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Community Perspectives of Mathematics and Statistics Support in Higher Education: Building the Infrastructure

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Abstract

Over the last two decades, mathematics support has, increasingly, been seen by higher education institutions as a vital mechanism for helping students enhance their mathematical and statistical skills, particularly as they make the transition to university study. Several studies have shown the growth of mathematics support across the higher education sector within the UK, Ireland and beyond. Others have demonstrated its impact upon learners. However, few have explored the extent to which mathematics support is embedded within institutions or the extent to which it is likely to be sustainable. Such analyses are important for both the institutions themselves and the many colleagues who are working to develop mathematics support into an area of study in its own right. Here we report on a survey of 47 institutions offering mathematics and statistics support within the UK. Findings show that, within many institutions, mathematics support is now embedded as part of student-focused institutional support provision. Further, its impacts are increasingly extending beyond those students who access the support: there is evidence that mechanisms are in place for feeding findings from mathematics and statistics support into mainstream teaching and learning and curriculum development. Significantly, the analysis shows that mathematics support offers good potential for sustainability such that the legacy of national endeavours to establish it more widely will continue to exist into the future.

1. Introduction

For over 20 years the phrase 'the mathematics problem' (LMS, 1995) has been used to describe the issues associated with many students arriving at university underprepared for the mathematical demands of their courses, and the associated challenges for those who

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teach them. While the 'mathematics problem' was initially observed within the engineering and science disciplines, evidence from a range of national reports now indicates that it is prevalent across a range of subject areas (see for example Croft et al (2015) for a summary).

In responding to this problem, the provision of additional 'mathematics support' for undergraduate students is now common practice in UK higher education, and 'mathematics support centres' are often the means of delivering such support. The term 'mathematics support' encompasses 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 within higher education. Such learning support is extra, non-compulsory and is designed to assist students in developing their mathematical and/or statistical confidence and skills.

Although mathematics support may have had its origins in supporting engineering and sciences students beginning their studies in higher education, it can in general be available to students from any discipline and at any level including postgraduate: *"Postgraduate courses, which are often more quantitative than their undergraduate counterparts, give rise to further challenges."* (Tolley & Mackenzie, 2015). Further, employer numeracy tests are an increasingly important part of the employment process: *"...after leaving university many graduates will find themselves faced with numerical reasoning tests when competing for jobs. Yet only 16 per cent of undergraduates studying subjects other than maths have an A-level in maths under their belt. 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."* (Willets, 2013).

Whilst there are variations between institutions in their approach to providing mathematics support, the term 'mathematics support centre' is usually taken to mean a dedicated, physical space in which mathematics support is offered. While centres may offer a range of self-help learning materials and space for peer-peer learning, an almost universal feature is the availability of a tutor (or tutors) in the centre at specified times for one-to-one or small group advice. Since 2000, there has been visible growth in the existence of such centres within UK higher education. In 2001, a survey undertaken by Lawson, Halpin and Croft (2001) identified that 46 out of 95 responding institutions offered some form of additional support for those learning mathematics; by 2012 Perkin, Lawson and Croft (2012) reported that this figure had increased to 88 out of 103 responding institutions.

There exists further evidence indicating mathematics support is becoming more widely embedded as part of institutional policy and practice. A recent survey undertaken by Tolley

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and Mackenzie (2015) sought to establish the views of senior management within UK higher education on the mathematical and statistical support needs of their institutions. Their report identified that a senior manager in every university questioned stated that students in their university had issues with their learning of mathematics and statistics and *“that unless they provide appropriate forms of learning support for mathematics and statistics, it is inevitable that there will be an adverse impact on their students’ satisfaction, retention, achievement and employability”* Further, and very much reinforcing the observations of Kyle (2010) *“mathematics support is now more visible and high-profile within HEIs and is seen as important for enhancing the student experience and aiding success”* (Tolley & Mackenzie, 2015).

While there is much practitioner activity relating to mathematics support, and emerging recognition from senior management of its importance, how it is delivered and managed varies enormously across the sector. This is an area that merits further study, particularly as higher education within England is undergoing a period of change. The 2017 Higher Education and Research Act 2017 (DfE, 2017) commits to replacing the Higher Education Funding Council for England (HEFCE) and the Office For Fair Access (OFFA) with a single sector regulator and student champion called the Office for Students, and the implementation of the associated Teaching Excellence Framework (TEF) has just entered its third year. As a consequence universities are being increasingly required to articulate their commitment to ensuring fair access and their efforts to ensuring all students receive a higher quality learning experience; mathematics support can be a contributor to both (Matthews et al, 2013).

The publication of the 2010 Independent Review of Higher Education Funding and Student Finance (Browne, 2010) signalled the start of a changed financial environment for higher education within England with students themselves making an increased contribution towards the costs of their education. In this new era the national, and additional, financial support that was once widely available to institutions from HEFCE (Trowler et al, 2013) to support learning and teaching enhancement and innovation activity has been substantially reduced. Mathematics support was a significant beneficiary of such funding from HEFCE, firstly through the Centres for Excellence in Teaching and Learning initiative (2005-10), then the National HE STEM Programme (2009-12), and most recently a direct activity grant (2013-16). With the removal of this external financial support and incentivisation, there is an increased onus upon higher education institutions to fund mathematics support activity for themselves, and as such, it is timely to try to explore just how sustainable the existing range of provision really is.

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2. Research Methodology

In early 2016 an online survey, consisting of 23 questions was undertaken, aimed at those working in mathematics and statistics support, with the purposes of:

- Exploring the roles and recognition of staff involved in providing mathematics and statistics support within higher education.
- Identifying current institutional practices and approaches in relation to the availability of provision, delivery and management of mathematics and statistics support.
- Reviewing the likely sustainability of mathematics and statistics support as currently established within the higher education sector.

