Reviewing the mathematics curriculum in a changing HE environment
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Abstract
Four crucial documents in recent years have challenged mathematics programme coordinators nationally to deliberate on the identity of their subject and programmes. In the new HE environment, there are significant challenges to be addressed and yet opportunities also to create something distinctive and exciting. In my role as Assistant Director of Education for Mathematics and Computer Science, I discuss the key recommendations of these four documents and their implications for mathematics at Exeter. I also describe an ambitious path for mathematics at Exeter to forge that reflects more closely the marketing aspirations of the University of Exeter and makes explicit the values underpinning the subject that are too often ignored.

Keywords: mathematics; subject identity; discipline values; Browne report; 2011 white paper

Introduction

In the light of the recent government white paper on Higher Education (BIS 2011) and the Maths at University report (MMG 2010) produced by the National HE STEM More Maths Grads pilot project, I will review the nature and identity of UK undergraduate mathematics curricula, with particular reference to the University of Exeter, and make corresponding recommendations for the direction of mathematics provision at the University of Exeter.

In the last few years, four crucial documents have forced mathematics programme coordinators to reflect on the nature of mathematics provision in Higher Education. Each presents significant challenges regarding the identity of the subject and taken together provide strong backing for maintaining and broadening the diversity of provision across the sector. The scope for institutions and programmes to develop and promote distinctive identities responding with new-found confidence to the needs of stakeholders is a considerable opportunity. Yet, the underpinning questions of identity and accountability are neither easy to answer, nor make for comfortable debate: what is a degree for? what are the values that underpin the subject at Exeter? how do these answers reflect the wider institutional picture? And then there are equally uncomfortable issues relating to transparency, transferability and comparability with respect to the subject nationally.

In Autumn 2010 and Summer 2011, two government documents – the Browne report (2010) and the white paper on Higher Education, Students at the heart of the system (BIS 2011) – set out a vision for the future of Higher Education in England. From 2012, the cap for tuition fees was raised to £9000

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per year for home undergraduate courses, with an open market in students with grades AAB or above at A-level. Those institutions with average tuition fees of less than £7500 became able to bid for up to 20,000 additional student places as part of the government's ‘social mobility’ agenda. The aim of the policies is transparent: to diversify higher education provision, providing greater choice for students and increasing the accountability of Higher Education Institutions (HEIs) to their stakeholders. The government challenged universities directly to rethink the aims and values underpinning higher education, requiring HEIs to work more closely with employers to ensure that tertiary education would produce graduates with the skills required to drive the future economy.

Following closely on the heels of the Browne report, mathematics departments convened a HE Mathematics Curriculum Summit (MSOR 2011) to ponder both the impact of the government's Higher Education strategy and the findings of the Maths at University report (MMG 2010) produced by the ‘More Maths Grads’ National HE STEM programme pilot project. Both reports celebrate the diversity of mathematics provision at degree level in the UK, but raised serious questions about who our mathematics undergraduates are and the skills and knowledge that a graduate must possess.

The topic of this article and the education documents discussed herein are particularly suited to my role as Assistant Director of Education for Mathematics and Computer Science. The discussion also encompasses some of the central themes of the University of Exeter’s PCAP course, from which this article arises: as a professional learning from my colleagues in the mathematics community, the recent literature on mathematics curricula and documents detailing government policy; as a teacher, considering the issues arising from these documents for the degree programmes that I help to manage; as a researcher, where appropriate comparing national evidence and analysis with data from local education projects.

Some difficult questions

I will attempt to discuss each of the challenging questions that arise as a result of the four documents cited in the Introduction, drawing on local data and comparisons with competitors and the national picture.

Q1. What is a degree for?

Reasons for choosing to study for a degree are extremely variable and complex, as are the underlying reasons behind the choice of subject and institution. To better understand the needs of undergraduate mathematics students, the ‘More Maths Grads’ project commissioned a survey into these student choices, with the findings being reported in the Maths at University report (MMG 2010). As part of a first-year undergraduate mathematics module at the University of Exeter, single-honours mathematics students also completed the survey (sample size 118; response rate 50%) and compared the data with the national picture. A copy of this survey can be found at http://empslocal.ex.ac.uk/people/staff/bc238/survey/survey.pdf (correct at 24/05/13). In line with the findings of the More Maths Grads survey, students at Exeter ranked employability as one of the key factors in choosing to study for a degree and choosing mathematics as their subject. Selected graphs from the survey of Exeter mathematics students are presented in Figures 1, 2 and 3 below.
Figure 1. Chart of responses for Question A2: ‘Please rate each of the following statements as a factor in your decision to go to university’.

Figure 2. Chart of responses for Question A3: ‘Please rate the importance of the following opportunities afforded to you by university study’.
Figure 3. Chart of responses for Question B2: ‘Please rate the importance of the following statements as reasons for you choosing to study maths’.

