The Mathematics Education Centre at Loughborough University

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This article describes the establishment of the Mathematics Education Centre (MEC) at Loughborough University, why it has been established, and its modus operandi. Whilst the MEC is a recent development, it builds upon much expertise and experience at Loughborough University in the field of Engineering Mathematics Education and upon a successful Mathematics Learning Support Centre.

Background

It has long been recognised that mathematics is an essential tool in engineering. Traditionally, all undergraduate programmes leading to degrees in engineering have included substantial mathematical components. Early work in the field of Engineering Mathematics Education can be found in the pioneering work of, for example, Bajpai et al. [1], [2]. More recent work can be found in the Proceedings of the IMA Conferences on the Mathematical Education of Engineers [3], [4], [5]. Loughborough University has hosted these conferences over the last decade.

Historically, most of the mathematics taught to engineering undergraduates has been delivered via 'service teaching' from Mathematics or Engineering Mathematics departments. However, in many Universities, territorial anxieties, dissatisfaction with the service provided, together with financial and other considerations, have led to engineering departments no longer outsourcing their mathematics teaching but delivering it in-house. This teaching is often now being carried out by engineering staff or by mathematics staff based within engineering, or by employing ex-school teachers, the latter particularly where it is perceived that remedial teaching is required.

Loughborough University has a long-standing reputation for providing quality engineering education. Currently there are around 2500 undergraduate engineering students studying a wide range of programmes including Systems, Chemical, Civil, Electronic and Electrical, Mechanical and Manufacturing, Aeronautical and Automotive Engineering. In 2001/2002 Senior Management at the University recognised the challenges facing those responsible for the mathematical education of engineers. They had become aware, through reports published by learned societies and the findings of professional institutions, that Universities throughout the UK were waking up to the challenges posed by significant numbers of students who were ill-prepared for the mathematical demands of their undergraduate programmes [6]. Reports by the Quality Assurance Agency had repeatedly attributed attrition from engineering courses to students' insufficient grasp of basic mathematical techniques [7]. Difficulties in recruiting to many engineering programmes nationally had also been reported [15]. Diversity of the student body was also continuing to increase, meaning that a traditional one-size-fits-all approach was unsustainable. In 2001, the report *Measuring the Mathematics Problem* [8] recommended that students entering mathematically based courses receive a diagnostic test upon entry, and further, that prompt and effective follow-up support should be available where necessary. It was against this background, and with an awareness of the groundwork already laid by the University through its Mathematics Learning Support Centre [9], and its work in the Mathematical Education of Engineers [10], [11], [12], [13], that a decision was made, early in 2002, to establish the MEC. Its aim was to work towards 'providing the environment and expertise to ensure that each and every student maximises their mathematical abilities'.

The Role of the MEC

The MEC [16] has three main areas of responsibility (Fig1):

1. Service Teaching: The MEC is responsible for the development and delivery of the majority of the mathematics modules taught to engineering students. Six academics drawn both from the Department of Mathematical Sciences and from the Faculty of Engineering form the core teaching staff of the Centre and, where necessary, additional teaching is bought in from the Department of Mathematical Sciences. These staff have been supplemented by new appointments in the form of a Learning Support Officer, a Learning Technologist, a mathematics tutor with responsibility for helping students with additional needs, and secretarial and reception staff. A part-time member of teaching staff brings the total complement of Centre staff to eleven.

2. The Mathematics Learning Support Centre: The MEC houses the University's Mathematics Learning Support Centre (MLSC) [17]. Whilst the MEC is responsible for the teaching of mathematics to engineers, the MLSC exists to provide a range of services designed to support *any* student at Loughborough University in their learning of basic mathematics and statistics. In particular, it aims to help students in the earlier stages of their studies, who might benefit from resources and tuition over and above that normally provided as part of their programme.

3. Materials Development and Dissemination: The MEC concentrates the scholarly activity of staff in the University whose interests lie in Mathematical Education. It provides a focus for a number of initiatives concerned with material development and dissemination both for use within the University and without, through a number of externally funded projects.

