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Recruitment and retention of students – an integrated and holistic vision of mathematics support

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Students' lack of preparedness for the mathematical demands of higher education is affecting a wide range of programmes in universities worldwide. In the UK this has been recognized at the highest levels and provoked several inquiries.

The ability to use mathematics in courses as varied as nursing, biosciences, and business is an essential skill for success. Any factors that diminish students' ability to perform competently will impact upon large groups. Consequences include failure, loss of self-esteem and financial losses. Conversely, strategies that improve performance lead to improvements in retention, progression and cost-effectiveness.

This article details the way a research-led university has faced the challenges and brought mathematics support high up its strategic agenda, leading to a university-wide support strategy. It describes the implementation of this strategy and shares experiences gained for the benefit of policymakers and practitioners who are interested in enhancing their own institution-wide support provision.

Keywords: mathematics support; progression; retention; statistics support; strategies for success

1. Introduction

It is now accepted throughout Higher Education that a change has taken place in most, if not all, UK universities and colleges. There has been a realization that within all institutions there are students who have not had the opportunity to develop fully the pre-requisite mathematical and statistical skills for their courses, and who need additional help in order to survive, progress and succeed. Those teaching in higher education, on a wide range of courses, are now coming to terms with the fact that significant numbers of their students lack many of the skills that they would have expected to have been mastered at school. This lack of preparedness has consequences for student and staff satisfaction, student self-esteem, retention and progression, and financial costs to universities and to students arising through failure to progress or complete a course.

The problem is not restricted to the UK. MacGillivray and Cuthbert [1] describe weaknesses observed in the mathematical confidence of first-year engineering students in Australia. Kajander and Lovric [2] discuss the 'transition gap' between secondary and

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tertiary mathematics in Canada. Attempts to bridge the ‘gap’ via bridging mathematics courses at the University of Hong Kong are described in [3].

This article first provides some background evidence that the problem is widespread throughout higher education in the UK and impacts upon many disciplines. After briefly describing the historical background to the provision of supplementary support at Loughborough University, it describes how a *university-wide* strategy to tackle the problem has been developed and implemented, describing in some detail the main parts of the mathematics support strategy. It will be of interest to university policymakers and practitioners and those who provide other university-wide support services in higher education institutions throughout the world.

2. Background

The report *Tackling the Mathematics Problem* [4, p. 1] noted:

the profound concerns of those in higher education about the mathematical background of students applying for courses in mathematics, science and engineering.

Engineering is one discipline for which mathematics is essential and there is evidence that many students are ill-prepared mathematically for the demands of their courses. The report *The Changing Mathematical Background of Undergraduate Engineers* [5, p. 5] notes:

Students are now accepted on engineering degree courses with relatively low mathematics qualifications in comparison with ten years ago.

In its inquiry into undergraduate physics, the Institute of Physics [6, p. 5] reported

... changes in the nature of mathematics courses at school level have led to students being less proficient and confident in the mathematical skills required by physics degree courses.

Engineering and the physical sciences have traditionally placed great importance on sound pre-university mathematics education and so it is to be expected that a lack of preparedness will have significant consequences for these disciplines. However, there is evidence that many other disciplines are now experiencing similar problems. Tariq [7] provides evidence of a decline in basic numeracy amongst first-year bioscience undergraduates between 1995 and 2000. In the context of numeracy as a key skill for all graduates, Tariq and Cochrane [8] note that even when students are confident in their own ability, this confidence may be misplaced since their evidence shows a mismatch between students’ perception of their ability and actual levels of competence. They highlight the need for universities to adopt a more holistic, rather than piecemeal, approach to key skill development. It will be apparent in what follows that this is a philosophy that the authors would endorse in respect of mathematics support for all students.

UK universities have responded imaginatively to tackle these challenges including development of summer schools, bridging mathematics courses and peer-support. An overview can be found in the LTSN MathsTEAM project (<http://mathstore.ac.uk/mathsteam/>). One approach is through mathematics learning support centres which many universities have now established. They vary in size, from small enterprises involving perhaps only one member of staff on a part-time basis, to fully fledged university-wide centres.

The remainder of this article describes the work undertaken at Loughborough University – a traditional research-led university – to develop a strategy for tackling

the problems cited in a holistic, university-wide way, and for supporting students with varied needs.

3. Historical background at Loughborough University

Provision of supplementary support at Loughborough had its origins in 1996 when funding was secured by the Department of Mathematical Sciences to establish a specialist centre. The primary aim would be to help many of the students embarking upon engineering undergraduate programmes. The initial bid was for funding sufficient to meet salary costs and overheads of a manager for a 2-year period, and to pay for a range of resources. Because of early successes, the Centre was established on a more permanent basis from 1998. From the outset the intention was to develop a 'front-line' and student-orientated service which would give students themselves access to facilities and help over and above that was normally provided. It was not the intention to become a 'teaching' support centre, although a by-product has been learning resources which many lecturers have used. Although the Centre was originally funded to support engineering students it was recognized early-on that many of its resources would be useful to a wider range of students and so facilities were opened up to any undergraduates who might benefit from them, and indeed to broaden the range of resources to include material relevant to other groups. Thus, the Centre aims to provide a very high quality of service and an exceptional range of learning resources to any student who wishes to take advantage. Details of the early experiences can be found in [9] and [10].

