sigma – a network working!

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Abstract

During the 1990s, the phrase 'the mathematics problem' came into common usage to describe the mismatch between the mathematical competencies of incoming undergraduates and those expected for the study of a range of disciplines in higher education. This prompted the establishment of a number of mathematics support centres. A strong community of practice in mathematics support has developed, primarily around **sigma**, a Higher Education Funding Council for England (HEFCE) designated Centre for Excellence in Teaching and Learning with later impetus coming through funding from the National HE STEM Programme and leading to the formation of the **sigma** Network¹. Most recently further impetus has come through HEFCE SIVS² funding to consolidate and develop the network. In this article we review the development of mathematics support provision, the growth of a community of practice and the strengthening of the network. We demonstrate that **sigma** today represents a vibrant and active community supporting and enhancing the experience of thousands of university students.

The mathematics problem

The phrase 'the mathematics problem' came into common usage amongst university academics in the 1990s. The broad meaning of the term was that incoming undergraduates in a range of disciplines, but at that stage primarily engineering and science, were under-prepared for the mathematical demands of their courses. A series of reports from professional bodies and learned societies began to provide evidence of the scale of the problem. Prominent amongst these reports were *Mathematics Matters in Engineering* (Institution of Chemical Engineers *et al.*, 1995), *Tackling the Mathematical Background of Undergraduate Engineers* (Sutherland and Pozzi, 1995), *Teaching and Learning Algebra pre-19* (Royal Society and Joint Mathematical Council, 1997) and *Engineering Mathematics Matters* (Institute of Mathematics and its Applications, 1999).

These reports primarily put the focus on the need to change pre-university mathematics education whilst, at the time, universities were struggling to deal with the reality of the mathematical competencies of incoming undergraduates. Studies by Hunt and Lawson (1996), Lawson (2003, 2004) and Todd (2001), based on diagnostic testing on entry to university, quantified the extent to which many students entering engineering and

¹ http://www.sigma-network.ac.uk

² SIVS Strategically Important and Vulnerable Subjects

science degree courses struggled with fundamental pre-requisites such as algebra, trigonometry and basic calculus.

At the end of the 1990s a summit of key 'players' in the higher education mathematics community took place to make an evidence-based case for the need for change. The outcome was the seminal report Measuring the Mathematics Problem (Hawkes and Savage, 2000). Shortly afterwards, the Government commissioned Professor Adrian Smith's Inquiry into Post-14 Mathematics Education that reported in 2004. The report. Making Mathematics Count (Smith, 2004) was far-reaching, making a series of recommendations, many of which were acted upon by the Government. These two key reports were influential on the provision of mathematics support throughout the higher education sector. The first stated that "Acute problems now confront those teaching mathematics and mathematics-based modules across the full-range of universities" (Hawkes and Savage, 2000:iii) and one of its recommendations was that "Prompt and effective support should be available to students whose mathematical background is found wanting" (Hawkes and Savage, 2000:iv). This message was reinforced by the Smith report: "Higher education has little option but to accommodate to the students emerging from the current GCE process" (Smith, 2004:95). Together, these reports had a significant effect on legitimising mathematics support and so it was that the mathematics support community began to flourish.

Sadly, the mathematics problem persists. A report by the National Audit Office *Staying the Course: the retention of students in higher education* (National Audit Office, 2007) noted that mathematics contributed to the low retention rates in science, technology, engineering and mathematics. The report observed that *"When science, technology, engineering and mathematics students are considered together, they are less likely to continue to a second year of study than students following other subjects"* (National Audit Office, 2007:24). It identified mathematics as a key contributing factor to these lower progression rates stating that *"Many students require some additional academic support, especially in the mathematical skills required in science, mathematics, engineering and technology"* (National Audit Office, 2007:32).

In the biosciences, *"Many biological science graduates have not studied mathematics beyond 16 ... their understanding of statistical techniques is low ... demand for statistics skills will increase."* (from the report *Skills Needed for Biomedical Research* (Association of British Pharmaceutical Industry (ABPI), 2008).