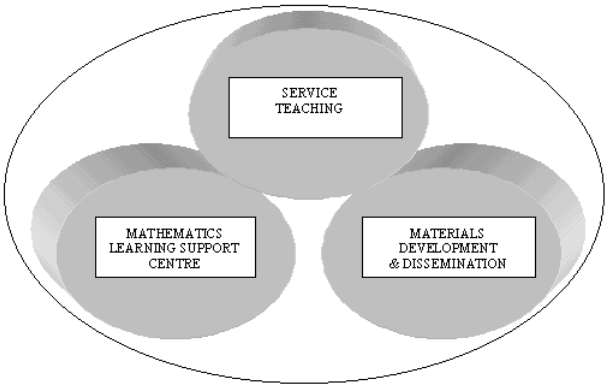

Fig 1 Schematic of the role of the Mathematics Education Centre

Issues Pertaining to the Running of the MEC

1. Management Committee: The work of the MEC is overseen by a Management Committee which includes senior representatives, including Deans and Heads of Department, from all three faculties in the University. Such high-level representation is regarded as invaluable both for the strategic direction of the MEC and also for securing its financial position.

2. Funding; The salaries of the Learning Support Officer and one receptionist are met centrally by charging the three faculties in proportion to the usage by their students as measured by number of students visiting the drop-in surgeries. Recurrent costs of the MEC, including staffing, are met from income received for service teaching, together with some additional contributions from the Faculty of Science and the Faculty of Engineering. Set-up costs were met by the Faculty of Science. The cost of providing additional tutoring in the drop-in surgeries is provided directly by the Department of Mathematical Sciences.

3. Location: The MEC has been located in refurbished accommodation adjacent to the Department of Mathematical Sciences, and very close to the Engineering Departments. It has been deliberately sited next to the existing Engineering Education Centre [18], which employs a number of project officers, developers and learning technologists engaged in supporting teaching staff. The proximity of the two centres is already leading to joint projects such as the accommodation within the MLSC of the Engineering Student Support Desk, and the development of mechanics handouts (see section 2, below). In addition, the national subject centre, LTSN Engineering [19], is co-located with the Engineering Education Centre, further enhancing scope for joint activities.

The remainder of this article describes some of the projects, systems and methods under development to try to achieve the MEC's aim of *'providing the environment and expertise to ensure that each and every student maximises their mathematical abilities'*.

The Work of the MEC

1. Service Teaching: At any one time, the MEC is responsible for teaching mathematics to around 1000 first and second year engineering undergraduates. The approach adopted by the MEC is two pronged.

Firstly, every effort is put into ensuring that each engineering student receives mathematics tuition which is of high quality, relevant and which will equip the

student for the mathematical demands of his/her course. High quality teaching materials, in the form of printed workbooks are used, in many modules, to supplement lectures [20]. These have been developed by some of the academic staff now working in the MEC. In addition, many of the engineering students sit regular computer based tests. Practice tests encourage students to practise standard techniques. The response from the students to the printed material and the testing regime has been very positive.

However, with an increasingly diverse intake it is vital that early steps are taken to try to prepare students for the mathematical challenges they will meet, and to identify those at risk of failing. This is the second approach adopted by the MEC. This work starts before the students arrive on campus, continues with diagnostic testing in week 1 and then follow up throughout the year. It is detailed below.

Pre-sessional Materials For many students it is useful to encourage them to engage in the revision / refresher process before they arrive. We prepared a booklet, *An Algebra Refresher,* which has been sent out for the past three years to students about to start programmes in mathematics, physics, mechanical and manufacturing engineering. It is sent in early September and students are encouraged to work through it before they come to university. Feedback has been positive, although it is difficult to measure efficacy. One suggestion from the students has been that a similar *Calculus Refresher* be made available. With LTSN MSOR funding this was developed and used for this first time in September 2002.

Diagnostic testing At the start of the current academic year, over 1000 first year students sat diagnostic mathematics tests, provided by the MLSC. This included over 600 first year engineering students. The tests took the form of paper-based multiple choice tests which were marked by optical mark reader.