While there already exists a tradition of undertaking sector-wide surveys in relation to mathematics support (see for example Perkin et al (2012) and Cronin et al (2016)), here the purpose was to build upon this previous work by seeking to understand the practice of establishing and delivering mathematics support rather than ascertaining the extent of current provision.

The survey was targeted at staff responsible for the day-to-day operation of the mathematics and statistics support provision within their institution. Appropriate ethical guidelines (BERA, 2011) were followed in conducting the research: its purpose was made clear at the outset, and responses were received on an entirely 'opt-in' basis. While personal information was collected, this was to assist should further follow-up be required. Any information that might identify an individual has been anonymised in the analysis that follows, and where changes have been made to quotations this is solely for the purpose of maintaining the anonymity of responses; any such changes are shown in [square brackets].

Grove and Pugh (2017) provide a 10-point framework for analysing the potential sustainability of learning and teaching initiatives. The survey questions directly address the seven (out of a total of ten) indicators on the framework that relate directly to sustainability at an institutional level, and as such, this paper is divided into two parts: the first part presents the findings from the survey, explores their significance, and identifies any features of practice that offer benefit to the wider mathematics and statistics support community. The second part then considers these survey findings relative to the framework of Grove and Pugh to explore the current 'sustainability case' for mathematics and statistics support within higher education.

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A total of 52 individual responses were received representing 47 higher education institutions within England, Scotland, Wales and Northern Ireland. Of the responses, 51 were from staff members (who formed the target audience for the survey), and so the single response from a postgraduate student was excluded. The multiple responses received from three institutions (including three from a single institution) presented a dilemma for analysis: for some aspects of analysis only institutional responses were required, whereas for others individual perspectives were needed. As such, using author knowledge of the respondents and institutional responses, three of the five entries representing two institutions were removed by data cleaning for the institutional aspects of the questionnaire; two entries remained for one institution as it is known that the university in question operates multiple mathematics support centres delivered by different individuals. As such the number of institutional responses equals 48, and the number of individual responses equals 51.

3. Institutional Representation

The institutional responses to the survey are shown within Table 1 and demonstrate wide representation from across the higher education sector. Many universities have formed groups with common interests and these include regional university associations and also so-called 'mission groups'; these are helpful for classifying responses although some institutions are unaligned with any group. The common 'mission groups' have been used: the Russell Group (representing the major research-intensive universities); University Alliance (a group formed of universities based in cities and regions); and, million+ (an association for modern universities). Up until 2013 there existed the 1994 Group which represented the smaller research-intensive universities; had this grouping continued, six institutions currently included as 'Unaligned' would have been classified in this 1994 Group.

Institution type	Number of institutional responses
Russell Group	11
University Alliance	12
million+	7
Unaligned	17

Table 1: Institutional responses presented by mission group (n=47).

4. Extent of Institutional Provision

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Evidence from Perkin et al (2012) shows that the extent of mathematics support provision within institutions has been increasing since 2002. However, the scale of provision that is available to learners is unclear – that is, how many hours of mathematics and statistics support are available during a typical week in term time? Table 2 shows that mathematics support is typically widely available to learners with over 75% of centres reporting that their provision was available for 10 or more hours per week, and almost 55% being open for more than 15 hours per week. In general, there is a clear trend that the longer the centre has been established, the greater is the number of hours of provision made available to learners. The fact that opening hours have increased over the years may be indicative of the value placed on a centre by the host institution; as the centre has matured it has proved its worth.

Many centres also offer support with statistical queries. However when seeking to explore the current availability of statistics support provision, it is evident that we need a clearer definition of what is meant by 'dedicated statistics support' as this led to a level of confusion amongst respondents:

"I am not entirely sure what is meant by dedicate[d] statistics support. I do offer statistics support to Undergraduate, Postgraduate and Staff but my role is not dedicated to statistics it is for any hidden mathematics within the HE context."

This reflects the fact that statistics support can encompass a wide spectrum: from what might be termed routine problems (determining standard deviation, etc.) up to the design of experimental research studies and subsequent data analysis using sophisticated statistical techniques associated with undergraduate projects and even postgraduate research. Perhaps a better definition to replace 'specialist statistics support' would be 'dedicated statistics support sessions offered by a specialist statistics tutor':

"Statistics support is offered during a specific drop-in session (due to a lack of statistics tutors) and appointments are available upon request."

Of the 29 institutions offering dedicated statistics support (Table 2), 27 made their provision available to undergraduate students. Eleven of the 29 institutions indicated that their provision was available to staff as well as undergraduate and postgraduate students. Providing support to staff highlights one of the perhaps overlooked aspects of mathematics and statistics support and that is its role within the staff development process for those working within institutions. Twelve institutions make statistics support provision available to undergraduates and postgraduates only, and a further three restrict their provision to

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undergraduates, although the flexibility of support centres in their willingness to support those beyond their target audience was noted in several instances:

"...can offer to postgrads if time available (we have a limited number of hours given to Stats support)."

"We have no remit to offer support to Research Students and staff. However, we do not routinely turn them away when they seek support from us."

		(Average) hours provision during term time per week				
		1-3 hours	3-5 hours	6-10 hours	10-15 hours	15+ hours
	Length of time institution offering mathematics and statistics support provision					
Offering dedicated statistics support (29 responses)	Less than a year (1 response)		1			
	1-3 years (4 responses)	1			2	1
	3-5 years (5 responses)			1		4
	5-10 years (7 responses)			1	1	5
	10+ years (12 responses)			2	1	9
Not offering dedicated statistics support (19 responses)	Less than a year (0 responses)					
	1-3 years (4 responses)	1		1	1	1
	3-5 years (4 responses)	1			1	2
	5-10 years (3 responses)					3
	10+ years (8 responses)			3	4	1
Totals		3	1	8	10	26

Table 2: Availability of mathematics support provision during term time (n=48).