In 2002 a significant development was the establishment by the University of the Mathematics Education Centre (<http://mec.lboro.ac.uk>). Recognizing the challenges associated with mathematics education, and particularly the mathematical education of engineers, the university made a strategic decision to develop a new centre, the *raison d'être*, for which would be much broader. It would subsume and enhance the original support centre, oversee the teaching of mathematics to Loughborough University's many hundreds of engineering students, and provide a focus for those staff interested in mathematics education. It went on to provide an infrastructure within which staff would be supported in making external grant applications, hosting national teaching and learning projects, and developing pedagogic research. The many fruits of this development will be described later in this article.

In 2005, in recognition of its outstanding contribution to mathematics and statistics support, the Centre achieved *Centre for Excellence* status from the Higher Education Funding Council for England. This award, won collaboratively with Coventry University, is worth £4.85 m over 5 years, well over half of which is being used to improve the student learning experience at Loughborough University. Key objectives include opening an additional drop-in centre, providing a postgraduate statistics advisory service, enhancing special needs support, developing innovative teaching approaches and underpinning all of this with a programme of pedagogic research. Details of this work are available at <http://www.sigma-cetl.ac.uk/>

4. Mathematics support as a strategic priority in the university

Loughborough University's Strategic Plan – *Towards 2016* – describes the university as a research-intensive institution, which integrates its research and teaching at every opportunity to provide a top-quality research-led learning experience for its students

(http://www.lboro.ac.uk/admin/policy/strategic_plan.pdf). The university's commitment to the development of mathematics support is long-standing as evidenced by its continued funding of this activity since 1996. That this and related activities are high amongst the strategic priorities of the university is evidenced in the plan which states that, nationally, the Centre will be known for leading-edge curricula including cross-campus specialist support in areas such as mathematics and statistics. The previous Strategic Plan (2002–2007) committed to the establishment of the Mathematics Education Centre – a commitment which was realized in 2002 when the new centre opened. This high-level encouragement for the work has been an important ingredient of the success. With the strategic importance of mathematics support recognized at the highest levels in the university it became essential to develop and implement a formal Mission statement. The current version can be found on the Centre's website <http://mec.lboro.ac.uk/pages/about.html>. It is interesting to note that Thomas [11] discusses measures to improve retention, particularly in respect of widening participation and recommends that these are carried out as a formal institution-wide activity and not just the responsibility of a few people 'who care'.

5. Overview of the mathematics support strategy

Since 2002 an *integrated* and *holistic* vision of mathematics support has been developed: one which acknowledges explicitly the real problems faced by many students when they arrive at university and which tries to address them, proactively and at many levels. By *integrated* it means that the Centre staff, collectively,

- (a) offer university-wide mathematics and statistics support to any students (<http://mlsc.lboro.ac.uk>); although primarily intended for those in the early stages of their work some groups of students make extensive use of the facilities throughout their first year and beyond.
- (b) teach modules of mathematics and statistics to specialist mathematicians and other non-specialist groups such as engineering undergraduates,
- (c) liaise regularly with staff in other departments to ensure that the curricula meet the needs of these departments and that the departments are made aware of the difficulties their students are facing and the solutions that are proffered,
- (d) contribute to national teaching and learning initiatives which deliver resources and advice for staff and students in other universities,
- (e) undertake pedagogic research: a unique research focus has been developed, having established a group of academics dedicated to mathematics education in the university sector.

This unique blend of teaching, support and pedagogic research, together with the integrated approach, ensures that the Centre is in a position to use its influence and the evidence gathered to bring about a positive change in the student experience and thus contribute to the *retention* of students.

Well-resourced, open-access drop in centres, staffed by well-qualified and experienced mathematics teachers are a key feature of the provision. Vulnerable groups, including students with disabilities, have been identified for special assistance. Students entering university with non-traditional backgrounds have been offered tailored courses. For those students who are extremely mathematics anxious, the *Eureka Centre for Mathematical Confidence* (<http://eureka.lboro.ac.uk/>) has been established. Mathematics support has

moved from a position of responding only when students report with problems, to a *proactive* service seeking out and addressing problems before they get out of hand. Most recently, the commitment to enhancement *for all* is manifest in the development of a Statistics Advisory Service for postgraduates, and a resource and activity centre for specialist mathematicians in later years. The Centre works with local schools to encourage young people to consider careers in mathematically based subjects – these involve bringing them in to the Centre to experience university mathematics and the support that is offered, at first hand. This *holistic* vision of mathematics support is used to promote the university and to emphasize the value placed on the quality of the academic support provided. Thus, the Centre contributes in a significant way to student *recruitment*.