However, in response to the question ‘Do you have any plans for a career when you have finished your degree? If yes, please indicate what you intend to do’, most students said ‘no’, and even those who said ‘yes’ rarely had a specific career in mind. It seems clear, therefore, that mathematics students at Exeter had a clear impression that whilst studying for a degree in a subject that they enjoy (for the most part), they would be developing skills crucial to graduate employment. This is a vision that very clearly mirrors the government’s vision (BIS 2011) of employers and degree providers working together closely to ensure that future graduates are equipped to meet the needs of business and industry. The University of Exeter’s Student Guild publication, *Vision for the Future of Higher Education* (Guild 2011), reinforces this message, emphasising the importance of subject-specific employability support and College adoption of an ‘effective and continuous employability communication method’.

To review the extent to which the mathematics degree at Exeter meets this need, we undertook a series of surveys across the year groups and programmes of study within mathematics. In our Year 2 survey (Bonner 2011), conducted in Spring 2011, most undergraduates identified the key skills desired by graduate employers. However, they also identified that the opportunities within their degree programme to develop these skills were mostly restricted to a single module in the first term of the first year. This message was re-emphasised during our student-led employability audit of the mathematics programme undertaken in Summer 2011 with a clear division between one or two ‘skills modules’ with a significant emphasis on employability and skills development, and the more ‘traditional’ mathematics modules.
Whilst the student-led audit demonstrates that there is clearly more to be accomplished in relation to skills development in the mathematics curriculum at Exeter, if anything, Exeter is significantly ahead of the game in relation to the national picture. The HE Mathematics Curriculum Summit report (MSOR 2011) makes sweeping but stark generalisations regarding the nature of such provision, declaring that ‘most mathematics degree courses do not include such skills development’ and that ‘there is a need to put skills development in place in the first two years of a programme to prepare students for the final year’, during which most courses have some form of project or dissertation. Even this, the report acknowledges, would not address the higher level skills such as team building and project management skills demanded by graduate employers and the CBI (The Confederation of British Industry). A most striking statement follows: ‘current mathematics teaching may not be fit for purpose’. Certainly our experience at Exeter indicates that the modules identified as particularly good for skills development employ radically different teaching methods and modes of learning to traditional lecture courses.

Of course, being a scholar of mathematics means more than developing generic graduate attributes. Both the Maths at University report (MMG 2010) and the HE Mathematics Curriculum Summit report (MSOR 2011) make significant attempts to analyse the key features both of a mathematics degree and of mathematics graduates. The central theme of these discussions focuses on the relation between subject knowledge and the subject skills that mathematicians must possess, reminding us that subject knowledge as measured by content is liable to blind us to the more important questions of whether our students think and act like mathematicians. I believe that there is an often overlooked element that is critical to this discussion – explicit study of the values that underpin the subject and the nature of knowledge. Ultimately, the reports declare strong support for the flexibility of the present MSOR subject benchmark and the range of mathematics degrees offered by UK HEIs, reflecting the diversity of the student body on mathematics programmes. The challenge for mathematics at Exeter is to find and communicate a new radical identity to prospective students, building on those areas of good practice relating to both generic and subject skills development and producing correspondingly uniquely skilled and desirable graduates.

Q2. What are the values that underpin mathematics at Exeter?

The mathematics community is divided, largely along ‘pure’ and ‘applied’ lines, about what constitutes mathematics – the pursuit of rigorous mathematical theory, or the modelling of real-world phenomena through mathematics, e.g. the debate in the HE Mathematics Curriculum Summit report (MSOR 2011). Both are found to a greater or lesser extent in most UK undergraduate degrees and often the blend, interplay and way in which each of these themes is developed give a mathematics programme its particular identity.

The almost obsessive debate about content versus skills can be seen as a proxy for tensions between the often-ignored competing value frameworks within the subject: formal mathematics and proof on the one hand versus the scientific principles, such as prediction and experimental verification, underpinning mathematical modelling. Acknowledging, however, this fundamental dichotomy within the subject suggests a way in which a mathematics degree programme can escape being characterised simply on a theoretical vs. practical scale and developed as the controversial, value-laden, imperfect tapestry of a subject that mathematics has always been.
This, then, is my vision for a unique radical attractive mathematics programme at the University of Exeter, in which the nature of subject knowledge, enquiry and discipline identity provide the foundations and continuing principles of reference for developing the subject. Such a degree would have as much (perhaps more) in common with a ‘Liberal Arts’ degree as a traditional mathematics degree.

Q3. How can mathematics at Exeter reflect and promote the institutional brand?