Statistics support, given the potential depth and breadth of the queries, means it must be delivered by specialist tutors with specialist expertise and preferably substantial experience in statistics. Additionally, the amount of time spent working on a single query can be significant and while institutions have models of delivery to reflect this, this has implications upon the extent of the service that they can provide. For example, some institutions offer

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bookable appointments of up to an hour which means the availability of statistics support to learners is more limited when compared to that of mathematics support.

Almost since the inception of the mathematics support centre, the traditional model of delivering mathematics support within higher education has been through drop-in based provision. Here, students can attend a centre at any time, during its hours of opening, to seek advice on their mathematical queries. Table 3 shows the results from the survey where respondents were asked to identify the main delivery models used for their mathematics support.

	Appointment Based	Drop-in	Appointment & Drop-in
Delivery modes used for mathematics support	5	14	29

Table 3: How is mathematics support delivered within your institution? (n=48).

It is interesting to note that while drop-in based provision is still highly prevalent, it seems there are many institutions (some 70% of respondents) having some form of bookable support provision for learners. As Table 2 shows, there were 29 institutions participating in the survey who offered dedicated statistics support, but here, 34 institutions reported that bookable appointments formed either a part, or the sole means, of delivering their mathematics support offer; it is evidently the case that bookable provision is no longer restricted for offering statistics support alone. What is not clear here is whether this move towards an appointment-based model reflects the more advanced nature of some mathematical queries, for example relating to specialist mathematics students in their later years of study, whether some support centres are offering their support in more of a tutorial or group format (although some respondents did report they offered this approach), or whether this is to address changed student expectations by providing a guarantee that they will be seen at a particular time or by a particular tutor with specialist expertise relating to their query.

5. Locations of Mathematics Support

When considering the nature of the physical space where the delivery of mathematics and statistics support takes place (Table 4) respondents were able to tick all options that applied to them. A common theme that emerged was how centres are using multiple locations and strategies in order to engage and target students more effectively with the provision that is available:

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"Appointments for 1 or 2 students are in dedicated space. Group appointments and Clinics (drop-in) are in different rooms that need to be booked. Most years we have sessions where we go to where the students are but it is not a fixed part of our provision."

"Central support is offered in our main library space. College/Department support is offered in college/department rooms."

"We have dedicated areas that are open when we are there and are student centred/social learning areas when we are not. We are mobile in the sense that we travel to where the students are and meet with them in social learning environments areas such as cafes across the campus."

Issues are known to exist whereby students who are most in need of mathematics and statistics support do not access the available provision. One of the key barriers identified by Symonds et al (2008) was a lack of awareness amongst such students of the location of the centre or the facilities it may offer. Taking support provision directly to students demonstrates a move towards a more proactive model for the delivery of mathematics support, and this in turn reflects how it is becoming increasingly recognised as an important part of the student support offer of institutions.

Dedicated space	Always same place but shared space	Different rooms as available	Mobile	Other
21	21	14	8	3

Table 4: Locations for the delivery of mathematics and statistics support. Note, here individuals have ticked all that apply which in some instances may be due to multiple locations existing within institutions.

In terms of the overall usage of the space made available for mathematics support within institutions (Table 4), the majority of universities who responded reported that they have either a sole-use dedicated space, or are located in a shared-use facility. Again this perhaps is indicative of the fact that institutions are investing strategically in their mathematics and statistics support provision, highlighting findings of Tolley & Mackenzie (2015), or that its visibility (in a regular location) is important for engaging, and indeed reengaging, learners:

"We will shortly be moving to a new, purpose designed space within a new library. This will increase our room size, but it may be used for other things at different times."

For those 42 institutions who reported that their centres had a dedicated location, these appear to be primarily based within other facilities where students from a range of

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disciplines will be present, for example libraries or student-focused buildings (Table 5). For those that responded 'other', centres were based in buildings that were used for teaching, student services, or academic skills. This reinforces the point that mathematics support centres are now accessible to students from across a range of disciplines, but also that mathematics and statistics support is now increasingly seen as part of a wider institutional 'offer' rather than as an independent or disciplinary 'service'.

In academic department	Library	Student Hub	Other
7	18	8	9

Table 5: Where mathematics and statistics support centres with a dedicated space are located within an institution. Note, here individuals have ticked all that apply which in some instances may be due to multiple locations existing within institutions.

To explore this further, respondents were asked whether they were part of, or working in conjunction with other institutional support or students initiatives: 33 respondents indicated that their provision was integrated or aligned in some way with other institutional services and 15 that it was not. A range of central units were mentioned which had differing names but, in the main, integration was with academic/student skills, learner support/development units, or the university library, all of which offered a variety of student-focused services:

"We are part of the study skills service which includes study skills, mentoring, PASS and maths/stats support and share space with these services."

"Part of Learning Development which, in terms of its student facing work, also offers Writing and Study Guidance."

"The maths team is located as part of a wider Learning and Language support team who contribute to a range of institutional initiatives around student success, employability and learning and teaching."

In some instances, although centres were integrated as part of a central university offering, the partnership nature of this arrangement was clearly articulated:

"We are part of the library professional services team and also have close ties with the School of"

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"We work with, but are not part of, the academic skills centre, widening participation..., Disability Services (I work for this department 1 day a week and we maintain links with them). We also work on projects with the Students' Union and a variety of academic and non-academic departments."