In developing this strategy, it has been recognized that it is insufficient to simply offer a drop-in or tutorial service alone. Feedback from staff at other universities indicates that offering a drop-in service alone will attract few students; if significant numbers are to be attracted and convinced of the value of returning there needs to be comprehensive marketing. There needs to be resources to help many different groups. These resources should be available in a variety of forms to appeal to the different preferred modes of learning found amongst diverse student groups. Help needs to be available *when* students need it and from staff who are well-suited to provide it. Sutherland and Dewhurst [12] express concern that university lecturers are not always the best people to be undertaking additional mathematics teaching and support. Tutors in the drop-in centre described here are carefully selected and given training. In short, support must be student-centred and evidence from the Centre demonstrates that when it is, students do want to make use of it, and do want to learn.

The strategy recognizes and is organized to reflect this. It can be considered conveniently in four parts (Figure 1).

Part 1: Preparation and facilitation

This part involves five distinct areas of activity which are undertaken independently of interaction with students. These are

- Developing the physical centre
- Developing and disseminating resources and support mechanisms

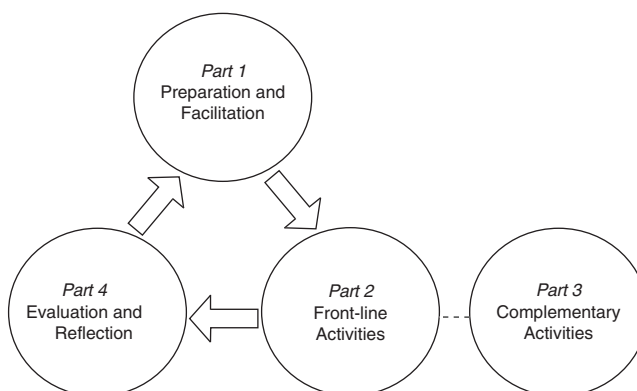


Figure 1. The four parts to the mathematics support strategy.

- Raising awareness
- Staff development
- Research to underpin support work

Part 2: Front-line activities

This part comprises front-line activities which impact directly on different student groups:

- Mathematics Learning Support Centre
- Support for vulnerable students

Part 3: Complementary activities

The support, which students need, clearly depends in part on what and how they are taught at university and the prior knowledge they acquire at school. This part outlines complementary activities undertaken by the Centre at Loughborough:

- Teaching of engineering mathematics
- Work with local schools

Part 4: Evaluation and reflection

Here the front-line activities are assessed and refinements are made.

An overview of the way in which this strategy is designed is shown in Figure 2 and its implementation is described below.

5.1. Preparation and facilitation

5.1.1. Developing the Physical Centre

As part of its strategy, the university provided space to develop a student work area dedicated solely to mathematics support. This is a well-furnished and comfortable environment in which students can: work alone, work in small groups, access online and paper-based learning resources and seek one-to-one help. Following the award of Centre for Excellence status, the Centre was enhanced by the opening of another location in the central part of campus, geographically placed to serve better the needs of some groups of students.

5.1.2. Developing and disseminating resources and support mechanisms

To enable large numbers of students coming from different departments and with varied backgrounds to be supported efficiently, it is essential that resources are available that both students and staff can call upon. In 2001 a study was undertaken to gauge the extent of provision of Mathematics Support Centres [13] and distil elements of good practice. About 95 UK higher education institutions reported back of which 46 had support centres. The number had increased to 66 out of 106 by 2004 [14] and is now significantly higher as more centres have been funded as part of the Centre for Excellence funding awarded to Loughborough and Coventry Universities. The study reported upon those facilities and resources most favoured and most used by students. The most commonly available resources were printed ones with over 70% of respondents indicating that paper handouts were available in the centre. The resources most valued by students (after the one-to-one support from staff) were paper handouts.

The Mathematics Education Centre has been at the forefront of developments to produce materials for resourcing support centres. It has worked with the UK Higher Education Academy's Mathematics, Statistics and Operational Research Network