Tracking individual students Following on from the diagnostic tests, all engineering students falling below a threshold mark were contacted by the Learning Support Officer and invited to the MLSC. 15% of the first year engineering students fell into this category. Some were shown the facilities available in the MLSC to help them. For others, action plans were put in place. Areas of weakness, identified by the diagnostic test, were addressed. Students were given handouts, with associated exercises, on these topics. They were asked to return fortnightly to monitor progress and direct study. In addition to this, approximately 400 first year engineering students were given computer-based tests on a fortnightly basis, as part of their mathematics courses. There was much liaison between the MEC and engineering departments. Departments were informed of the results as soon as practically possible and personal tutors encouraged those students, not doing well, to go to the MLSC. In addition, tutorial attendance was closely monitored and departments were informed of attendance at regular intervals.

Database A database was set up to track students' progress, both individually and collectively. Tutorial attendance data was entered into the database, as were diagnostic test results and engineering students' coursework marks and the details of the action plans. For a given engineering student, one can readily see their test results, their attendance rate at tutorials and whether they are completing the action plan work (Fig 2), if set. For a given department, one can see tutorial attendance figures (Fig 3) and test results (Fig 4).

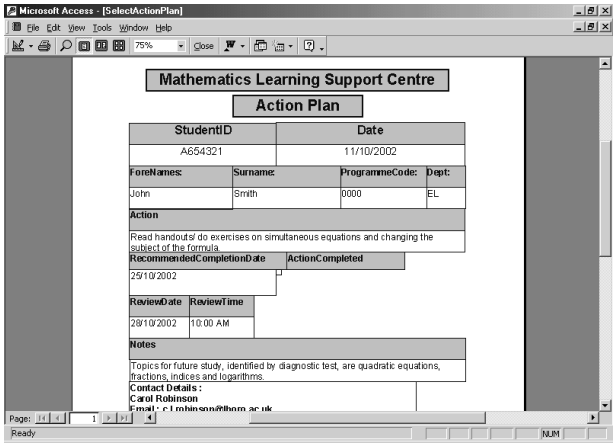

Fig 2 Database report – Action Plan for an individual student

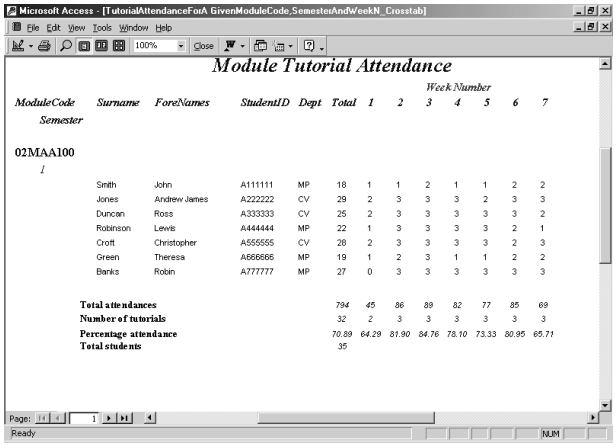

Fig 3 Database report – Module Tutorial Attendance

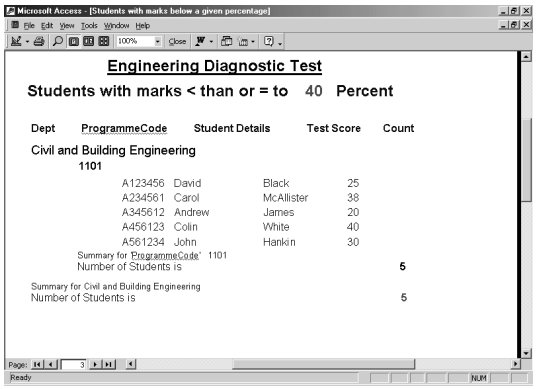

Fig 4 Database report - Students falling below a given mark in the diagnostic test

