence '*I use the lecture to* …. . Sixteen written responses were offered, among them *'to explain concepts', 'to stimulate students to think'*, *'to give feedback'* and *'to interact with my students'*.

When asked about the purpose of teaching mathematics at university, the vast majority agreed with the statements *'to develop skills to solve a mathematical problem'* and *'to gain insights into the nature of mathematics'*. Agreement with a third statement, *'to prepare students for a career that involves using mathematics'* was less unanimous. Here 61% agreed while 32% did not. An open response 'box' was given for completing the sentence *'Teaching mathematics at University is about preparing students …'.* Among the responses were expressions of the form *'to develop problem-solving skills (and confidence) that can be applied outside mathematics', 'to think logically', 'to pass the exam'* and *'to gain personal satisfaction (and pleasure) from engagement with mathematics'.*

3.2 About Students

At a ratio of 2:1, respondents agreed/disagreed with the statements that their current cohort of students were *'competent* in *A-level techniques'*, *'coped well with the module'* and were *'as mathematically prepared as the students from the previous year'*. An open response style was adopted for respondents to complete the sentence *'If a student is stuck I would suggest to them that they (first) ......'* .The most frequently suggested strategy was *'come and talk to me/see me',* which suggested a very personal involvement with students. This response was given on 13 occasions. Other responses were of the form *'go over lecture notes / work on the problems'* (12), *'ask in tutorial'* (7), *'visit the Mathematics Learning Support Centre'* (5) and *'discuss with fellow students'* (2). A further question asked respondents to estimate the attendance rate for their module. Just over half of all respondents gave an estimate of 41% to 60% and one third gave a higher estimate of 61% to 80%.

3.3 About Developing Teaching

The vast majority (90%) of lecturers said that they *'had discussed teaching strategies with a colleague'* and had found it *'helpful'* to do so. However, only about 50% of respondents said that they *'would welcome meetings specifically arranged to discuss teaching approaches'.*

A second aspect centred on a question regarding a reduction in teaching duties. Here the views expressed were much more divided, with an almost equal number of respondents indicating that they *'would / would not welcome a reduction in teaching duties in order to concentrate more on research'*. On the other hand, respondents were almost unanimous in their response to the statement *'I would welcome a removal of all teaching duties (on a permanent basis) in order to concentrate more on research'*. With one exception they all disagreed.

4. Implications and further work

In social practice theory [4], learning is seen primarily as situated in participation in a community of practice. This practice includes both the activities designed to promote learning (such as lectures, the Mathematics Learning Support Centre) and the perspectives of staff and students participating in the activities. Here we have focused on the staff and their views of teaching. Responses suggested that staff found talking with colleagues helpful in learning more about teaching and that they found talking with students helpful in overcoming students' difficulties.

Participants showed less agreement on the role of the lecture. As most teaching takes place in the form of lectures, the role of the lecture could valuably be explored further. There are other questions to explore such as, what has been the impact of new technologies on the role of the lecture, for example, the introduction of an on-line learning and communication space? In what ways is lecturing seen to contribute to teaching and what are its advantages and disadvantages? How do lecturers work effectively with large numbers of students? To what extent is attendance/non-attendance at lectures perceived to have an impact? In what way and to what extent does the community of mathematicians at a university define the practice of teaching and learning to teach mathematics. We are exploring these questions as part of our ongoing research in which the survey is just a first step.

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Some problems associated with running a Maths Support Service

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Abstract

There exist a number of reports that offer examples of good practice in setting up and providing mathematical support in Higher Education. In many cases a standard model of drop-in or surgery classes supplemented by online learning resources is adopted. This paper examines the problems associated with such a model following a critical review of the provision of Maths Support at Cardiff University. Key features of the support such as the effectiveness of drop-in support, the flooding of the service by groups of students, and the provision of a statistical consultancy are discussed. Commentary is also provided on the attempts made to manage these problem areas and investigations into possible alternative approaches.

1. Introduction

In the study by Perkin and Croft [1], it is recorded that of the 106 universities in the United Kingdom, 62.3% offer some form of mathematics support. It is also highlighted that a predominant feature of many of these services is the provision of drop-in or surgery classes along with supplementary learning resources. Given the reliance of this approach to deal with the so called 'Maths Problem' in Higher Education, this paper attempts to outline some of the practical problems inherent in such a model following a review of the key elements of the Maths Support Service (MSS) at Cardiff University.