It was evident that some centres had either recently become more closely aligned with other institutional services, or that this is likely to take place in the future:

"just moved to be managed within the library"

"Currently in discussion over future provision with central services"

"This is likely to change in the future, as there [are] plans for Maths Support to be part of a planned [centre] which will incorporate all student support mechanisms."

The level of integration, collaboration, or alignment with other institutional services, again reinforces findings from Tolley and Mackenzie (2015) that institutions are becoming more strategic about how their provision of mathematics and statistics support operates, and as such are now viewing it as an increasingly important part of the student support provision that an institution offers.

With the emergence of a range of new technologies being used within teaching and learning, respondents were asked whether they offered online or virtual mathematics and statistics support to explore whether the delivery approach might have changed beyond the key relationship of a tutor working either one-to-one, or with small groups of students. In their responses 31 institutions indicated that they offered some form of online or virtual provision. In many cases this was of a passive form, making resources available either online or through a virtual learning environment:

"We have a wiki page and a series of online questions"

"We have lots of bespoke online resources which are freely available, we have a rudimentary online course"

In others, there were instances of social networking tools being used to provide mathematics and statistics support such as Facebook to enable online discussions:

"We have a Facebook group for maths / stats support in the Department..."

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"We have a...Facebook page, which is a new development since September 2015."

For other respondents, there were more interactive forms of remote support offered, either via email, telephone, or Skype. Particularly, reference was made to this form of support for either statistics or for those on distance learning programmes:

"We offer some guidance via our webpage and offer Google hangout sessions for students on placements or those who are unable to make it to campus for a variety of reasons."

"Statistical advisory appointments can be accessed via Skype."

"Generally, it's statistics help when online support takes place. Students can email their query to the stats support tutor."

In another institution the online service 'Howcloud' is being trialed to provide asynchronous support to students to allow them to access video, text and annotated tuition.

However, as noted by one respondent, the extent of student engagement with virtual forms of support is not always high, and as such this itself is perhaps an area that merits further study:

"We offer email support and also we offer skype support, aimed at distance learners, however this hasn't been utilised at all."

This emergence of, or at the very least an exploration of new ways of, delivering mathematics and statistics support, is perhaps not surprising for several reasons. There is a new generation of staff involved in mathematics support (12 out of the 51 survey respondents indicated that they had been working in mathematics support for three years or less) who may have themselves engaged with technological approaches during their own studies, and as such are exploring how this might be incorporated as part of their own teaching duties. Additionally, students, as well as being more technologically able and so perhaps expecting to make greater use of new technologies in all aspects of their studies, increasingly want support 'around the clock' and this is exemplified by the 24hour opening of some university facilities, particularly around exam time. Conversely, given that online support for teaching and learning has now been around for quite some time, it might seem surprising that just over a third of institutions responding to the survey do not have such a presence for their mathematics and statistics support activities.

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6. Management Oversight of Mathematics Support

We have already considered the extent to which mathematics and statistics support now appears aligned with other institutional services, for example student support or academic skills. While 33 respondents indicated there was a level of integration, it was not always clear who had the management responsibility for the mathematics and statistics support provision itself. In questioning respondents specifically on this aspect, of the 48 responses received, 29 indicated that their mathematics and statistics provision was a central institutional service, 13 indicated management responsibility rested with an academic department, and 6 indicated 'other'. For those who indicated 'other', this was typically because there was some form of joint working between an academic department and a central institutional service:

"We have a partnership model. The Library manage the staffing and facilities, the School of Mathematics provides academic expertise."

"Mixed. Finance provided by [learner support unit]. Day-to-day running organised by Maths group in School of [removed]. Annual report required by [learner support unit]."

For those centres that were managed by a central university service, while the name of this service unit varied greatly between institutions, it was typically associated with a student focused service and examples included: the library, academic skills, student (learning) support, and student services.

Again it was noted that, in addition to central support, there were instances of departments who provided their own mathematics and statistics support provision:

"There is a centrally funded and managed service, but there are also a couple of disciplines who fund and organise their own support."

"The [faculty] manages it's [sic] only support as this was set up as part of the HE STEM project."

Given these management arrangements, the associated reporting and governance processes and structures were also explored (Table 6).

	Yes	No
Length of time institution offering mathematics and		

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statistics support provision		
Less than a year (1 response)	0	1
1-3 years (8 responses)	3	5
3-5 years (9 responses)	4	5
5-10 years (10 responses)	7	3
10+ years (20 responses)	7	13
Totals	21	27

Table 6: Are there governance and reporting arrangements in place for your centre? (n=48).

Perhaps surprisingly there were more centres without clear governance and management processes/structures in place (27 centres) than with such arrangements (21 responses). Where formal procedures were not in place, there was recognition that this may change in future:

“nothing currently but I expect that to be formalised soon”

“We are trying to develop reporting back to Schools whose students use the service, but this is not yet fully in place.”

Where some centres acknowledged there were not formal arrangements, there were indications that instead there existed some form of informal reporting arrangement:

“There are occasional reports to PVC and also to the [advisory board], but that is concerned with much more than the maths support”

“I’ve seen some mentions in academic committee minutes but there is no direct interface between maths/stats support and the university’s internal committee/decision making systems.”

“We have a networking group that we meet with who we feed back to on [support centre] activity. There isn’t a steering or advisory group.”

The interesting finding here, however, is that almost two-thirds of centres who have been established for more than 10-years do not have formal government or reporting arrangements in place. Perhaps one reason for this is that centres over 10 years old are perhaps not attracting the same level of institutional attention as when they were first established; as a centre becomes a more accepted part of the established infrastructure the need for a steering or advisory group becomes much less. The following anecdote does

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indeed raise the possibility that when centres are deemed to have 'proven their worth', they perhaps receive less management attention and reporting/governance arrangements are relaxed:

"Had advisory group when setting up in 2002. Now have discussions with head of [unit with responsibility for support provision]. Brief report required by [that unit] (written by me)."