In the period from December 2010 to July 2012 there were no fewer than twelve major national reports focusing on elements of pre-university mathematics education. For example, in 2010, the Nuffield Foundation published the report *Is the UK an outlier: An international comparison of upper secondary mathematics education* (Nuffield Foundation, 2010). It showed that in England, Wales and Northern Ireland less than 20% of students study any mathematics post-16. However, in 18 of the 24 developed countries in the study the figure is over 50%, in 14 it is over 80% and in 8 it is 100%. In 2011, the Advisory Committee on Mathematics Education (ACME, 2011a). This report sought to further quantify elements of the problem; in particular, as a consequence of the woefully low post-16 participation rate in mathematics education identified in the Nuffield Report, it addressed the number of students entering higher education who were under-qualified mathematically. The conclusion was stark: *"We*

estimate that of those entering higher education in any year, some 330,000 would benefit from recent experience of studying some mathematics (including statistics) at a level beyond GCSE, but fewer than 125,000 have done so" (ACME, 2011a:1). Other reports include: Mathematical Needs – The Mathematical Needs of Learners, (ACME. 2011b), Mind the Gap (Institute of Physics, 2011), A world-class mathematics education for all our young people (Vorderman et al., 2011), Digital technologies and mathematics education (JMC, 2011), Solving the Mathematics Problem (RSA, 2012), Maths in A level science 2010 examinations (SCORE, 2012), Maths in A level assessment (Nuffield, 2012), Mathematics made to measure (Ofsted, 2012), International comparisons in Senior Secondary Assessment (Ofqual, 2012), Higher Education in STEM subjects, (House of Lords, 2012). The findings from these other reports are all in a similar vein and are an indication of the severity of the challenges faced by those responsible for teaching mathematics in higher education.

Whilst the case for mathematics support has been established for a number of years, there is now a growing body of evidence that support in statistics is also needed for students from a range of disciplines. Reports have highlighted problems with statistical and quantitative skills. For example, "*The UK is weak in quantitative skills, in particular but not exclusively in the social sciences and humanities… another reason for the poor skills of undergraduates is the dearth of academic staff able to teach quantitative <i>methods.*" (British Academy position statement *Society Counts: Quantitative Skills in the Social Sciences and Humanities* (2012)). Further evidence of the mathematics problem being recognised in the social sciences can be found in the establishment of the Q-Step Programme³. This £19.5m initiative is described as a "*strategic response to the shortage of quantitatively-skilled social science graduates*". Funded by the Nuffield Foundation, the Economic and Social Research Council (ESRC), and the Higher Education Funding Council for England (HEFCE), this five-year programme starting in 2013 has established Q-Step centres in 15 universities to develop new programmes, courses, work placements and pathways to postgraduate study.

The level of concern being demonstrated by so many different national bodies and stakeholders is compelling evidence that 'the mathematics problem' has not been solved.

What is mathematics support?

Colleagues in the higher education sector have not stood on the side-lines waiting for a solution to this problem but have been proactive in trying to address the problem in a number of ways. Provision of additional *mathematics support* for undergraduate students is now common practice in the majority of UK higher education institutions (see below), and *mathematics support centres* are frequently the means of delivering such support. The term '*mathematics support*' means activities, facilities and/or resources provided to support and enhance students' learning of mathematics or statistics whilst the student is enrolled on a programme of study at undergraduate or postgraduate level. Such learning support is extra, optional, and non-compulsory and is designed to assist students in developing mathematical and/or statistical confidence and skills. In general the students can be studying (almost) any discipline, at any level of higher education. Some might wonder why we say that the students can be studying almost *any* discipline. A couple of

³ http://www.nuffieldfoundation.org/q-step

examples illustrate this point. Students about to graduate who decide they want a career in school teaching will be required to pass a mathematics test whatever their own subject; this hurdle can be very intimidating for those who never liked mathematics at school and stopped studying it when they completed their GCSEs several years earlier. In addition, potential employers of new graduates increasingly use numeracy tests as part of their selection process.

"And after leaving university many graduates will find themselves faced with numerical reasoning tests when competing for jobs.... Often they will have forgotten much of what they once knew, and even if they haven't, their confidence in their own abilities may be low."