A terse description of the MSS will be given, before detailing some of the problems encountered thus far and what might be done to nullify such problems in the future. These will include an examination of the role of the tutor (and student) within a drop-in session, the problem of being overrun or 'flooded' by a particular student group during a session, and the need or otherwise of setting up a formal statistical consultancy. Some of the positive practices and unexpected bonuses of running the service will also be presented, along with a small number of typical student profiles (see Appendix) to give benchmark scenarios for open-ended discussion.

2. The Cardiff University Maths Support Model

Following a successful small scale pilot initiative in 2005, the MSS was set-up in 2006, with contributions from the School of Mathematics and central University Learning and Teaching funds. The MSS is advertised as being freely available to all students, not just those studying a mathematically based degree, with the initial focus being on those students making the transition to university (e.g. preliminary and first year students). In particular, the aims of the MSS are:

- To promote the MSS among all current students, prospective students and staff.
- To create a relaxed environment where students are encouraged to discuss any of their mathematical problems.

- To assist students to develop a sound basis in the mathematical skills necessary to succeed in their particular subject areas.
- To work closely with individual Schools to improve the subject specific resources available (including assistance in subject specific tutorials if required).
- To monitor the provision of mathematical support across UK institutions, endeavour to apply examples of good practice and develop innovative approaches to further enhance the service provided.

It should also be noted that:

- The MSS is **not** intended to be used as a replacement for, or alternative to, any mathematical teaching provided by individual departments.
- It is **not** intended for the facility to be used as a mathematical/statistical consultancy.

In order to meet the aims outlined above, and following examples of good practice as outlined in [2], a model consisting of drop-in sessions was considered to be an effective and sustainable approach to adopt. The sessions are managed by a small number of enthusiastic members of staff from the School of Mathematics and a number of postgraduate students with experience in delivering tutorial sessions. In addition to this provision, a website utilising the many learning resources already available was created. For full details regarding the MSS the reader is directed to the corresponding website [3].

3. Problems Encountered

As outlined in [4], an important part of professional development is to review and reflect upon your own progress. This process of analysing your strengths as well as your deficiencies also applies to the development of any service. So despite a positive initial phase of development, some of the important and successful practices of the MSS are scrutinised below and ideas on how to further enhance the support being provided are outlined. To help investigate some of the problems in more detail we pose the following questions.

3.1 Are the drop-in sessions really helping the students to help themselves?

The one-to-one nature of a drop-in session provides a unique opportunity, in terms of university education, to get to know a student and to investigate their understanding of a particular concept. However, quite often students desire a quick-fire answer to a problem, with emphasis placed on how to enhance their marks, but not necessarily their understanding of a concept. So, it has potentially come to the view of some students, that the MSS is a useful stopover to get the few extra marks they need and not necessarily a relaxed mechanism to 'chew the fat' of some topics with someone who has a bit more experience.

Tutors are reminded that their role is not to provide solutions to students but to encourage students to explore ideas and find their own solutions. Nevertheless, it is very easy for the focus of discussions to be on what the tutor does as opposed to what the student can do, particularly if the session is very busy. As a result, the 'support' provided can develop into an individual mini-lecture on a particular topic. Students are often very appreciative to receive this refresher but given that they have already been lectured on the topic, and tend to have detailed notes, just repeating the information already available to them is probably not the most effective use of a MSS tutor, even if the ideas are presented in a more clear and digestible manner than previously.

Both general education literature [5] and that in a mathematical context [6] suggest that more active learning takes place when students are encouraged to engage with material, form their own ideas, and challenge their misconceptions. Therefore an alternative approach would be for tutors to develop a style based around posing effective and sometimes challenging questions. As well as hopefully encouraging a deeper approach to learning, this method also potentially makes more efficient use of the time available in a drop-in session. The initial MSS model focused on matching an 'expert' with a problem. This can lead to difficulties if the expert is busy, or not available. Hence, by shifting the focus back onto the student, expectation on the tutor to provide 'the answer' is reduced and less time is wasted waiting for a particular tutor to become available.

