sigma Σ
network for excellence in mathematics and statistics support

Senior Management Perspectives on Mathematics and Statistics Support in Higher Education

A research report by
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HIGHER EDUCATION FUNDING COUNCIL FOR ENGLAND hefce

The research was conducted with the support of members of the **sigma** Network Directorate:
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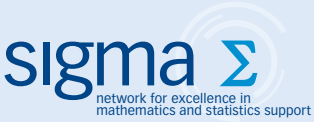

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1. Executive Summary

1.1 In 2013, HEFCE funded the **sigma** Network to further embed mathematics and statistics support across the HE sector in England. A key part of this work is to explore existing and future high-level needs, including the assistance institutions might welcome from HEFCE and the **sigma** Network in ensuring appropriate provision. The investigation reported here has collected and analysed senior management perspectives on mathematics and statistics support needs.

1.2 Semi-structured interviews were conducted with senior managers (typically Pro-Vice-Chancellors) from a sample of 23 institutions from across the mission groups. Questions addressed included:

- the challenges facing students in relation to mathematics and statistics;
- how those challenges are being addressed;
- the degree to which support is embedded and visible;
- plans and intentions with regard to the provision of support;
- how institutional priorities are determined;
- the external support that universities would value.

The resultant interview data were subjected to a 'thematic induction' and key analytical themes were summarised. Close attention was paid to appropriate ethical guidelines for educational research. Institutions have not been named and every attempt has been made to preserve their anonymity.

1.3 The challenges facing institutions across the sector with regard to mathematics and statistics are multi-faceted. Some of these challenges relate to students' prior mathematical experience. Only a small proportion of post-16 students continue to study any form of mathematics prior to entering HE and many of these students have developed a dislike or even fear of mathematics. Furthermore, some universities report that many students who have achieved high grades in A level mathematics seem unable to apply their mathematical skills in the context of their discipline of study. Other challenges relate to graduate attributes. Universities are under increasing pressure to produce graduates with good levels of numerical skills in order to compete successfully in the labour market or to be capable of undertaking advanced study, with many disciplines becoming increasingly quantitative at higher levels.

1.4 All of the HEIs questioned reported having students who are challenged by mathematics and statistics. These are not confined to the mathematical sciences and STEM disciplines, but extend to a rapidly increasing range of subjects that make use of quantitative methods, and to courses in which little or no use is made of mathematics or statistics but whose graduates often face numerical reasoning tests when seeking to enter employment. Postgraduate courses, which are often more quantitative than their undergraduate counterparts, give rise to further challenges.

1.5 The aforementioned challenges were attributed to:

- the fact that only a small proportion of students entering university have studied mathematics post-16;
- inhomogeneity amongst undergraduate cohorts;
- the fact that a GCSE grade C is insufficient preparation for many degrees which do not have a mathematics entry requirement above this;
- the difficulty many with an A-level in mathematics have in applying their knowledge to solving unfamiliar problems;
- supporting students with disabilities and specific learning differences in their learning of mathematics and statistics;
- the negative attitudes of some students to studying any form of mathematics or statistics.

1.6 Furthermore, all the universities questioned recognised 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. Every university had identified issues and initiated some form of response. Further, mathematics support is now more visible and high-profile within HEIs and is seen as important for enhancing the student experience and aiding success.

1.7 Learning support for mathematics and statistics varies widely across the institutions sampled, ranging from that which is restricted in scope and embedded in the design and delivery of selected modules in particular programmes through to comprehensive systems of university-wide support (often including drop-in facilities in a mathematics and statistics support centre) that can be accessed by all students. The extent to which mathematics and statistics support has become visibly embedded as a core part of institutional provision and practice also varies across the institutions questioned, being a recent, small-scale innovation in some, and university-wide and long established in others.

1.8 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. 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.

1.9 Coupled with such developments, a number of institutions reported they were considering requiring a full A-level in mathematics for entry to some courses, but given the already mentioned (see Paragraph 1.3) issues with low post-16 participation rates in mathematics, this may prove challenging.

