In the recent past, measures have been put in place nationally to ensure that all students embarking upon undergraduate programmes with a strong mathematical content have access to resources that will ease their transition into higher education. Universities have taken a variety of steps to ease any problems at the school/higher education interface. Substantial effort is going into initiatives designed to encourage more school students to study mathematics in the post-compulsory sector and to improve the quality and preparedness of those that do.

However, evidence recently published refers to some problems emerging in later years, particularly year 2 of single honours mathematics programmes, with disillusionment amongst parts of the cohort and high drop-out rates, at least in some institutions. This ought to concern the mathematics community because, whereas the more widely reported ‘mathematics problem’ was largely concerned with non-specialist ‘users’ of mathematics (e.g. engineers), the groups under consideration here self-select to study mathematics at university. Furthermore, some of those who do succeed in HE are not well-prepared for postgraduate study. Concerns have been raised at the highest levels about the number and quality of ‘home-grown’ entrants to mathematics PhD programmes and these have long-term effects for the UK science base.

This paper will briefly review mathematics support at the transition. It will then pose questions about the ways in which support might be developed so that undergraduate mathematicians in their second and third years might be better supported and encouraged to become even more confident, competent and independent learners. It will suggest work designed to improve the preparedness of those students who might consider postgraduate research in mathematics. The role of the Higher Education Academy Maths, Stats & OR Network, and other bodies with national influence such as Sigma – the Centre for Excellence in Mathematics & Statistics Support, is discussed with a view to opening a constructive discussion about what the community as a whole can do to enhance the learning experience of these students.

1 The challenge at the transition

The mathematics higher education community is well aware of the challenges facing those who teach mathematics to both specialist mathematics students (those who come to university to study single and joint honours mathematics programmes) and non-specialist ‘users’, such as engineers and physical scientists. Increasingly, other groups (e.g. nursing tutors) are also finding that their students neither possess the requisite mathematical skills nor are keen to acquire them.

We won’t go over old ground here, but those who are not familiar with the difficulties which have emerged over the past 15 years or so should consult the many research papers or reports from learned societies and professional bodies listed in references [1...9].

The higher education mathematics community has responded enthusiastically to the challenges at the transition (see Appendix I for a list of several of the many initiatives). Government, somewhat belatedly, and following lobbying by the professional bodies, learned societies and individuals, has acted and set in place initiatives to improve both mathematics teaching in schools and the supply and quality of students who want, and are qualified, to study.
mathematics in the post-compulsory sector. Universities are tackling transitional problems through, for example, provision of summer schools, and bridging mathematics courses. An overview has been published by the LTSN MathsTEAM project (http://mathstore.ac.uk/mathsteam). Another approach is through support centres which many universities have now established. Perkin & Croft [10] provide a review of provision nationally and the MSOR Network has published the guide Good Practice in the Provision of Mathematics Support Centres [11]. Universities now have access to a range of quality resources e.g. the Subject Centres of the Higher Education Academy, the FDTL4 project Mathematics Support at the Transition to University which has developed mathcentre, the FDTL4 project Helping Engineers Learn Mathematics (HELM), and the mathcentre project. There are also substantial resources available from earlier projects although increasingly, it has not been possible to upgrade these to run on modern operating systems. Initiatives exist to increase the supply of mathematically-capable school leavers, e.g. the National Further Mathematics Network, the National Academy for Gifted & Talented Youth, and the Millennium Maths Project. The new National Centre for Excellence in Teaching Mathematics has a remit which includes developing CPD for teachers. Effects of these have yet to feed through into the HE system.

2 Emerging issues

While it would be untrue to say that the problem at the transition has been solved, it is the case that (a) an ample supply of free, good quality resources are available to help any students serious about remedying their shortcomings, and to help academic and support staff who aspire to assist students who struggle at the school/university interface, (b) a significant proportion of universities have invested substantially to put palliative mechanisms in place (e.g. support centres), and (c) there are several high profile, well-resourced national projects designed to increase the supply of mathematically qualified school leavers, and to improve teaching quality and continuing professional development of mathematics teachers.

However the ‘mathematics problem’ has several other dimensions. One is the ‘mechanics problem’ highlighted by Robinson, Harrison & Lee [12]. There are others - and these impact upon the specialist mathematics community rather than non-specialist users of mathematics.

Firstly, in 2002 Brown et al. [13] published work in respect of Student Experiences of Undergraduate Mathematics arising from a three year ESRC funded project that examined progress and attitudes of single honours mathematics undergraduates in two research-led universities. Their report notes “for many of those staying [on the course] attainment was average and below, the problems of coping with the work were accompanied by growing disillusionment with mathematics; generally, although with some exceptions, students enjoyment of the subject declined over time”. Many did not adapt well to develop new styles of working in order to cope at University. “Such students became mildly depressed in the second year and seemed to lack immediate sources of support and the motivation to seek these out”. The research investigated failing second year students. From the same study, Macrae et al. [14] write: “it is difficult to know what more the university could do to support these struggling students especially as they tend to withdraw when faced with lack of success and many find it difficult to talk openly and honestly about their situation. However, faced with widening participation, universities need to put in place increased support structures to encourage struggling [second year] students to seek help before it is too late”.