In parallel with portfolio reviews conducted by each College at the University of Exeter, the institution has also been carefully considering the institutional ‘brand’. As a research-intensive university, central to this identity will be the principle of research-led education. This has clear connections with the enquiry-based learning approach that would drive learning in the mathematics degree programme envisaged above. Whilst mathematics at Exeter (or even nationally) appears to have rarely harnessed such techniques, there is a wealth of mathematical materials available to support this approach. I will review a couple of notable contributions in this area.

*How to Think Like a Mathematician* (Houston 2009) is a modern textbook that aims to encourage students to act like mathematicians. In the introduction, the author discusses his motivations for writing the book and is unapologetic in his criticism of the current education environment:

‘Unfortunately, [students] are not taught to have a questioning nature, they are taught to have an answering nature. They expect us to ask questions and for them to give the answers because that is the way they have been educated. This book aims to give them the questions they need to ask so they don't need me anymore.’

I have used this book to support a first-year module on proof with some limited success. There is a great deal of interesting material here, based on relatively little mathematical content, including non-trivial chapters on how to read and write mathematics, how to solve problems (as distinct from ‘exercises’) and how to know whether you really understand something. At a meta-cognitive level the book is rather paradoxical in the sense that it is essentially convincing students to act in a certain way that the author deems fitting for a ‘mathematician’, but such a textual (and contextual) analysis could form an equally interesting topic of study!

*Surreal Numbers* (Knuth 1974) is perhaps an even more interesting text. It is written as a dialogue between two former students who discover a short mathematical transcription that they attempt to decipher and understand. The dialogue attempts to demonstrate how enquiry-based learning in mathematics operates and the author uses this also as an opportunity for his characters to savage traditional mathematics lecture courses. The text is designed to support an advanced undergraduate or graduate enquiry-based course on the same subject and the author states explicitly that they wish for the students to engage with not simply the mathematics but also with understanding the distinct and complementary ways that his characters approach the mathematical process.

Employability support, as discussed earlier, is becoming increasingly important and will become a key feature of the student experience that Exeter will continue to offer. Mathematics at Exeter has a significant head-start over its competitors in embedding graduate skills into the mathematics curriculum. Significantly more can be done, however, and discipline-specific, as well as institution-
wide, projects at Exeter are addressing issues such as employer engagement in curriculum design and authenticity of assessment.

A third key feature of the Exeter undergraduate experience is Student Engagement. Mathematics at Exeter has long been acknowledged as a model for student-staff engagement with a particularly active Student-Staff Liaison Committee (SSLC) and student mathematics society. In recent years, the SSLC has worked to change first-year assessment processes and establish a teaching code of practice, while a final-year student project supported by the Students as Change Agents programme investigated and made recommendations regarding the use of technology-enhanced learning in mathematics, reporting to the SSLC and senior staff. In latter years, we have worked to bring these extra-curricular opportunities into the mathematics curriculum and we now regularly see 3rd-year group projects exploring curriculum design issues such as effective research-led education, improving feedback, and effective resource design, each considered specifically in relation to the discipline-specific requirements of mathematics students.

Mathematics is therefore well-placed to promote Exeter’s institutional brand, but needs to work to develop these initiatives further for the benefit of all mathematics students and to ensure that good practice is embedded across the curriculum and not just in isolated areas.

Uncomfortable truths

In addition to the challenges of renegotiating the identity of our programmes in the new Higher Education environment, there are a number of features of the present Higher Education system that are likely to be incompatible or increasingly strained in the future. Perhaps the most significant of these is the notion of comparability of degrees: as institutions diversify further and seek to forge new and distinct identities for their programmes it is likely that present metrics for comparing institutions will become ever more meaningless.

As a consequence of divergent curricula, the ability of students to transfer between institutions may well be curtailed, putting even greater pressure on students to make the right decision from the start regarding where they choose to study. But if this is to work, institutions must also be prepared to be much more transparent about the nature and philosophy of their degree programmes.

Moving away from traditional mathematics lecture courses to enquiry-based learning is also a significant task, requiring not simply the development of new modules but investment in staff training to ensure that we are upskilled to teach in a new and challenging way. There needs to be an explicit recognition, also, that students will have a transition to make to a new kind of learning, for which they also need preparing.

Conclusion

I have discussed how the new Higher Education environment highlights new and difficult challenges for mathematics provision at Exeter, with reference to the wider national picture. These challenges represent opportunities for mathematics at Exeter to find a new identity, building on some excellent
foundations, and develop a truly unique student experience reflecting the institutional brand of the University of Exeter. However, there are significant risks and threats to mathematics at Exeter both in adapting and in refusing to change. Our anticipation of these challenges and our responses as a discipline will determine the future success of mathematics at the University of Exeter – I would hope that our ambition would always be to be world-leaders, setting the standard for mathematics curricula in the twenty-first century.

References