2. The Mathematics Learning Support Centre: A Mathematics Learning Support Centre was established in the University in 1996. This year sees a major expansion with a new fully re-furbished and upgraded location and additional personnel and resources (Fig 5). During term-time, the MLSC is open every Monday - Friday, from 9 am - 5 pm. A secretary/ receptionist is on duty throughout this period to welcome students and to offer general advice on facilities available. Experienced teaching staff are available each day from 10 am - 12 noon and 2 pm - 5 pm. Students can drop-in during these hours to receive help, no appointment being necessary. Academic staff from the MEC and the Department of Mathematical Sciences provide some of this support, with an appropriate credit recorded on their timetabled teaching commitment. The remainder is provided by the Learning Support Officer. In addition to this help with mathematics, the MLSC employs a statistician for 3 hours per week to staff a statistics drop-in session. Staffing is seen as a key resource. Most students who use the MLSC cite the one-to-one help as being of particular value. Building student confidence is of huge importance and requires staff who are patient and approachable. When teaching staff are not present, the MLSC is promoted as a place for quiet study and a resource base. Many groups of students, other than engineering students, benefit from the additional mathematics support offered by the MLSC.

Fig 5 Students working in the Mathematics Learning Support Centre

Facilities Facilities within the MLSC include formula leaflets and an extensive range of handouts on many topics, ranging from GCSE to first year university level. Some of these are designed for engineering students, others for students from a business school/economics background. Basic statistics, as well as mathematics, are covered in these handouts. Textbooks, including recommended textbooks for engineering mathematics courses, are available for consultation. GCSE, A-level and mathematical modelling videos can be viewed in the centre. Graphical calculators are available if required. In addition, the MLSC has a suite of PCs with computer assisted learning packages, diagnostic tests and computer algebra packages. Open learning materials are available via the MLSC's web-site.

Diagnostic Testing and Supplementary Workshops Diagnostic mathematics tests are provided by the MLSC, upon request, to any department within the University. In the current academic year, students of Economics, Mathematics, Physics, Human Sciences and the Science and Engineering Foundation Studies students, as well as the first year engineering students, sat such tests. Follow up procedures are negotiated with each department and all students taking diagnostic tests are informed about the help available to them via the MLSC. In many cases, students falling below a threshold mark are invited to the MLSC to see at first hand the resources available. Where appropriate, students can be directed to the supplementary workshops, run by the MLSC, on key topics such as basic algebra, calculus and statistics.

Supporting Students with Additional Needs The MLSC employs a part-time mathematics tutor to provide tuition for students with dyslexia and dyscalculia. The tutor has extensive experience of working with such students and takes part in staff training sessions to raise awareness of the issues amongst other staff working in the MLSC. These involve training in how to recognize dyslexia and the importance of confidentiality in dealing with these students. There is a private office, leading off the main work area, where these students receive tutoring and support. Funding for this work comes from Local Educational Authorities, who pay for the individual students to receive support, and also from the University. Recently the tutor has been working with staff at two other local universities to establish a network of those interested in mathematics support for those with dyslexia & dyscalculia [21] . In addition to the above, the MLSC works closely with the University's Disabilities & Additional Needs Service to provide extra support for any student with additional needs. This year, one-to-one tuition has been provided for a blind student.

Editor's Note: See p13 for dyslexia support at the Centre

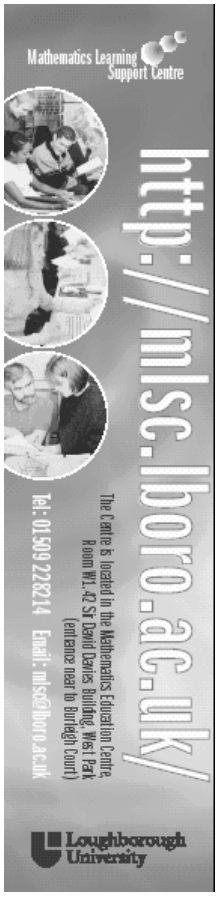

Fig 6 Bookmark advertising the Mathematics Learning Support Centre

Engineering Student Support Desk The MLSC houses the newly established Engineering Student Support Desk [22]. It exists to support student learning within the Faculty of Engineering and aims to identify and promote the numerous resources that are available to help engineering students. Study skills advice is available and workshops on, for example, preparing technical reports and giving presentations are offered. Handouts are being developed on basic engineering topics such as mechanics. The desk is staffed two afternoons per week.