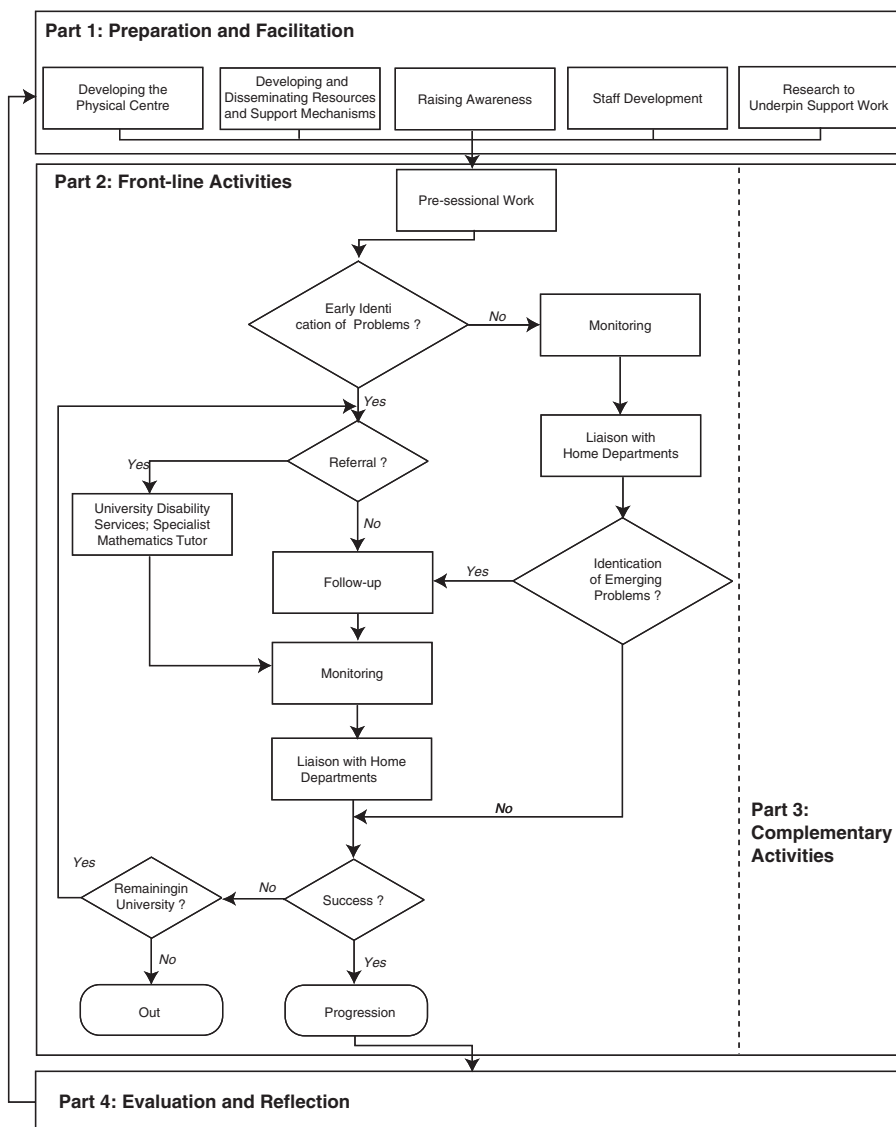


Figure 2. Overview of the mathematics support strategy.

(<http://mathstore.ac.uk>) and other universities to make much of this material publicly available. For example, through the mathcentre website <http://www.mathcentre.ac.uk>, students and staff have free access to handouts, video tutorials, diagnostic tests and exercises on a wide range of basic topics known to cause problems at the transition to university study (arithmetic, algebra, trigonometry, functions and graphs, geometry, vectors and calculus). Engineering Mathematics First Aid Kit leaflets (<http://www.mathcentre.ac.uk/staff.php/packs/>) are very popular with students, as are Facts and Formulas leaflets (<http://mlsc.lboro.ac.uk/paperres.php>).

A substantial curriculum development project, led from Loughborough, has been HELM (Helping Engineers Learn Mathematics; <http://helm.lboro.ac.uk>). Workbooks and computer-based assessments covering most topics studied in first- and second-year

engineering mathematics courses are available under licence at a modest cost. For those staff seeking help in the mathematics support of students with additional needs, the DDIG website is an invaluable resource (<http://ddig.lboro.ac.uk>).

5.1.3. *Raising awareness*

It is essential that there is a high level of awareness amongst students and amongst staff to enable them to direct students. Anecdotal evidence from colleagues in other universities suggests that where staff have simply made themselves available at specific times to offer additional support uptake is, in general, poor. Mathematics support mechanisms need to become embedded in the culture of the university. Furthermore, over time students must learn that there is an expectation that they will use the support mechanisms to improve their situation, and in turn must see them as valuable resources.

Efforts to develop such an environment begin even before students apply to the university through a presence in the university prospectus, and through links with local schools. An important aspect of the strategy is for Centre staff to play an active part in open days. The Centre maintains a presence centrally on such occasions and visitors are also directed to the Centre to see facilities at first hand, and to discuss particular concerns with Centre staff.

The Centre has leaflets to advertise its facilities and these are distributed to approximately 3000 first-year students in their first weeks at university. Leaflets are also available in the library and posters are displayed around campus. Some academic staff use the Centre to distribute mathematics workbooks and this has the advantage of encouraging students to familiarize themselves with the Centre's location. All students are informed about the Centre, via leaflets, emails, induction talks or by one of their lecturers. Some visit the Centre with their personal tutors to see the resources available. A recent development has come from the students themselves who have developed a promotional DVD (<http://mlsc.lboro.ac.uk/services.php>). Recommendation by a lecturer is known to be important as feedback from students cite this as one of the main ways of alerting them to the presence of the Centre. This is encouraged through Staff Development activity as described below.