It is clear that implementing such an approach is not without its difficulties. In particular, it is likely to make some students feel less comfortable, and care would have to be taken not to intimidate them with the questioning. Therefore, consideration of the various forms of student motivation [7] and learning styles [8] that exist should not be underestimated. For example, in [7] Seifert refers to following theories:

- Attribution theory - the perceived cause of an outcome. E.g. effort, luck, mistakes by the teacher.
- Self-efficacy theory - a person's judgement about his/her capability to perform a task at a specified level.
- Self-worth theory – the judgement one makes about one's sense of worth and dignity as a person.
- Goal theory - behaviours that are a function of desires to achieve particular goals.

Each of these concepts can be directly related to the students that walk into maths support services every day. For example, self-efficacy is strongly associated with students who believe they 'can't do maths', and furthermore, all support services will have experienced students who adopt a strategic approach to learning, i.e. the attainment of high grades with or without understanding (Goal theory). Simply being aware of these factors influencing student engagement can be powerful tools that aid the development of the support provided.

Given the range of approaches adopted by students, it is vitally important that tutors are given time and opportunity to enhance the skills necessary to provide appropriate support. To assist with this we have created four 'typical student profiles' which will form the base of a workshop prior to the next academic session. Here all MSS tutors will be encouraged to share and reflect upon the range of strategies that could be employed in the varying circumstances. The profiles are included in the Appendix, and the reader is invited to add their own thoughts on effective approaches to dealing with such queries, by submitting their comments on the web form available via the Cardiff University Maths Support website [3].

3.2 Can we be better prepared to cope with the service being flooded by students?

By flooding, we refer to large groups of students, possibly with the same query, attending a drop-in session at the same time. This is an issue that did not arise during the first year of running the MSS, but increased student attendance during the last academic year has at times put a significant strain on resources. Of course, this could be seen as a positive aspect in terms of student engagement with the service; however, it can also have a detrimental effect on the level of support provided.

This situation puts extreme pressure on the tutors to minimise the waiting time for students, especially as some students expect to be individually led through a range of examples by a tutor. This can lead to 'quick fixes' being used instead of establishing the actual root of a problem. Therefore, the argument for a more student focussed approach as outlined above becomes even more relevant.

The methods currently adopted during incidents of flooding are twofold. Firstly, additional tutors are timetabled 'on standby' for each of the sessions. This provides a more cost-effective approach for covering busy sessions, given that due to the informal nature of a drop-in session, it is virtually impossible to predict in advance when the flooding will occur. In addition, for incidents involving large groups of students with similar queries, a practice of re-locating the corresponding students to an alternative venue has been adopted. The re-located group is still overseen by a tutor, but the temptation to provide a lecture to the group is resisted. Instead the group are encouraged to work together and discuss various ideas and approaches to the problems. The importance of dialogue in learning is often undervalued in mathematics, where the common perception is one of individuals working alone in an attempt to obtain the solution to a problem. However, as highlighted in [9], Carnell reports on how "a community of learners generates knowledge". Indeed, in practice it has proved to be very effective with students actively taking part in sessions by explaining and presenting ideas to others in the group. As a result a more concerted effort in general is adopted to encourage discourse among students within all drop-in sessions.

Requiring a 'breakout' room of this nature is not something that was originally anticipated, and having a room available cannot always be guaranteed. Therefore, is it possible for an alternative model to be considered? One possibility is presented by examining the findings of the Counselling Service at Cardiff University [10], [11]. In an attempt to reduce their extensive waiting lists and the number of repeat visits required, the perhaps counterintuitive step of increasing the time allocated to an initial support session from 20 minutes to 90 minutes was taken. It had the desired effect. Despite seeing approximately the same number of students as in 2007, as of September 2008 the Service has no waiting list for the first time in ten years. It was found that spending this additional amount of time with the client during the first meeting allowed problems to be explored and a plan to be formulated regarding future goals, thus reducing the requirement of future support.

This approach may not be suitable for all queries faced by a maths support service, but it does fit the ideology of helping students to help themselves. As a result, a similar method will be trialled by the MSS in Cardiff during the forthcoming academic year, with particular focus on students who believe they 'can't do maths' and groups of students undertaking project work.