Staff Development Reception staff, conversant with the full range of resources, provide a valuable service in making students aware of what help is available. Training is undertaken in order that reception staff can learn about the resources and how to deal with queries from students. Likewise teaching staff, at the drop-in sessions, have an important role in raising students' awareness of resources other than one-to-one help. This is important in encouraging independent learning. Thus training for the teaching staff is also provided. In addition to familiarisation with resources, techniques for coping when the MLSC is busy are discussed, as well as clarifying who the MLSC can help. This can sometimes be an issue, as research students and final year project students are tempted to come to the MLSC and it has neither the resources, nor expertise, to help them.

Publicity Making students aware of the resources and help available in the MLSC is a vital part of our work. This is done by a variety of means. Posters are displayed and leaflets distributed. Leaflets include a map of how to find the MLSC. In addition, students are emailed with information and given a link to the MLSC web-site. Several other mechanisms are in use, including bookmarks (Fig 6) which are available, for example, in the Library and campus bookshop. Recommendation by a lecturer is also important, as a considerable number of questionnaires completed in the MLSC cite this as the main reason for a student coming to the centre.

Usage Statistics All students coming to the MLSC are asked to sign in. A receptionist enters the student's ID, together with date and time, into the same database which is used for tracking students. Usage statistics can then be easily generated. One can see which department's students are using the MLSC and keep a tally of how many students are using the MLSC (Fig 7). We have found that the hours when teaching staff are on duty are the most popular. These statistics are invaluable for putting forward the case for continued funding and for informing departments about whether their students are seeking help from the MLSC.

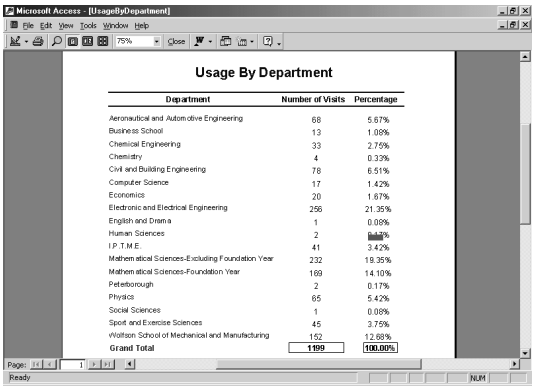

Fig 7 Database report – Number of visits to the MLSC, grouped by department

Measures of Effectiveness There are many ways in which the effectiveness of the MLSC is assessed. Students are encouraged to complete questionnaires to provide feedback on which facilities they use and to comment on what they find most helpful and what they think could be improved. Within the database, a record is kept of the number of repeat visits by students. The high number of repeat visits indicate that students visiting the MLSC are gaining benefit from it. It is difficult to claim that a student, who was likely to fail or drop out, has been prevented from doing so solely by the help received from the MLSC. However, some of the dyslexic students, supported by the MLSC, have cited the support received being the over-riding factor in their success at University. With the implementation this year, of action plans as a follow up to diagnostic testing, we shall have an additional measure of effectiveness. The progress of these students is monitored, by the MLSC, throughout the semester.

3. Materials Development and Dissemination: The MEC provides a focus for several other initiatives.

Externally Funded Projects The FDTL4 funded project, Helping Engineers Learn Mathematics [23], led by staff in the MEC, is a collaborative activity between a wide consortium of universities. It is developing

paper- and computer-based learning resources for engineering mathematics including computer assisted assessments and modern, relevant engineering examples developed with engineering departments. An LTSN funded project is hosted by the MEC and represents a consortium developing materials aimed at easing the transition from school to university mathematics.

Resources Some of the resources developed by staff in the MLSC are now available for use at other institutions. For example, the Algebra Refresher and Calculus Refresher booklets can be ordered directly from LTSN MSOR, at cost price. Electronic versions are freely available and Welsh language versions can be ordered. The MLSC's leaflet of mathematical Facts & Formulae has been re-published by the LTSN and is available free of charge for distribution to students.