The Right Hon David Willetts MP, Robbins Revisited: Bigger and Better Higher Education (Willetts, 2013)

The term 'mathematics support centre' is usually taken to mean a dedicated, physical space in which to offer mathematics support. Tutors are available in the centre at specified times for one-to-one or small group advice. The centre may be used to house a bank of learning resources so that students are encouraged to help themselves and not rely solely on the intervention of a tutor. Many centres offer students workspace to encourage learning communities. There is often access to computing and other facilities such as video. Practice differs from university to university. There is variation in where support centres are located. They may be in a mathematics (or other) department or in a central service such as a library or skills centre. Some involve peripatetic tutors moving from location to location in 'Maths Cafes'. Some centres employ staff dedicated to offering mathematics support whereas others bring in mathematics and statistics lecturers and postgraduate tutors. Increasingly, support centres are the focus of related initiatives, for example offering diagnostic mathematics testing of new students. supporting students who have additional needs and preparing students for employers' numeracy tests. Many centres have successfully sought funding for other teaching and learning projects and so they can very usefully provide a focus for those staff who are interested in wider issues of mathematics education. Because of the nature of the work, some mathematics support tutors work in relative isolation – they may be the only maths specialist in a skills centre, or the only mathematician in a university that does not have a mathematics department. This is where the **sigma** Network has an important role to play.

sigma - 2005-2013

In 2005, the **sigma** Centre for Excellence in University-wide Mathematics and Statistics Support (**sigma**-CETL), led by Loughborough and Coventry Universities, provided opportunities for universities to establish substantial provision to address the mathematical needs of their students. By 2010, the **sigma** Network had been initiated to share practice, resources and experience across the higher education sector; there now exists a wealth of free publications and learning materials available from the **sigma** Network and **math**centre websites⁴. In 2011, **sigma**'s work was recognised through the Times Higher Award for Outstanding Support for Students. In making the award the judges' citation, given by Liam Burns, President of the NUS, stated "**sigma** is a fantastic example of institutions recognising genuine concerns in standards and acting in a positive way to address them".

⁴ <u>www.sigma-network.ac.uk</u> and <u>www.mathcentre.ac.uk</u>

The work and influence of **sigma** has extended beyond England. In the period 2010-2013, working within the HEFCE- and HEFCW (Higher Education Funding Council for Wales)-funded National HE STEM Programme, **sigma** helped establish mathematics support in 22 universities across England and Wales through the awarding of start-up funding and direct mentoring. In 2008 **sigma** sponsored and supported colleagues in Scotland as they established the Scottish Mathematics Support Network⁵, hosted initially at the University of St Andrews and later at the University of Glasgow. In 2009 the Irish Mathematics Learning Support Network⁶ was established, again with support from **sigma**. Today, both of these networks are thriving and Scottish and Irish colleagues contribute enthusiastically to the wider mathematics support centres run by members of the **sigma** Network in order to learn about our work, returning home to develop support centres in their own institutions.

Research undertaken by sigma demonstrated that by 2012 the majority of UK universities were providing some form of additional mathematics and statistics support. In 2012, 119 UK higher education institutions were surveyed and responses received from 103 (87%) across the range of mission groups and unaligned institutions. Of the 103 responding institutions, 88 were identified as having some form of mathematics support. The level of support is wide ranging, from ad hoc help for struggling students in some institutions to a dedicated support centre in others. In some, support is available only to first year undergraduates on specific courses whereas in others it is available to all students and staff. The full findings of the survey are reported in Perkin, Croft & Lawson (2013a,b). They broadly indicate that the need for support is not directly related to students' entry qualifications – the level of support provision in those institutions whose students have the highest entry qualifications is similar to that in other institutions. In an attempt to measure the number of institutions providing extensive support services the authors introduced the concept of a 'highly visible centre' - one which was staffed for at least ten hours per week and for which there existed specific web pages providing information to students. In 2012, 30 of the 103 responding institutions were categorised in this way, again across the range of mission groups. Since 2012 there has been further significant growth as we describe below.

sigma - 2013-2016

In 2013, HEFCE, with the endorsement of the Minister of State for Universities and Science, provided funding of over £800,000 to the **sigma** Network to establish a threeyear follow-on programme to maintain and further embed mathematics and statistics support across English higher education institutions. Whereas previously the work of **sigma** was focused upon supporting practitioners, an additional and key part of the current work is to explore existing and future *high-level sector needs* in relation to mathematics and statistics support. This includes identifying both the support universities might welcome from the Funding Council, and how the **sigma** Network can aid senior management within universities to ensure the provision continues to meet institutional needs in a sustainable manner.