5.1.4. *Staff development*

A university-wide programme of staff development activity to inform staff about the work of the Centre and the ways in which it can help staff and their students is a useful contribution. The Centre runs workshops to inform academic staff of developments in school mathematics curricula and the ways in which these impact upon higher education. Another workshop looks at difficulties faced by dyslexic and dyscalculic students when learning mathematics and explains the provision currently available. For all staff new to lecturing there is a specific programme of activities. The strategy includes embedding the courses described above within this programme.

A seminar programme involving external speakers has been used to inform Centre staff about developments elsewhere. There is also specific training for staff involved in the support centre itself – those who tutor during the drop-in sessions learn about resources available and how to use these so that their time in the Centre can be employed efficiently. Receptionists also have training to ensure that they can present a helpful and reassuring front when students arrive for the first time.

5.1.5. *Research to underpin support work*

The Strategy of the Mathematics Education Centre recognizes explicitly the importance of underpinning its work with pedagogic research, in order to inform developments, make evidence-based changes, and to evaluate its various initiatives, as well as to contribute generally to the knowledge base and research literature. The research is highly focused upon mathematics education in the higher education sector and seeks to explore, analyse and impact upon policies and practices within the higher education sector and beyond. The Centre is unique in the UK in comprising a group of academics who are not only practising teachers of university-level mathematics but also researchers of the teaching, learning and support of mathematics at this level. This symbiotic relationship, associating research and practice, has enabled new research questions to emerge, hypotheses to be tested and new modes of teaching and support to be explored. Just a few examples of this work are given below; the interested reader is referred to the Centre's website (<http://mec.lboro.ac.uk>) for details of the full range of activities.

Wherever possible the interventions in support of students are closely monitored and evaluated. One such initiative, reported in Bamforth et al. [15] was designed to support incoming engineering undergraduates who had non-traditional mathematics qualifications via a pre-sessional summer school. The research was based on detailed recording of the uptake of support offered, and comparison with the coursework and examination marks of the different groups of students. Questionnaires were used to investigate student perceptions of the support system. The research tackled the issue of the widely varying mathematical background of students accepted onto mathematically based subjects, and retention of these students. It also demonstrated that with considerable extra help such students can succeed. Results are not always positive however – an important finding was that students, who are given extra help to enable them to succeed in the first year, often go on to fail in the following year when the intensive help is no longer available. Whereas the summer school started to tackle problems before students started their university engineering course, some initiatives are designed to work with struggling students throughout their first year. The paper by Symonds et al. [16] reports research into an initiative introduced to support physics students who were mathematically less well-prepared than some of their peers. The students were taught in a separate group, using different materials and a different teaching style, but the same assessment methods were used for both groups. An evaluation of the initiative was conducted, by comparing attendance data, coursework results and examination results. A key outcome of the initiative was an increase in the module pass rate from 48 to 67%. Moreover a significant finding, which had not previously been reported in the literature, was that well-prepared students, who failed a mathematics module, tended to fail the course as a whole. This was not the case for less well-prepared students and suggests that efforts directed to helping these students in mathematics are worthwhile in terms of their overall potential to progress.

There is increasing awareness in the UK of the need to attend to the educational requirements of students with disabilities. Indeed, recent legislation makes it unlawful for universities to discriminate against disabled students, including students with learning disabilities such as dyslexia. Moreover, universities are required to be proactive in the support of students with disabilities and to make reasonable adjustments so that disabled students are not placed at a substantial disadvantage. In 2000, it became apparent to staff working in the Centre that some of the students seeking mathematics help were dyslexic, but little was known about ways in which these students might be supported. Several research questions emerged such as 'Does dyslexia impede the learning of

mathematics in higher education, and if so what are the particular difficulties encountered and can these be overcome?' Case study work by Perkin and Croft [17] showed that dyslexia does have the potential to impact negatively on success and progression in mathematics, but that with dedicated, specialist support and by teaching students alternative strategies they can overcome many hurdles and succeed. Mathematical problems are even more acute for students who are dyscalculic. Research by Trott and Beacham [18] has been undertaken to develop a screener designed to alert professionals to university students who may have this learning disability. Prior to their work, no such tool existed. Screeners that were available concentrated on screening children and were inappropriate for adults and a higher education environment. The paper describes the development of test items, and initial trials confirmed the screener's potential to discriminate between students who have/have not got dyscalculia. Follow-up work reported in [19] describes extensive trials involving students at 23 institutions. Trott is now working with a publisher to make the screener widely available.