In the case of two slightly newer centres (5-10 years old) this also may also be emerging:

"There had been a steering group during the pilot phase of the Centre. In the last two years, some reporting had been made to the university's teaching committee. The future is uncertain as to whether this specific format will continue as it is not deemed necessary."

"Reporting not as substantial as start when we reported to the PVC via Learning and Teaching Sub Committee. Now it is part on a summary report for Student Services Department"

While the relaxing of formal reporting and governance processes can reflect the success and professionalism of the centre in delivering a service, it can have its downsides. There are particular issues associated with building collaborations and generating buy-in from across an institution and with securing longer-term funding and staffing resources. A further issue is when it comes to championing the case of, and achieving recognition for, the individuals who are working to provide a high-quality service – if senior management are not aware of the endeavours of those providing front-line mathematics support, accessing institutional reward and recognition mechanisms can be much more difficult.

Considering those centres that had in place clear reporting and governance structures, there were instances of reporting taking place as part of a much wider process:

"The Student Learning Service writes an annual report on its activities which include maths support. The annual report is forwarded to the hierarchy [Removed but equivalent to Head of Academic Practice Unit and Pro-Vice Chancellor for Teaching and Learning]."

"We had a steering group for the first year - reported to them 3 times. The [service unit with responsibility for the support] reports to one of the University committees - the maths support provision is included."

"Maths reporting is completed as part of the wider reporting on academic skills support provided by the institution."

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In terms of the actual mechanism by which reporting took place, this was typically through either a written report that was submitted within the institution, verbal reporting to an individual (Pro-vice Chancellor or Associate Dean) or a report to a university committee. In one institution, reporting arrangements for the centre were aligned with key institutional indicators:

“We produce and [sic] annual report focusing on some Key Performance Indicators (KPI) as well as reflecting on the year and planning for the next. We used to have a steering group and then an advisory group. We are in the process of formalising the KPIs more in line with 'sister' services e.g. Careers.”

Given management arrangements for mathematics support were found to be largely resting outside of academic departments, respondents were asked whether there were mechanisms in place to allow any findings emerging from mathematics and statistics support, for example common misconceptions within a particular cohort of learners, to be communicated back to their departments so that they might feed into mainstream teaching and learning (Table 7). This is of particular importance as mathematics support can play a strategic enhancement role within institutions. It provides a way of identifying specific issues that may impact upon the student learning experience, for example if a number of students from a cohort present with similar issues; these issues, if not addressed, may go on to be reflected in subject-level metrics of teaching and learning. Given this, there are real advantages in institutions using their mathematics support provision to identify and drive enhancements at a course or programme level – this will be particularly important if the Teaching Excellence Framework continues to progress at a disciplinary level.

	Mechanisms for feeding in findings	
Formal reporting arrangements in place		
Yes	Yes	16
	No	5
No	Yes	8
	No	19

Table 7: Are mechanisms in place for feeding findings from mathematics and statistics support into mainstream teaching and learning? (n=48).

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Responses were equal in number (24 each) for 'having' and 'not having' mechanisms to feed findings into mainstream teaching and learning. Where respondents indicated that mechanisms were not in place this should not necessarily be taken to indicate there were no arrangements; as seven respondents indicated, there are in fact informal processes that can be adopted ranging from conversations, learning and teaching seminars, to a collaborative approach by working directly with the department in question:

"There's nothing to stop me sharing information about maths/stats support with teaching staff and I do so periodically but there is no institutional mechanism for this."

"Not directly - but work has been disseminated via LT seminars (this has been driven locally)."

"There is no 'mechanism' but we would discuss issues within the weekly meeting and agree a reasonable way forward. This may include feeding back to a department and offering to work with them, for instance."

However, it is important to acknowledge here that in such instances, this approach is likely to be down to the work of individual(s) and the contacts they have established through their endeavours. Should they leave their mathematics support duties, there is a risk that this collaborative approach may be lost.

What was particularly evident when analysing responses to this question, was that where formal reporting arrangements were in place, mechanisms to feed findings into mainstream teaching and learning were more prevalent which is perhaps no surprise given the ready-made nature of reports and summaries. Where academic staff were involved in delivering mathematics support, the mechanisms for informing mainstream teaching and learning are fairly self-evident:

"A key strength of our Departmental level support is that it's staffed by the lecturers who deliver the relevant mainstream teaching. We have compulsory data analysis modules...So, our Departmental stats support is extremely well integrated into mainstream teaching and learning."

Presentations at a range of institutional events were cited as an important mechanism by 7 respondents including annual learning and teaching conferences and organised seminars although as is always the case with such events, there are no guarantees that staff from the relevant department will be present. A much more targeted approach involves direct engagement with the department, either through departmental committees:

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"I am able to e-mail lecturers directly and also address [them] in departmental meetings/programme boards"

participation in away days:

"findings from successful embedded work has been presented at school away days thus providing academic staff with exemplars of possible ways to embed maths"

supporting departments with their curriculum development:

"Involved in the school's portfolio refresh and design of new mathematics module."

and contributing to the delivery of departmental provision:

"I am often asked to assist with delivering hidden mathematics guest lectures. These lectures can be informed based on feedback from 1 to 1 student sessions. Using this, we start from where the students are rather than where they think they are or think that they should be."

In one institution a dedicated steering group that oversees the teaching of mathematics to non-mathematicians has been established to act as a mechanism for not only sharing information, but also developing a coordinated institution-wide approach to supporting learners with their mathematics and statistics. Related, there is direct evidence of mathematics support being used to aid, or enhance the work of other institutional units:

"We work in conjunction with [Removed], which provides support for students with disabilities and specific learning differences."