1.10 The overwhelming majority of those interviewed recognised the value of some level of national collaboration in respect of mathematics and statistics support. At the most basic level, this provides for sharing of resources and experiences to help avoid 're-inventing the wheel'. There were repeated requests for contextualised learning resources. Many respondents pointed to contributions beyond the provision of resources that national collaboration could enable.

1.11 The provision of CPD was a frequently recurring theme. Two principal foci for CPD were distinguished. Firstly, the needs of specialised staff working in mathematics and statistics support were identified, with several respondents suggesting that there was a need for appropriate training leading to some kind of recognised or professionally accredited status. The second focus related to the embedding of mathematics and statistics support within modules. Staff in a range of disciplines need CPD to assist them in both the development of appropriate curricula and in the contextualised delivery of quantitative material.

1.12 Higher levels needs were also identified in relation to more strategic issues such as the dissemination not only of products (systems and resources) but also of processes including leadership, strategic thinking, brokerage, and promoting engagement with staff and students across the institution; helping institutions to develop their own capacity for curriculum innovation and organisational change; and, guidance targeted at HEI senior managers with responsibility for the strategic planning of the student experience.

1.13 The value of a single 'go-to organisation' that was the 'first port of call' in issues relating to mathematics and statistics support was frequently acknowledged. There were some differences of opinion about how such an organisation might operate – with some institutions favouring regional collaboration but others suggesting groupings of 'like universities' would be more effective. It was suggested that such an organisation might provide such things as bespoke on-site training, and on-going mentoring and guidance regarding evaluation of the effectiveness of mathematics and statistics support.

1.14 The accumulated intellectual capital of the **sigma** Network is respected and valued by many HEIs across the sector. This includes the knowledge and understanding **sigma** has acquired about mathematics and statistics support, and its established networks of collaborating institutions, organisations and communities of practitioners.

1.15 The need for mathematics support across all subjects is a major challenge that all HEIs surveyed regard as likely to continue. The **sigma** Network has the human resources and organisational structures to continue to play a leadership role in the development and dissemination of effective practice in the provision of such support.

2. Introduction

2.1 For many years, well-documented concerns have been expressed with regard to the mathematical skills and preparedness of undergraduate students as they begin their university courses, and of graduates moving into the workplace. These concerns are not directed primarily at those studying mathematical sciences or going into mathematical jobs, but more in relation to those studying in other disciplines before entering what might be termed 'graduate employment'. In a recent CBI survey (2013), only 21% of employers reported being 'very satisfied' with the basic numeracy skills of graduates entering the labour market.

2.2 In 2005, the **sigma** Centre for Excellence in University-wide Mathematics and Statistics Support, funded by HEFCE, began to provide opportunities for universities to establish substantial provision in order to address the mathematical needs of their students. By 2010, the **sigma** Network had been initiated to share practice, resources and experience across the HE sector, and there now exists a rich and varied collection of free publications and learning materials available from the **sigma**-network, **math**centre and **stats**tutor websites[1]. In addition, research by Perkin et al. (2013) demonstrated that the majority of universities were providing some form of additional learning support for mathematics and statistics.

2.3 In 2013, HEFCE funded the **sigma** Network to establish a three-year programme of work with a view to maintaining and further embedding mathematics and statistics support across HEIs in England. Whereas previously **sigma** had focused primarily on supporting practitioners, a 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 HEIs might welcome from HEFCE, and how the **sigma** Network can assist senior management within HEIs in ensuring that the provision continues to meet institutional needs in ways that are both fit for purpose and sustainable.

2.4 The aim of this enquiry, therefore, is to produce evidence that can be used to inform the future activities of **sigma** and to offer a carefully researched analysis to HEFCE of the strategic needs and priorities of the HE sector in England with regard to learning support for mathematics and statistics as perceived by senior managers from a carefully constructed sample of HEIs.