A final example will illustrate that the support provision is not purely remedial, and as has been stated, represents enhancement for groups of non-struggling students. Focus group work by Croft et al. [20] has been used to inform the development of a resource and activity centre for specialist mathematicians in order that more of them retain a positive attitude to studying mathematics, and so that those who want to undertake postgraduate study are better prepared. The work yielded interesting perspectives on peer support, independent learning and how students see their careers developing. An action research methodology has been adopted whereby refinements to the provision will be made year-on-year as the centre evolves.

5.2. Front-line activities

5.2.1. Mathematics Learning Support Centre

There are two dedicated locations on campus for mathematics/statistics support. These comprise open plan areas where students can drop in to receive one-to-one help. No appointment is necessary. Additionally, there are side rooms for group study and quiet study. Computers are available at both locations. Receptionists staff both centres and this is seen as a very important asset to the centre as there is always a member of staff available to welcome students and offer advice on resources. Academic staff from the Mathematics Education Centre and the Department of Mathematical Sciences provide 40 h per week of one-to-one help. Postgraduate students provide back-up support when the centres are busy. This support includes help with mathematics and statistics software packages. In addition to the drop-in service for mathematics and statistics, there is a Statistics Advisory Service for postgraduate students and final-year project students. All of this is free at the point of service. (Further details are available at <http://mlsc.lboro.ac.uk>.)

Pre-sessional materials are sent out to hundreds of students in the weeks before they start university. The centres have several hundred textbooks, including many which are the recommended texts for different mathematics/statistics-based modules. Diagnostic tests are available for individual students and for whole cohorts of students. Workshops are offered throughout the year. Topics include preparation for employers' numeracy tests, statistics, basic algebra and calculus, calculator use and accessing online resources.

Monitoring of students' progress is vital to ensure that students encountering difficulties are identified and appropriate action can be taken. Monitoring is carried out in a number of ways. A database was established to track usage of the drop-in facility.

This information is used to determine which students are using the Centre most and identify which programmes of study they are following. An important part of the strategy is then to liaise with students' departments. Such liaison allows information to be fed back and steps can then be taken within the departments to address any underlying problems. Departments can also provide information to the Centre on prior qualifications of students and thus the pre-session courses and other work can get off to a good start.

5.2.2. Support for vulnerable students

Vulnerable groups, including students with disabilities, have been identified for special assistance. Before students arrive at university, measures are taken to identify and deal with potential problems early on. For example, a residential pre-session course [21] has been offered to groups of students who do not have the background in mathematics that historically would have been required. Each year, with the arrival of new students at university, a priority is to identify those who would benefit from support and tuition over and above that which is normally provided. One vehicle for this is diagnostic testing. Engineering, physics, human sciences and economics students are some of the, over 1000, students who take a diagnostic test at the start of the term. Threshold marks are set for each test and students achieving marks below the threshold are identified as being 'at risk'. Prior qualifications, self-referral and tutor referral are also used as indicators of students who may be 'at risk'. Proportions of 'at risk' students within departments range from very low to about 15–20%.

It is becoming common to find that some of the students identified as being 'at risk' have specific learning difficulties, often dyslexia and occasionally, dyscalculia. The Centre is able to offer specialist mathematics and statistics help from a team of dedicated tutors with particular expertise in specific-learning difficulties. If appropriate, the student will be provided with one-to-one support. Other students who have been helped include those who are blind or partially sighted.

Although early identification of 'at risk' students is carried out, there are some students for whom problems arise only after commencing study at university. Close liaison with many departments means that students who are not progressing well are referred by their departments. Moreover, other central services, such as the careers service and disability services refer students to the Centre. Finally, self-referral by students is also a common means of identifying emerging problems.

It is essential that students identified as 'at risk' are offered appropriate support. At Loughborough University, the provision for 'at risk' students is extensive. Lunchtime refresher courses in basic mathematics and statistics are run throughout the year. One-to-one help in mathematics and statistics is available, through drop-in surgeries at two locations, for 40 h each week. For some students personal action plans are drawn up. A member of the Centre's staff meets with the student on a regular basis and the student is given actions to follow up before the next meeting (Figure 3). The outcome of these initiatives is commented upon in Section 5.4.

5.3. Complementary activities

5.3.1. Teaching of engineering mathematics

In 2006–07, the Mathematics Education Centre was responsible for the delivery of 18 mathematics and statistics modules to engineering undergraduates. Most of the staff

The screenshot shows a Microsoft Access window titled 'Microsoft Access - [SelectActionPlan]'. The report is titled 'Mathematics Learning Support Centre' and 'Action Plan'. It displays the following data:

StudentID		Date	
A654321		11/10/2002	
ForeNames:	Surname:	ProgrammeCode:	Dept:
John	Smith	0000	EL
Action			
Read handouts/ do exercises on simultaneous equations and changing the subject of the formula.			
RecommendedCompletionDate		ActionCompleted	
25/10/2002		<input type="checkbox"/>	
ReviewDate	ReviewTime		
28/10/2002	10:00 AM		
Notes			
Topics for future study, identified by diagnostic test, are quadratic equations, fractions, indices and logarithms.			
Contact Details:			
Carol Robinson			
Email: c.l.robinson@lthm.ac.uk			

At the bottom, it shows 'Page: 1' and 'Ready'.