This reflects some of the mathematics specific issues associated with supporting students with disabilities and specific learning differences (Cliffe, 2015; Trott, 2015) that mathematics support has, over the years worked to address, and that it is now sharing more widely.

7. Sustainability

Through the work of **sigma** significant external support, include financial, has been made available to help institutions establish their mathematics and statistics support provision. For example, through the National HE STEM Programme 22 new mathematics and statistics support centres were established, and through **sigma's** most recent direct funding from HEFCE provision has been established at a further 10. The important question is, therefore,

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whether this provision will now be sustained since the external financial support provided by **sigma** ended in July 2016.

While sustainability is most likely be an issue associated with the end of external funding, even for established centres, longer-term funding concerns may never be too far away. Of the 48 institutional responses received for the survey, 19 were from centres established by **sigma** since it commenced its activities in 2005.

		Established – likely to continue for foreseeable future	Funding needs be negotiated each year	Funding in place for fixed period (>2 years)	Imminent danger of closing	Other
	Length of time institution offering mathematics and statistics support provision					
sigma support to establish new mathematics support provision	Less than a year (1 response)			1		
	1-3 years (6 responses)	4	1			1
	3-5 years (4 responses)	2		1		1
	5-10 years (4 responses)	6				
	10+ years (4 responses)		1	1		
All other (non- sigma established) centres	Less than a year (0 responses)					
	1-3 years (2 responses)	2				
	3-5 years (5 responses)	4			1	
	5-10 years (4 responses)	4				
	10+ years (18 responses)	14	2	1	1	
	Totals	36	4	4	2	2

Table 8: Likelihood of mathematics and statistics support being sustained in responding institutions (n=48).

Overwhelmingly (Table 8) respondents indicated that they felt their provision would be sustainable, and this was independent of how long their institution had been offering mathematics and statistics support. Several respondents indicated that they were aware of the support of senior management for their work, but this was in no way universal. It appears that the positive views of senior management towards mathematics and statistics support, as expressed within the work of Tolley and Mackenzie (2015), may not be reaching those who are actually providing the service to learners.

While such findings relating to the suitability of mathematics and statistics support provision are clearly positive, there is clearly a need for caution. Some respondents cited that there

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remains an annual challenge to secure funding to maintain their centre, and highlighted uncertainty if this ceased:

"Have support from the Institution to further embed maths and stats support, in principal agreed for at least 2 years...We only got this as I got fed up with the annual negotiation for funding and refused to continue in this manner next academic year. The annual negotiation reduced staff morale and dedication to this service (as we seem to have been permanently short staffed since setting up the maths support centre)."

"We are funded by Widening Participation. I am not sure what would happen if we no longer received this funding."

Others noted that there were limits to what could be achieved with the level of funding they currently have available:

"The funding is quite small, so this can be a limiting factor in expanding the provision."

This will be particularly important if the uptake of mathematics and statistics support by students continues to grow, and how their expectations as to the level and quality of service they may have come to expect can be reasonably managed.

While the nature of the responses from the 47 higher education institutions (and 48 centres) indicate a very positive story, with 75% of respondents reporting their centres are likely to continue for the foreseeable future, there were a number of institutions who indicated that funding negotiations need to take place on either an annual or bi-annual basis. More worryingly, however, there were several responses which indicated that the critical role of staff members as the key providers of mathematics and statistics support is perhaps not being considered. Several responses indicated that some institutions were looking to reduce costs by cutting staff:

"The University is making redundant most of the staff teaching mathematics who incidentally is the only staff grouping that serves in the maths/stats support centre."

"Having dealt with a record number of students last session it was a surprise to find my FT post placed at risk and then replaced by a 0.4 FTE post."

Clearly sustaining any form of mathematics support provision requires a level of ongoing financial resource, but it is very much the case that not everyone, even if they have a strong mathematical background, is suited for providing this support (Croft & Grove, 2016). As

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such, institutions, if they are to maintain a service that meets the needs and expectations of learners must ensure they engage staff with not only the necessary subject knowledge but also the skills and expertise to work with learners who may be amongst some of the most vulnerable within an institution. Cutting specialist mathematics and statistics support staff is a false economy and can cause serious problems for managing student expectations and their satisfaction.

8. Applying a Framework for Sustainability to Mathematics and Statistics Support

Following an analysis of the projects and activities undertaken through the National HE STEM programme, Grove and Pugh (2017) have identified a framework of ten indicators which they suggest can be used to identify whether an activity is likely to be sustainable after its initial 'pump priming' funding ceases. While it is clearly the case that any activity will require some form of investment (financial or human), this framework was designed with a single project or activity in mind; here, in the case of mathematics and statistics support we have a wealth of national activity undertaken over the last ten years, much of it supported in some way through the work of **sigma** (Croft et al., 2015).

While the framework can be applied to individual centres, it is more appropriate to explore the broader question of whether mathematics support, as a shared activity across the higher education sector, can be sustained. This exists in two parts: the practice and provision of mathematics support as led by higher education institutions, and the scholarship of mathematics and statistics support as led by the individuals who work within it. Such an analysis is timely as one of the key requirements for **sigma**, following its most recent three-year activity grant from HEFCE, has been to embed a sustainable portfolio of mathematics and statistics support activity across the sector.

Pugh and Grove (2017), note that sustainability is realised when one, or more, of three possible outcomes are achieved: 1. The activity continues unchanged in its current form; 2. An institutional decision results in the activity being embedded or continued in an alternative form; or, 3. Staff are equipped with a new outlook or skills that they continue to deploy throughout their careers. Here we consider seven of Grove and Pugh's (2017) indicators that relate specifically to the institutional aspects of sustainability. They allow us to explore whether the senior management commitment for mathematics support, as noted by Tolley and Mackenzie (2015), is validated by those working to deliver this support within institutions. The remaining three indicators, relating to sustainability through the

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influences, activities and scholarship of the individuals involved in mathematics support, will be considered in a future work arising from this study.