[1] www.sigma-network.ac.uk, www.mathcentre.ac.uk and www.statstutor.ac.uk

3. Design and conduct of the research

3.1 Through preliminary discussion between the researchers and the **sigma** Directorate, it was concluded that the aims of the research would be best served, not by means of a questionnaire survey, but through a series of in-depth interviews i.e. by the adoption of qualitative rather than quantitative research methods. It was further concluded, that given the fact that senior academics in universities were being asked to participate in the research at an extremely busy time of the year (May-July 2014), it would be necessary to adopt an eclectic approach to the conduct of the research interviews by offering them an opportunity to respond to the research questions by telephone, email or a combination of both[2].

3.2 The questions on which the interviews were to be structured were arrived at through discussion with the **sigma** Directorate of the objectives that could be derived from a critical examination of the aims of the research i.e. what information, if it could be obtained, would most usefully serve its underlying purposes. That analysis resulted in the identification of the following research questions, which were then used as the basis for conducting all of the interviews with representatives from HEIs in the research sample:

- What challenges do undergraduate and postgraduate students face in relation to mathematics and statistics in different subject disciplines across the whole institution?
- What support for mathematics and statistics is currently offered to those students within the institution?
- To what extent is mathematics and statistics support well established and embedded in that it forms a visible part of the core provision (e.g. through explicit reference to it in its OFFA statements or by having resources such as staff time allocated to it)?
- What are the needs, priorities and intentions of each institution with regard to mathematics and statistics support in the short-, medium- and longer-term?
- By what means have those needs, priorities and intentions been determined at the institutional level?
- Are plans in place for the development of new mathematics and statistics support provision (or, if applicable, an extension of provision that already exists)?
- How can institutions across the sector be better supported in their attempts to further develop and embed mathematics and statistics support in a sustainable manner?
- How might the external assistance institutions require with regard to mathematics and statistics support be provided nationally (e.g. through the **sigma** Network and/or by other means)?

3.3 The above questions were sent in advance by email to all those who had agreed to be interviewed along with an accompanying statement about the aims of the research and the ethical framework within which it was being conducted (see **Appendix 1**). The interviews themselves were then organised around the key questions, though in practice the interviews were 'semi-structured' (Kvale and Brinkmann, 2009) in that the schedule was planned in advance in order to determine the general structure of the interview, construct the main questions to be asked and ensure a degree of consistency from one interview to another. The precise details were then worked out during the course of the interviews – those being questioned being given opportunities to construct answers at length in their own words in response to what, in effect, was a series of open-ended questions. Some generic prompts were also used (see **Appendix 2**) to facilitate elaboration and broader coverage of each question, along with probes aimed at exploring answers in greater depth (Drever, 1995).

3.4 By way of preparation for the interviews, university websites were studied in order to become familiar with background information about such matters as the programmes of study offered by an institution, and the forms of learning support it publicised as being available to students. Similarly, OFFA statements were checked for each HEI in the sample for evidence of explicit references to mathematics and statistics support.

3.5 Notes were taken at the time of the telephone and face-to-face interviews, and permission was requested (and in all cases granted) to make an audio recording of what was said. The 'field notes', the audio recordings and email exchanges were subsequently used to produce an accurate and detailed account of the interviews, and to identify possible statements that might be cited in the report.

3.6 Once completed, the interview data were subjected to analysis by a process known as 'thematic induction' i.e. what was said in relation to each question was examined not just in the context of the individual interviews, but in relation

[2] Of the 24 interviews conducted for the purposes of the research, in the first instance 17 were by telephone, 6 were by email and 1 was face-to-face.

to what others had to say about the same topics, or 'themes' (Braun and Clarke, 2006). These themes were then used as a starting point to analyse the data and thus, identify, code, sub-code, cluster and categorise emerging themes, as necessary. The thematic analysis, therefore, was driven by both the research questions and the content within the data. The key analytical themes relating to the research questions are outlined in **Appendix 3**.

3.7 During the planning and implementation of this investigation, attention was paid to the ethical guidelines for educational research, as outlined by the British Educational Research Association (BERA, 2011). All of those questioned for the purposes of the research were given reassurances about the ethical framework within which the interviews were being conducted. In particular, they were informed that the researchers would: treat in confidence anything they said (or supporting documents they provided); undertake to use their data solely for the purposes of the study; and, that the main outcomes would be set out in the form of a report that would be made available to a wide readership across the HE sector. Any concerns they might have had about this matter were discussed with them at the time of the interview. In keeping with those undertakings, institutions have not been named in the report, and every attempt has been made to preserve their anonymity.