Figure 3. Database report – action plan for an individual student.

involved with teaching mathematics to engineering students use HELM workbooks and associated computer-assisted assessment. These resources have been developed through the involvement of staff in major, national, teaching and learning projects.

The HELM learning resources consist of workbooks, computer-aided learning (CAL) courseware and computer-aided assessments (CAA). High-quality printed workbooks cover the basic engineering mathematics in topics such as calculus, algebra, Fourier analysis, Laplace and z -transform methods, ordinary and partial differential equations, complex analysis, numerical methods, probability and statistics and modelling. The importance of contextual and engineering problem solving approaches to motivate the learning of mathematics for engineering students is recognized by the inclusion of engineering examples and two workbooks devoted to engineering case studies.

The CAL courseware consists of on-line interactive lessons complementing some of the earlier workbooks. However, now the Centre is taking advantage of advances in technology to develop podcasts which can be easily delivered via our virtual learning environment (VLE).

Helping Engineers Learn Mathematics uses an integrated web-delivered CAA regime for both self-testing and formal assessment. Students are typically tested five times each semester with questions delivered over the web. They can take as many trial (formative) tests as they like, thus encouraging them to engage more in their own learning, before taking a one-attempt summative test. This pattern of study followed by assessment helps motivate students to keep up with their studies, thereby improving achievement and progression. A major benefit for staff is that CAA reduces the burden associated with continuous assessment. A possible concern associated with flexible access facilitated via web delivery is that of cheating in unsupervised summative testing.

As well as being used to support lectures, the HELM resources can be used independently by students allowing them to work at their own pace. Consequently, they are ideal for self-learning too.

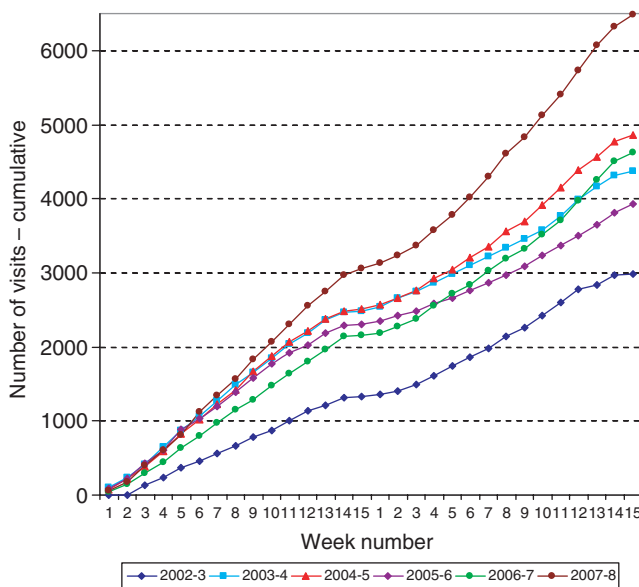
Centre staff are keen to ensure that the syllabi they deliver are relevant to the engineers of the future. Consequently, they keep pace with degree programme development by tailor-making some first-year modules to align them to their incoming students' qualifications and to their course requirements. This was the case in 2006–07 for students studying Materials Engineering. The year 2007–08 saw some new modules introduced for students of Civil Engineering, in which Matlab, a computer algebra package used widely in industry, was introduced in the first year, first semester, mathematics module. Staff in the Centre also teach on modules for mathematics undergraduates and Science and Engineering Foundation Year students.

The Centre monitors the mathematics progress of the engineering students it teaches. Tutorial attendance is recorded, as are diagnostic and computer-based test results. As engineering students sit regular computer-based tests as part of their assessment in mathematics, tracking of individual students or whole cohorts is then possible. Students who are not attending/not performing well in tests can be identified and offered support, if appropriate. Information on attendance and test results is regularly sent to departments and personal tutors receive the information. Departments can then quickly act upon the information and intervene to advise any students who are not performing well. Centre staff have established regular meetings with engineering teaching coordinators to ensure the service provided is meeting the needs of their students.

Centre staff are also proactive in seeking to integrate new technologies into the teaching of mathematics and statistics, where appropriate. New teaching facilities have come on-stream which provide superb opportunities for doing this. In preparation, teaching staff have attended training sessions in the use of interactive whiteboards and hand-held voting devices and a number of them have now trialled some of the new technologies. In addition, seminar speakers have demonstrated how they use technology in their own institutions.