1. Embedding the Importance of Sustainability at the Outset

Of the 47 higher education institutions (and 48 mathematics and statistics support centres) sampled within this survey, 18 of them had received support (financial and guidance) from **sigma** to establish their mathematics support provision; a further five received support to enhance their existing provision. In particular this funding was made available as part of either the **sigma** CETL initiative (2005-2010), **sigma's** work in the National HE STEM Programme (2009-2012), or most recently as part of its HEFCE individual activity grant (2013-2016).

Funding was awarded as part of a competitive process where those submitting proposals had to secure senior management support and explicitly articulate how their activities would be sustained after core funding had ceased; additionally, institutions were required to commit a matched-level of funding as part of their commitment. Exploring the response to the sustainability question for the 19 new centres established by **sigma** yields the results shown in Table 8.

Overall, just under two-thirds of the **sigma**-established centres indicated that they were likely to continue for the foreseeable future (and none indicated they were in imminent danger of closing), and this was almost identical to the figure for the non-**sigma** established centres (which was exactly two-thirds). The key difference, however, is that **sigma**-established centres are typically much younger than the non-**sigma** established centres. While it is to be expected that more mature centres will have proved their worth within an institution and as such are more likely to be sustained, amongst newer centres this is a positive finding. It reflects not only the requirements of **sigma** for institutions to consider sustainability when bidding for a centre, but perhaps also in the value now placed upon mathematics and statistics support by institutions and as articulated by Tolley and Mackenzie (2015).

2. Proven Starting Point

Mathematics support is not only well established, but the extent of provision has continued to grow over the last ten years (Perkin et al (2012)). Much work has been done on how to set up a support centre (see for example Mac an Bhaird & Lawson, 2012), how to train those delivering provision (Croft & Grove, 2016), how to gather feedback (Green, 2012), and how to evaluate institutional mathematics and statistics support provision (Matthews et al,

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2013). There are now also many different models and approaches for individuals to adopt and utilise (Marr & Grove, 2010). Additionally, there are many freely available, high quality, mathematics and statistics support resources available on **sigma** supported websites such as mathcentre and statstutor which can be used as the basis for establishing support provision.

The resource base for anyone looking to establish or develop their mathematics and statistics support is therefore extremely strong, furthermore as we shall discuss later, there is a large and active community of practitioners willing to support others with the development of their provision. As an example, this was exemplified through the work of **sigma** where experienced mentors were allocated to help those who were new to establishing such provision:

"Of most use to us was our mentor who was happy to share their mistakes, so we could avoid them and gave practical advice that will give us the best chance of sustaining our mathematics support programme."

From Grove (2013)

Although this scheme was funded and enabled visits between institutions to take place, mechanisms now exist for sharing practices electronically, for example, through the electronic **sigma** JISCMail mailing list.

3. Up-Front Investment

In the case of **sigma**-established centres, funds were made available to pump-prime their start-up by enabling the purchase of equipment and resources; this included direct financial resource from **sigma** and a level of matched funding from the institution. Furthermore, **sigma** has put in place a substantial knowledge-base to help institutions establish their provision by building upon the (proven) models and resources of others; by making this freely available, the mathematics support community itself has contributed to the up-front investment for any institution establishing or enhancing its mathematics and statistics support provision.

While there will always be a requirement for staff time, with evidence that some institutions are investing in dedicated staff, it is evident from the results of the survey (Table 4) that institutions are investing in the facilities for mathematics support as evidenced by centres increasingly having a regular and visible presence within institutions. Initial up-front investment appears to involve institutions making available a regular, but shared, location where mathematics and statistics support can take place. Of the **sigma**-established centres less than three-years old six out of the seven reported they had the same regular location

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but that the facilities were shared; for the **sigma**-established centres over three years old, 50% of these reported having their own dedicated space. As such, while there is evidence of up-front investment, through both **sigma** and the hosting institution, there also appears evidence of ongoing investment by institutions in their mathematics and statistics support provision as it matures.

4. Alignment of Activity with Wider Priorities

It is evident from the senior management survey of Tolley and Mackenzie (2015), that mathematics support is now often seen as part of a wider institutional 'offer':

"Decisions related to the development of the provision are often not taken in isolation but as part of wider strategic considerations. In some cases the developments will build upon previous experience and work within existing organisational structures, whereas in others the need to make transformational changes has been acknowledged and priority is being given to developing and implementing plans for university-wide systems of support."

Such findings were reinforced in the survey: it is not only the case that mathematics support centres work in conjunction with other institutional centres (such as student support, academic skills, and the institutional library), but they are increasingly embedded as an integral part of this provision and this is further validated through their reporting arrangements. It is also known that many institutions make explicit reference to their mathematics and statistics support provision in their OFFA Access Agreements (Grove, 2013).

5. Institutional Commitment

In many ways the commitment of institutions to their mathematics support provision can be demonstrated by evidence of how provision is embedded as part of a wider institutional offer. While the findings from this survey are important evidence, it is the views of senior management that are critical. Again as noted by Tolley and Mackenzie (2015):

"Many of the institutions sampled recognise the need to further develop the support they offer and to extend its scope and/or improve its effectiveness"

and:

"The need for mathematics support across all subjects is a major challenge that all HEIs surveyed regard as likely to continue."