4. Determining the research sample

4.1 At the outset it was difficult to predict how HEIs would respond to the invitation to participate in the research, especially when the request was being made (April-May 2014) at the start of a very busy period in the academic year. Nevertheless, the aim was to build an interview sample that was large enough and sufficiently diverse for the outcomes of the study to have credibility. In order to do that, it was necessary for the final interview sample to be as representative as possible of the 100+ universities that make up the HE sector in England.

4.2 Bearing in mind such factors as the limits imposed by the small-scale funding available for the research, and the time taken to arrange and conduct the interviews as well as to process and analyse the outcomes, it was decided that in terms of target numbers a minimum of 15 would probably be acceptable, but that a figure closer to 25 would be preferable.

4.3 It was decided that as far as possible the sample chosen should reflect the diversity that exists within the HE sector in England by the inclusion of institutions drawn from each of the university mission groups. In turn, it was thought that meeting this criterion would ensure that the sample included examples of what UCAS (2014) refers to as 'high tariff', 'medium tariff' and 'low tariff' 'providers' – a classification of universities based on the average levels of attainment of the applicants they accept[3]. It was also recognised that institutions with strong links to the **sigma** Network (e.g. through funding arrangements and/or other forms of engagement) should not be over-represented in the sample.

4.4 The final interview sample consisted of 23 universities, which in terms of membership of different mission groups, was made up as follows: Guild HE = 3; million+ = 2; non-aligned = 6 (including former members of the now defunct 1994 Group); Russell Group = 5; and, University Alliance = 7. The average entry tariffs of those institutions were evenly distributed across all three levels of HE 'providers' identified by UCAS. Finally, of the 23 universities in the interview sample: whilst two had been closely involved in the **sigma** initiative since its inception, thirteen had no history of formal involvement with the network; and, four of the remaining institutions had only recently (2013-14) become recipients of funding from **sigma**.

4.5 The process of building the research sample was initiated by a letter addressed to the 'PVC (Learning and Teaching)' of every university in England from Professor Duncan Lawson (Pro-Vice-Chancellor for Formative Education, Newman University) on behalf of the **sigma** Network informing them about the aims of the research and inviting them to support it, either by responding themselves to a set of interview questions or by nominating a colleague to do so on their behalf. The letter (see **Appendix 4**) stressed that it was a high level strategic senior management perspective on learning support for mathematics and statistics that was being sought rather than the views of practitioners responsible for the design and day-to-day delivery of such support to students.

4.6 The researchers and **sigma** Directorate considered each subsequent offer of support and, in light of the predetermined criteria for the size and composition of the research sample and the institutional position and status of the individual nominated to participate in the research, either accepted the offer or in a small minority of cases 'held in reserve'. Follow-up messages were sent to HEIs that had not responded to the initial request for an interview. As the sample began to grow and take shape in terms of its composition those secondary requests became increasingly targeted; and, contact networks were used in a small number of cases in order to finalise the sample.

4.7 The interview with the Director of OFFA was not part of the original research plan - though perhaps in retrospect it should have been. It arose out of a meeting with the **sigma** Directorate at which areas of mutual interest in relation to access to HE and learning support were discussed including the **sigma** research. The subject of that discussion was explored in greater depth by means of a telephone interview conducted by one of the researchers at a stage in the research when the majority of interviews had already been completed. Whilst considering the same issues that were discussed with representatives of HEIs, the outcomes offered a different but complementary perspective on the topics under consideration – one that helped to put HEI support for mathematics and statistics into a wider strategic context (see **paragraph 5.5**), and as such helped to inform the subsequent analysis of the interview data.

[3] 'Tariff 'is a numerical summary of qualification levels with regard to entrance to HE. According to UCAS (2014) each group of providers accounted for around a third of all UK 18 year old acceptances in recent university admission cycles.