⁵ https://sites.google.com/site/scottishmsn/home

⁶ http://supportcentre.maths.nuim.ie/mathsnetwork/

[*sigma*].... is establishing approachable maths support services at institutions across the country. Thanks to their work, politics students suddenly confronted with a regression analysis have someone to turn to. STEM (Science, Technology, Engineering and Mathematics)undergraduates too are receiving expert support to bring their maths skills up to speed."

The Right Hon David Willetts MP, Robbins Revisited: Bigger and Better Higher Education (Willetts, 2013)

sigma's work is scrutinised by an Advisory Group consisting of high profile representatives from the higher education sector and professional bodies, including the Institute of Mathematics and its Applications. Activities fall into four distinct areas of delivery. The first area is national activity aimed at consolidating the community of practice. Regional hubs, established at six institutions during the National HE STEM Programme (covering the North-West & North Wales, the North-East & Yorkshire, the Midlands, Eastern England, the South-West & South Wales and the South East (Figure 1)), are responsible for organising workshops and providing opportunities for the sharing of good practice at a local level.



Figure 1: A map showing the six **sigma** hub regions.

Each hub has a co-ordinator. They, together with the ring of contacts and local activists that they have assembled around them provide the day-to-day face of **sigma** for tutors working in mathematics support centres across the regions. The work of the **sigma** hubs is co-ordinated by the Chair of the **sigma** Network (Figure 2).



Figure 2: sigma hub co-ordinators away day in July 2014

A website (<u>www.sigma-network.ac.uk</u>) provides information to the community. There are regular e-newsletters and a free email discussion list at www.jiscmail.ac.uk/sigmanetwork. Mentoring is freely provided to newcomers, there are tutor-training workshops, and opportunities for undergraduate students to work as summer interns on teaching and learning projects. **sigma**'s annual conference (CETL-MSOR: Continuing Excellence in Teaching & Learning – Mathematics, Statistics and Operational Research), which has been held annually since 2006, will take place at least until 2016. The 2014 conference was held at Cardiff University and the next will take place at the University of Greenwich on September 8th/9th 2015. The conferences attract around 100 delegates from a wide range of higher education institutions and newcomers are always made welcome. It has been able to demonstrate outstanding contributions to the field of mathematics and statistics support.

The second area of activity is the distribution of funding to set up new mathematics and statistics support in institutions with little or no existing provision. Matched funding from the institution together with senior management endorsement is a requirement. Following two rounds of funding calls, **sigma** has been able to support new activity in the following institutions: Bournemouth University, Halesowen College, King's College London (Figure 3), Lancaster University, Nottingham Trent University, Royal Holloway - University of London, University of the Arts London, University of East London, University of Greenwich, University of Leicester, Vision West Nottinghamshire College. Experienced mentors have been recruited to help these new centres to thrive over the coming two years.



Figure 3: Paolo Battistotti and Shan Luo, Maths Support Tutors at King's College London

The third area of activity is concerned with provision of resources to the community. *math*centre (www.mathcentre.ac.uk) is the open access website established in 2003 with mathematics resources for both students and staff. Usage data⁷ indicates that the site is well-used attracting approximately 125 000 users viewing 1.3 million pages. Staff resources have been expanded by the addition of key reports and publications relating to mathematics support. The open access website *stats*tutor (www.statstutor.ac.uk) was launched in 2012 with case studies and resources for students in higher education studying statistics. Usage statistics⁸ show that *stats*tutor was accessed by approximately 13,000 users for just under 17 000 sessions. For both sites, the *math*centre and *stats*tutor Community Projects enable the resource banks to expand by facilitating high quality peer reviewed resources developed by academics and support practitioners to be made available to a wider community. sigma is providing funding to the community for members to develop additional resources.