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As such, the challenges associated with student learning of mathematics and statistics are well recognised by those making strategic decisions within higher education institutions, and mathematics support itself is clearly seen as a recognised solution. Further, there is evidence that institutions are committing to their activities in this area through dedicated staffing appointments, and there are examples of support centre staff being rewarded and recognised for their endeavours which we will report on in a future work.

6. Wider value

Mathematics support centres had their origins in the early-1990s where their primary mission was to support science and engineering students who were struggling with the mathematical skills and knowledge needed to successfully make the transition to university. In the time since, they have demonstrated that they can grow and adapt to support students from a wide range of disciplines and years of study, either at the transition to university, throughout their studies, or when supporting those undertaking employer numeracy tests at the transition to the workplace. Further, a number of centres also offer tailored and specialist provision for students who have additional needs and specific learning differences.

Through the survey, centres have demonstrated that their provision has developed and expanded to meet students' needs. At one level, this may be through increased hours of opening. Additionally, many institutions now provide statistics support, and the models of delivering this have developed from the drop-in approach associated with problems in mathematics, to an appointment based model. The support itself is no longer offered solely to non-mathematicians beginning their university studies; there is evidence that some centres are also supporting specialist mathematics students in their later years of study (Croft & Grove, 2015), and others make their provision available to staff within the institution. As such, it may very well be the case we need to revisit the definition of exactly what constitutes 'mathematics support' as this has clearly broadened. Also, there are signs that mathematics support is broadening still further with many institutions offering some form of virtual support. While in many cases this may be passive, in others, new technologies are being used to deliver asynchronous support to learners based outside the main university campus; with higher education in the UK continuing to itself change, and students seeking to learn 24 hours a day and in new ways, this is likely to be a continued area of focus and growth for the mathematics and statistics support community. Mathematics support has demonstrably diversified, and through those involved will

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continue to do. As such, its value is now wider than that which was originally envisaged during the initial phase of **sigma** between 2005 and 2010.

7. Evaluation

Many of the institutions responding to the survey indicated that there were formal reporting arrangements to convey the scale/impact of their work; for a number of others, even when arrangements were not classified as formal, informal mechanisms were noted as being in place. For those centres whose funding is renewed on an annual basis, it is likely there will be some form of evaluative requirement linked to their funding. As such, evaluation of mathematics support, in some form, is an essential part of the provision for both monitoring and planning purposes:

"All support is logged onto a CRM system, this is a new system by [which] my manager hopes to run reports at the end of the academic year."

"A yearly report of the usage of [the support centre] is created for management with our collected data."

Many individuals have gone beyond evaluating student engagement with their centres to exploring impact upon students and their learning. Not only this, as noted within the survey, examples were presented of how mathematics support is now going on to inform the design and delivery of the wider undergraduate curriculum. In 2012, a review of the research literature relating to mathematics and statistics support (Matthews et al., 2013) highlighted almost 80 published academic works relating to mathematics and statistics support. If such a review was undertaken now, the volume of such works would undoubtedly be greater – mathematics support has become an area of academic study very much in its own right.

Implications of the Framework

Considering the institutionally-focused aspects of the framework of Grove & Pugh (2017) for the **sigma**-established mathematics and statistics support centres yields a very positive case for their longer-term potential for sustainability. In particular, this appears linked to the approach used by **sigma** when establishing these centres, particularly relating to the requirement that institutions explicitly consider their sustainability at the outset, but also that mathematics and statistics support now forms part of a growing and vibrant national, and indeed international, community. Many of the arguments considered here for the **sigma**-established centres are also applicable for the non-**sigma** established centres, and taken as a whole, the evidence does point to an important longer-term role for mathematics and statistics support within UK higher education.

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9. Conclusion

There exists an increasing array of evidence highlighting that mathematics and statistics support is now widely offered by higher education institutions within England. The recent work of Tolley and Mackenzie (2015) to gather senior management perspectives on support provision offers insight into the value placed upon such provision by senior management; the findings from our survey reinforce their work. The data show that not only is mathematics support available within a range of different types of institution, as identified by their mission group, but that it is extensive in both its extent (number of hours) and range (backgrounds of the individuals to whom it is available). Significantly, there is evidence that the way in which mathematics support provision is 'positioned' within an institution is becoming increasingly strategic; in many cases there is alignment with other student-focused services and mechanisms are in place for institutions to utilise their findings from offering mathematics support to feed into main-stream teaching and learning. For a number of years there has been much debate relating to the embedding of sustainable teaching and learning interventions within UK higher education; our findings show that the approach adopted by **sigma**, when establishing mathematics support provision as part of its national activities, in terms of requiring matched institutional support and a clear plan for longer-term sustainability has paid dividends with supported centres showing a high likelihood of longer-term sustainability as perceived by those who lead them. More broadly however, the evidence indicates that mathematics support appears a sustainable part of the teaching and learning provision within UK institutions.

The data from the survey also gives an interesting snapshot of mathematics and statistics support and demonstrates that it is itself part way through a transition: what may have started as a cottage industry (Kyle, 2010) has progressed to becoming a respectable academic practice and is now well on the way to becoming a part of the general institutional student support infrastructure in most higher education institutions. The centres represented through this survey are all at different points in their evolution and as such represent a spectrum of mathematics and statistics support provision within the UK from which we can learn. While, like much of UK higher education, they are affected by external factors, the changing educational landscape has helped accelerate their development along with the support of **sigma** which has not only directly led to the establishment of many new centres, but also has enabled effective practices and ideas to be freely shared.

In this paper, we have focused upon what might be termed the (infra)structural aspects of mathematics and statistics support provision. However, equally important are the staff who

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work to provide this front-line support. Our survey has also explored the role of these individuals, the recognition and support for their development that they receive from their institutions, and the contribution that they make to the overall sustainability of mathematics support provision. These aspects will be reported in a future work.

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