5.3.2. Work with local schools

The Centre is strongly linked to external networks that support and explore mathematics teaching at school – networks which provide links to schools which are centrally involved in the preparation of students for university study and the transfer from school to university. For example, the Centre hosts the Leicestershire Further Mathematics Network Centre which provides opportunities for school students to study advanced, award-bearing courses in mathematics whilst still at school. Students either attend the university on a weekly basis, or in some cases university staff teach the students in their own schools. Thus, the Centre has been able to contribute to a national programme which in 2007–08 alone has resulted in a 20% increase in the number of AS Further Mathematics, and a 15% increase in the number of A2 Further Mathematics qualifications awarded. Related work with younger school students is designed to encourage them to consider careers in mathematically based subjects and to bring them into the Centre to experience university mathematics and the support that is offered at first hand. One such event – a workshop on mechanics – is described in Lee et al. [22]. Thus the Centre contributes in a significant way to the continued supply of young people into our discipline areas – and thus to student recruitment at many other universities in addition to Loughborough.



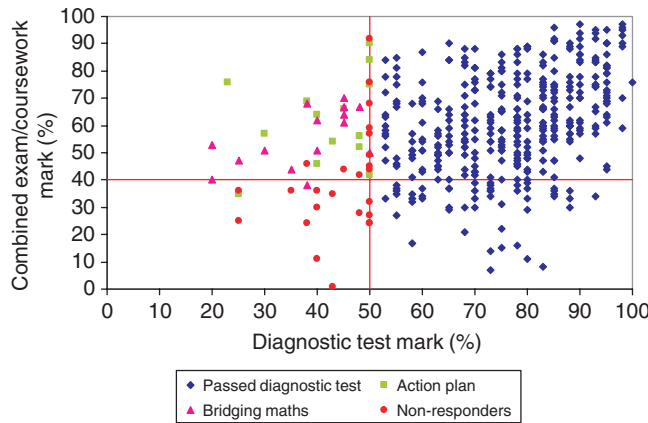


Figure 5. Effectiveness of action planning and bridging mathematics.

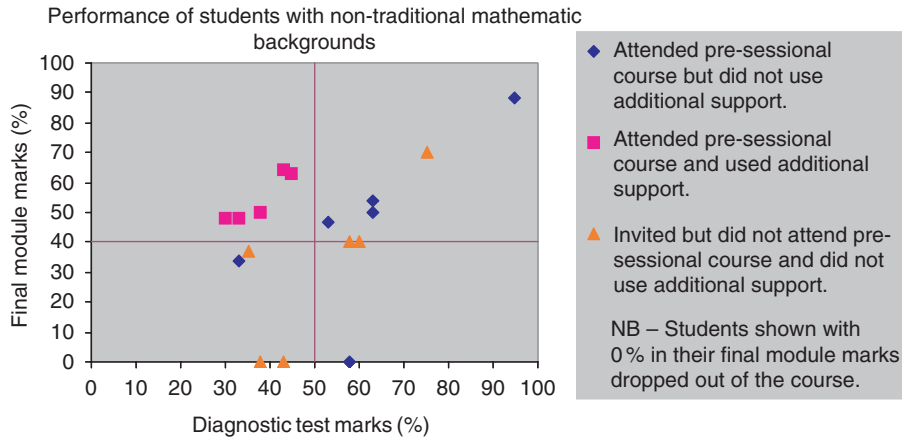


Figure 6. Effectiveness of pre-session courses and additional support.

but who took advantage of the support offered, either by engaging in personal action planning, attending a specially designed bridging maths course or attending a pre-session course and taking advantage of follow-up support, went on to successfully complete their mathematics modules. Liaison with engineering departments is underway to address the issue of students who do not respond to offers of help.

Success has also been achieved with students who have additional needs. The number of dyslexic students receiving mathematics support has grown since the inception of the service in line with trends experienced by those supporting English language. The growth now appears to have ceased and the numbers stabilized. The number of students either self-referring or being referred to support staff by Faculty since 2001 are shown in Table 1. It turns out that not all of these need mathematics support. For example, in 2007–08 a total of 31 out of the 42 students received support, compared to 46 out of the 47 in the equivalent period of 2006–07.

Table 1. Demand, by faculty, from students with additional needs seeking specialist help.

Faculty	Number of students needing specialist help						
	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08
Engineering	3	5	7	20	19	14	18
Science	7	11	15	24	26	24	13
SSH	2	10	13	12	15	9	11
Total	12	26	35	56	60	47	42

6. Conclusion

The university-wide support strategy detailed here reflects the view that to tackle the Mathematics Problem requires a holistic approach, the involvement of different professionals, and the adoption of a philosophy which puts students' needs at the heart of activities. Cause and effect are difficult to establish because there are many factors which influence a student's decision to study and/or remain at university – their choice of course, the difficulties they face – personal, emotional, financial and academic. Nevertheless, we believe that Mathematics Education Centre initiatives such as those described herein have led to a much improved student learning experience for those willing to engage with them and could provide a basis for others who wish to provide or enhance their own provision. The need for mathematics support is likely to continue into the future and universities need to be prepared for this.

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