Sharing Good Practice Further information on mathematics support can be found in contributions by MEC staff to the handbook *Good Practice in the Provision of Mathematics Support Centres* [14] and to the LTSN MathsTEAM project.

Concluding Remarks

The MEC is still in its early stages and time will tell whether the efforts being expended do indeed yield dividends in terms of maximising student potential, attracting new students to the university, supporting and retaining existing students. Early feedback from students is encouraging and the MEC is responsive to their constructive comments. Anyone interested in learning more about the MEC or visiting to see work in progress is invited to contact Dr Tony Croft (a.c.croft@lboro.ac.uk) or Dr Carol Robinson (c.l.robinson@lboro.ac.uk).

References

[1] Bajpai, A.C., Mustoe, L.R., and Walker, D. (1976) Mathematical Education of Engineers: Part 1 – a critical appraisal. Int. J. Math. Educ. Sci. Technol. 6 (3), 361-380.

[2] Bajpai, A.C. and James, D.L.G. (1985) Mathematical Education of Engineers – a Future Perspective. Euro. J. Eng. Educ., 10 (3/4), 277-283.

[3] Proc. IMA Conference on the Mathematical Education of Engineers, Loughborough, UK, 1995. Clarendon Press, Oxford, UK.

[4] Proc. IMA Conference on the Mathematical Education of Engineers, Loughborough, UK, 1997. Clarendon Press, Oxford, UK.

[5] Proc. IMA Conference on the Mathematical Education of Engineers, Loughborough, UK, 2000. Clarendon Press, Oxford, UK.

[6] Sutherland, R., and Pozzi, S. (1995) The changing mathematical background of undergraduate engineers: a review of the issues. The Engineering Council, London, UK.

[7] Croft, A.C., (2001) Following up cycles of QAA subject assessments for non-mathematicians, MSOR Connections, the newsletter of the LTSN MSOR Network, 1 (2). May 2001.

[8] Hawkes, T., & Savage, M.D., (eds) (2001) Measuring the Mathematics Problem, Engineering Council, UK.

[9] Croft, A. (2000) A Guide to the Establishment of a Successful Mathematics Learning Support Centre, Int.J.Math.Educ.Sci. & Tech. Vol.31 No.3 431-446.

[10] Croft, A.C., Danson, M., Dawson, B.R., Ward, J.P., (2001) Experiences of using computer assisted assessment in engineering mathematics, Computers & Education, Vol. 37 No.1 pp53-66.

[11] Croft, A.C., & Ward, J.P., (2001) A modern and interactive approach to learning Engineering Mathematics. The British Journal of Educational Technology, Vol. 32, issue 2, pp 195-208.

[12] Mustoe L.R. (editor) (1999) Engineering Mathematics Matters, Curriculum Proposals to meet SARTOR3 requirements for Chartered Engineers and Incorporated Engineers. The Institute of Mathematics and its Applications, Southend on Sea, Essex.

[13] Mustoe, L.R. & Lawson, D.A. (2002) Mathematics for the European Engineer - a Curriculum for the Twenty-First Century. A report by the SEFI Mathematics Working Group. SEFI HQ, Brussels, Belgium.

[14] Lawson, D., Croft, A.C., & Halpin, M. (2001) Good Practice in the Provision of Mathematics Support Centres. LTSN MSOR Ref 3/01

Web Addresses

[15] "Set for Success" Final Report of Sir Gareth Roberts' Review, April 2002 http://www.hm-treasury.gov.uk/

[16] The Mathematics Education Centre, http://mec.lboro.ac.uk/

[17] The Mathematics Learning Support Centre, http://mlsc.lboro.ac.uk/

[18] The Engineering Education Centre, http://eec.lboro.ac.uk/

[19] LTSN Engineering, http://www.ltsneng.ac.uk/

[20] Open Learning Workbooks, http://learn.lboro.ac.uk/olmp/

[21] Dyslexia and Dyscalculia Interest Group, http://ddig.lboro.ac.uk/

[22] Engineering Student Support, http://engstudent.lboro.ac.uk/

[23] Helping Engineers Learn Mathematics, http://helm.lboro.ac.uk/