However, it should be noted that these findings are not ubiquitous. For example, Povey & Angier [15] cite very different experiences of students in their own institution. Their context though was different in that the students they researched were all on mathematics education courses and training to become secondary mathematics teachers. Their students’ interaction with undergraduate mathematics was designed to be much more exploratory, negotiable, personal, social, supported and collaborative – and as they note, in clear contrast to the mathematics delivered rather more traditionally. The students they describe, whilst starting from a relatively weak background, went on to succeed. This is an important point, given the dire shortage of mathematics teachers in schools. It would be tragic if many of those students on single honours mathematics courses who might make good teachers are turned off the subject because of the way it is delivered in higher education.

Secondly, concerns have been expressed about the quality and numbers of UK PhD entrants in the mathematical sciences and cognate disciplines. The Review SET for Success [4] draws attention to the quality of PhD entrants to Science, Engineering and Technology departments:

“A particular concern of many respondents to the Review was the quality of PhD students, both at the commencement of their study and on completion of it.”
It noted also that there had been a slight decline, from 1996-1999, in the proportion of PhD entrants in mathematics with a First or 2:1 degree. Over the same period there has been a slight increase in the proportion of such degrees awarded. (However, the Mathematical Sciences continue to attract the highest proportion, over 95%, of such students across the SET disciplines – this is quite different from the much lower proportions seen, for example, in Chemistry and Engineering). The Review did note that no firm conclusion should be drawn from their data in respect of mathematics.

The report *Where will the next generation of UK mathematicians come from?*, published by the Manchester Institute for Mathematical Sciences [16], notes:

> “the domestic supply of mathematically competent manpower is in such decline that in many areas (including... post-doctoral fellows and appointments to academic positions) we are now dependent on trawling recruits from other countries”

and

> “In order to maintain the quality of postgraduate recruitment, public funds are increasingly being used to support students from other – mostly EU – countries."

> “It becomes essential to ensure that our national curriculum and incentive structure allows our schools and universities to produce home-grown research mathematicians of sufficient calibre to compete with those from other countries.”

An international review of UK Research in Mathematics was undertaken in 2004 on behalf of the EPSRC and the Council for Mathematical Sciences (CMS) [17]. It comprised of 13 world-leading mathematicians and statisticians all based outside the UK. Amongst other issues, they were asked to comment upon the adequacy of the current three year PhD model prevalent in the UK.

> “The system of three-year PhDs can only work if there is excellent A level education at the school level. Our perception is that A levels are weaker than they used to be. The result then is that this produces many students who cannot compete with graduates from abroad.”

In 2005 HEFCE designated mathematics a *strategic and vulnerable subject* [18], recognition which can only help the discipline continue to secure additional government funding:

> “Mathematics has seen a fall in activity of 9.3% (1800 ftes, 1999/2000 - 2004/4). However total activity remained nearly 17500 in 2003-4 providing a substantial base on which to build.”

It is therefore incumbent upon the community to ensure that those students who we do manage to recruit are retained, motivated, well-served and in turn will help revitalise the discipline. It is these dimensions to the ‘mathematics problem’ that we suggest need to be explored further, and the Academy is keen to promote this view.

### 3 Supporting the specialist and the more able

Given the scenarios painted in the previous section the questions that arise are concerned with:

- Improved pedagogies informed by existing research
- Extension of the role of existing support mechanisms
- Development of resources
- Professional development of academic staff
- New research, including into ways of developing independent learners
- Support of new mathematics postgraduates (not with teaching but with focussed research and study skills).

How can existing pedagogic research be used to improve practice? Can we understand better the identities of students who choose to learn mathematics? In what ways are they, and their learning styles, different from their predecessors and can we adapt our methods of teaching and their methods of learning in order to better achieve our objectives?

Much effort has been expended in developing support centres and other mechanisms at the transition. Can and should these be extended to offer support to students in later years? Is it sufficient to say that if these students cannot cope in year 2 then the problem is theirs not ours? What does this say about the current design of our programmes and our university admissions procedures?

Are there any resources which could be developed and made available nationally in order to help, at least, some of these students? Whilst it is obvious that specialisms increasingly emerge as students progress through the HE system, there may be a core of material which most students should be required to understand. Is there such a core and can resources be developed to support it?
There is undoubtedly a role for the professional development of academic staff. The gap between student performance and staff expectations continues to widen. The myriad of changes in schools and the increasing recruitment of staff from overseas means that many are unfamiliar with the UK education system and what it is delivering. How this professional development can be incorporated when staff have substantial, and very different, demands placed upon them will surely continue to be a source of tension.