The final area of activity is concerned with sustainability of the network. Looking beyond 2016, it is recognised that a sustainable base needs to be established for the future. It is critical that mathematics support remains firmly embedded within the higher education sector through the practices of individuals and institutions; its profile needs to be raised along with increasing the number of individuals and institutions who engage. A vital element of sustainability is the establishment of a community of practice of sufficient critical mass that there will exist within it the capacity to continue many aspects of this project without becoming over-reliant on external sources of funding. To this end, the central **sigma** team along with the Chair of the **sigma** Network are setting in place measures to build a sustainability strategy. An important aspect of sustainability is the recognition by senior university managers of the importance of mathematics and statistics support. There are promising initial signs that this recognition is forthcoming, evidenced by a number of institutions making reference to mathematics support in their OFFA Access Agreements. For example:

⁷ Google Analytics 01/07/2013 – 30/06/2014

⁸ Google Analytics 01/07/2013 - 30/06/2014

The York Maths Skills Centre has been set up to provide University-wide support for elements of maths learning which is independent of departments and which complements departmental provision... The successful establishment of the Mathematics Skills Centre to support students across a wide of range of disciplines was identified as a 'Feature of Good Practice' by the QAA in its 2012 Institutional Review.

> University of York Access Agreement 2014/15

A high-level sector needs analysis has begun. This is taking the form of interviews with senior staff (generally at Pro-Vice Chancellor level) in order to understand more about how they see the mathematics and statistics support needs of their students being satisfied and developed at an institutional level, and how **sigma** can assist in this regard. A report will be available by the end of 2014 and is expected to shape **sigma** developments over the remaining two years of funding and provide an evidence base for informing thinking at HEFCE. It is recognised that there are several other key organisations, particularly the Office for Fair Access (OFFA), the Q-Step Centres and professional bodies, which have an interest in sustaining the work of **sigma** and work already started will continue in order to develop linkages with them.

Is it worth it?

Increasingly, the work of the community of practitioners is being underpinned by scholarship (Samuels and Patel, 2010). The evidence base for the value of mathematics support is growing as more practitioners are systematically analysing data and reporting how students supported by their Centres are performing, and often outperforming non-users. There is a growing body of research examining the operation and impact of support centres. **sigma** has reviewed the existing literature (Matthews *et al.*, 2013) and evidence is shown of the evaluation of support centres in the following areas: the collection of data and the challenges that are presented in both quantitative and qualitative studies; analysis demonstrating centre usage and activity; analysis showing the impact of centres on students, staff and the institution. The *math*centre website provides links to the growing range of studies⁹. The **sigma** quarterly newsletters also record recent research outputs related to the efficacy of mathematics support, so there is a wealth of evidence available to support the community's work.

Going forward

In 2007, the University of St Andrews report - *Responding to the Mathematics Problem* - *the implementation of institutional support mechanisms* (Marr and Grove, 2010) - contained a Foreword by Dr Joe Kyle, University of Birmingham. He wrote ".....Looking back, I probably regarded mathematics support as a form of cottage industry practised by a few well meaning, possibly eccentric, individuals, who may themselves have been hard pushed to offer a credible rationale for this work...... Now only a few years on, we see that the concept of mathematics support has not only become firmly embedded in

⁹ <u>http://www.mathcentre.ac.uk/types/research-papers/measuring-the-effectiveness-of-support-centres/</u>).

UK Higher Education, but colleagues have moved on to gather data on the way students use such resources and look for optimal strategies for the delivery of this support, and this is perhaps the most convincing evidence of acceptance. Mathematics support came of age in the first decade of the 21st century. What might once have been described as a cottage industry now plays a respected and widely adopted role in Higher Education".

Over the last decade, the field of mathematics and statistics support has continued to grow and has benefited from significant injections of funding that have enabled the community to thrive, support for students to be considerably enhanced through new centres and new activities, and high quality resources to be developed. The current injection of funding from HEFCE will enable further growth and consolidation up to the end of the funding period in July 2016.

A call to action

Anyone involved in mathematics and statistics support in higher education, or with an interest in this field, is encouraged to join the growing **sigma** community by visiting the website, subscribing to the JISCmail list, contacting their local **sigma** hub co-ordinator and contributing to events.

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