3.3 Should the MSS be providing a Statistical Consultancy?

As outlined in section 2 above, it is not intended for the MSS to be used as a statistical consultancy. However, since its inception, the MSS has experienced a sharp increase in the number of students requiring statistical assistance with detailed research work, with more and more examples bordering on consultancy work. To date the MSS has been fortunate to have tutors with the necessary experience available to meet the demand (in most cases), but it has been increasingly necessary to inform students on what are acceptable levels of support. Furthermore, with the sometimes subjective nature of statistical analysis, it was felt necessary to produce a disclaimer to protect tutors in case suggestions, particularly for research work, were misinterpreted in any way or incorrect. This has now been adopted on all MSS feedback forms and is outlined below.

Disclaimer: The role of the service is to support students to produce their own work. Therefore it is the responsibility of the student to verify any methods/results discussed during the sessions and any subsequent work that is produced.

Given the obvious demand for more complex statistical support/consultancy the MSS has assisted the University in putting forward proposals for additional statistical support specifically for research work to run in conjunction with the current service. In the meantime however, resources will continue to be made available to assist in queries of this nature, albeit in an informal manner.

It should also be noted that providing this form of support has also led to some unexpected bonuses. Relationships developed from initial support has helped with communication between Schools and created further inter-disciplinary research and teaching opportunities. Individual tutors have also benefited in some cases by being included as co-authors in corresponding research work.

4. Further considerations

Clearly there are many other considerations that need to be taken into account when setting up and running a maths support service of this nature, such as funding, staffing, not to mention the formal measurement of the effectiveness of such services (which is probably worthy of a research project of its own!). For a more exhaustive list of considerations the reader is directed to the work of Lawson, Croft and Halpin [2].

It should also be noted that despite the issues presented here, setting up and running a mathematical support service is an extremely rewarding experience which can make a difference, as the following typical student comments make clear.

> *"Brilliant, really helpful, would probably have dropped out if it wasn't for Maths Support." Year 1 student* – Music

> *"Would fail without the help." Year 2 student* – Maths

> *"I have spent a long time looking for somebody who might be able to help me with my statistical problem and nobody has been able to offer me the level of support and information that I have required or that the tutor has just provided me with. It has made such a refreshing change to come away from a meeting feeling like I understand what is possible with my data and confident enough to try it out for myself."* Doctoral Researcher – English, Communication and Philosophy

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Appendix

Mathematics Support Service: Typical Student Profiles

Student A – "I can't do maths"

Student A is currently on a Chemistry degree scheme with a high numeracy content. As the main focus of the degree scheme is Chemistry, and not the numeracy, the numeric part of the course is taught very quickly with multiple question sheets set. Student A has never felt particularly confident with maths, and the high turnover of work that he has to do makes him feel less and less secure about his ability.

Student A attends Maths Support with a file full of jumbled notes, half attempted question sheets and an uncompleted coursework that is due in the next few days. When he is approached by a support tutor, and asked what the problem is, he replies "I can't do maths".

Student B – "Here is my data, what statistical test do I use?"

Student B is a postgraduate student in Optometry, and has been collecting data for her thesis over the past three years. When it comes to finally analyse the data, Student B's supervisor, who knows very little about statistics, recommends that she attends the Maths Support Service.

Student B also has little experience of statistics, and has only picked up some key terms and concepts from browsing the internet. She is getting really frustrated as she feels isolated, and doesn't know anyone in her home department that can help with statistics.

Student B attends Maths Support, with a laptop and a spreadsheet full of data. After explaining to a tutor the story behind the data, she asks "What statistical test do I use?"

Student C – "How do I integrate – my exam is later this afternoon"

Student C has an exam later this afternoon and so runs into Maths Support with just a few pens and pencils. He always leaves things until the last minute, and is still unsure how to integrate some simple functions, but he wants to be quickly taught the basics so that he might do better in the exam this afternoon. Student C can stay for twenty minutes only, and so asks a tutor "How do I integrate?"

Student D – "How do I do question 4?"

Student D is a Maths student, who has been working on a coursework assignment in the library. She manages questions 1 to 3 fine, but comes to a halt has soon as she sees question 4. Student D looks at the time, and notices that a Maths Support session is happening down the corridor.

Student D walks into Maths Support with the coursework sheet, and asks the tutor "How do I do question 4?" Afterwards, she calls into Maths Support again, and asks "Is my answer correct for question 2?"