There is a need for more pedagogic research intended to bring about positive change in the lecture theatre and the classroom. Too many students are disengaged from what is on offer now, but the community does not understand why, nor what can be done about it. Practice which is working well needs to be better disseminated and taken-up elsewhere.

Given these questions, what can the Higher Education Academy do to support all involved in the teaching, learning and assessment of mathematics specialists within Higher Education?

In order to help answer this question the Academy has established a dedicated website which is intended to promote discussion, and provide a forum for sharing of new ideas. To kick-start the process it is commissioning two mini-projects, each worth up to £5000 intended to address some of the issues outlined above.

The Call for Proposals can be found on the Network’s website and the closing date is June 30th 2006.

4 Conclusions

We have drawn attention to the fact that the ‘mathematics problem’, well documented since the 1990’s now has manifestation beyond the transition to university. We have explained that the community has responded to transitional problems in many ways, but suggest that much more could be done to address issues emerging in later years. We have proposed a role for the Higher Education Academy MSOR Network and other bodies and hope we have opened this area up for a fruitful discussion about ways forward.

A website has been established (www.mathstore.ac.uk/lateryears) which will be used to collect and report upon the views of the higher education mathematics community, and which will seek, where appropriate, to respond to the challenges described here. We encourage all members of the community to share their views on the issues highlighted by visiting and contributing to the site.

References


Appendix I

The following list of resources have either been developed specifically to support students making the transition to university in a subject with a significant mathematical component, or are appropriate for use by such students. All resources are available online, although those that have not been recently updated are marked [Historical]:

- CALM (Computer Aided Learning in Mathematics) http://www.calm.hw.ac.uk [Historical]
- CALMAT http://www.calmat.gcal.ac.uk
- Geomaths http://www.ucl.ac.uk/Mathematics/geomath/frontpage.html [Historical]
- HELM (Helping Engineers Learn Mathematics) http://helm.lboro.ac.uk
- mathcentre http://www.mathcentre.ac.uk
- mathtutor http://www.mathtutor.ac.uk
- MathinSite http://mathinsite.bmth.ac.uk/
- mathwise http://www.bham.ac.uk/mathwise
- METRIC http://metric.ma.imperial.ac.uk
- School of Mathematics & Statistics, University of Plymouth http://www.plymouth.ac.uk/mathaid
- STARS (creation of STAtistical ResourceS from real datasets) http://www.stars.ac.uk
- STEPS (Statistical Education through Problem Solving) http://www.stats.gla.ac.uk/steps
The Maths, Stats & OR Network
Mini-Projects in Teaching & Learning
Summer 2006

Call for Proposals

Closing Date: 30th June 2006

The Maths, Stats & OR Network is offering funding for two mini-projects to commence in the autumn of 2006. Up to £5,000 is available for each. Proposals must align with the specific objectives outlined below.

Objectives

During the last few years the Network has been instrumental in providing resources, advice and staff development activities that have sought to address some of the well-documented school-university transitional problems for both specialist and non-specialist mathematicians. It is now keen to develop its support for teaching and learning of single- and joint-honours mathematics undergraduates particularly beyond their first year of study. Emerging research suggests that there is room for improving the experience and support of these students with a view to increasing motivation, engagement and levels of achievement. This is true both of the mainstream and those who are more mathematically gifted. This Call is concerned with the development and embedding of such support.

Whilst any well-argued case will be considered, the following are indicative of the sort of projects that might be funded:

- A pilot study using existing pedagogic research to inform, develop or enhance change in practice.
- A study of the ways in which the wide variety of mathematics support currently used at the transition\(^1\) can be extended.
- A scoping study to inform development of support resources.
- Professional development of academic staff.
- A project to study effective ways of developing independent learners.

Outcomes should be transferable throughout the Maths, Stats & OR community and be freely accessible. As a minimum, anticipated outputs should include an article submitted to MSOR Connections and a contribution to the Network’s Annual Conference.

The Application Process

The application form will be the basis upon which your application will be judged. We ask that you include the following details:

- The applicants background in teaching within the area.
- A clear statement of the outputs and outcomes of the project.
- A clear statement of the project timetable.
- A well-defined dissemination strategy.

Section 5 (Proposal and Activities) of the form is where you should provide details of the scope and dimensions of the project and any additional information that supports your proposal.

For the final section (Budget) provide as much detail as is possible. Please note that no payment towards Full Economic Costs will be made. It is anticipated that the contribution of your host institution to the project will be a waiving of Full Economic Costs.

To download a copy of the application form please visit:

http://www.mathstore.ac.uk/lateryears

\(^{1}\) LTSN MathsTEAM Project (http://mathstore.ac.uk/mathsteam/)