5. The wider context of the research: the changing HE system

5.1 The external or 'top-down' factors that have been responsible for the changes affecting the whole HE system in England are well known and thoroughly documented in the literature (see e.g. Barnett, 2011, 2007, 2004, 2000a, 2000b; Browne 2010; McCulloch, 2009; Scott, 1995). The systemic changes include the move away from an elite to a mass system of tertiary education, broadening participation, 'marketisation' through the introduction of student tuition fees, the new emphasis given to the quality of the students' experience, the importance attached to their recruitment, retention, achievement and employability, the publication of league tables and the reduction in funding through HEFCE to support such sector-wide initiatives as the Centres for Excellence in Teaching and Learning (CETL), Subject Centres and the National HE STEM Programme.

5.2 Whilst some of the above changes were initiated earlier, the HE sector in England has experienced a dramatic period of reform following the introduction of the White Paper 'Higher Education: Students at the Heart of the System' (Department for Business, Innovation and Skills, 2011). As a consequence, the proportion of funding for teaching provided by direct grant from HEFCE has declined, and the proportion from student contributions (supported by government subsidised loans) has increased[4]. The stated aims of the new tuition fee regime were to: create a more financially stable sector; improve even further student engagement and experience and widen access to HE by groups hitherto under-represented. In order to stimulate competition within the sector, the number of institutions with the title 'university' has been allowed to grow (along with other HE providers). Student number controls were initially strategically relaxed, and then abolished altogether, allowing 'high tariff providers' to admit more high-achieving A-level students at the expense of others in the sector. One important consequence of this in the present context is the increased competition for funding derived from external sources. This increases the probability that the HEIs in England will become more dependent than they were previously on funding provided internally for such initiatives as the systematic enhancement of student learning support including that allocated to mathematics and statistics.

5.3 The Office for Fair Access (OFFA) is now an integral part of the operating environment of institutions in the HE sector in England. It was set up under the Higher Education Act 2004 to make sure that the introduction of higher tuition fees in 2006-07 did not deter people from entering HE for financial reasons. To that end universities and colleges were explicitly required to commit to increasing participation in HE among under-represented groups. OFFA is the independent public body that helps safeguard and promote fair access to HE. The main way that this is achieved is by approving and monitoring annual 'access agreements', which all universities and colleges in England must have if they want to charge fees above £6000 per annum. OFFA then monitors the progress of institutions in meeting their access agreement commitments on an annual basis. It also has a role in identifying and disseminating good practice and providing universities with advice based upon knowledge drawn from across the sector.

5.4 For HEIs the student experience is at the centre of their response to this new and radically different operating environment. In this context, research on behalf of the HEA by Temple et al (2014) into a small number of case-study institutions has shown that the externally-driven reforms outlined above have brought about significant changes in organisational structures, policies, and processes resulting in changed institutional cultures. These changes have occurred in different ways depending on the type of university - the research-intensive universities responding differently from the others in the sample. In general it was found that the latter were responding by centralising student services, standardising procedures and strengthening senior management controls, and in so doing tending to reduce discretion and decision-making at departmental level. On the other hand, the research-intensive institutions were by and large seeking to use existing structures and institutional cultures to encourage greater concern for the students' experience on the part of both academic and professional staff, rather than to engage in comprehensive organisational change.

5.5 In 2014, a joint report to the Department for Business, Innovation and Skills (BIS) from OFFA and HEFCE set out a shared national strategy for combining fair access to HE with student success. The strategy seeks to address the following key issues across the student lifecycle: access (the gap in participation rates between people from advantaged and disadvantaged backgrounds, and between students with different characteristics, particularly at the most selective institutions or 'high tariff providers'); retention and success (the differences in experience and attainment for different student groups); and, progression to further study or to employment (differences in outcomes and progression to further study or graduate employment for different groups of students in HE). Whilst the focus of the report is on combining fair access and success for students from disadvantaged backgrounds, it also advanced the view that the adoption of a broader, coherent whole lifecycle approach would benefit all students attending the full spectrum of HE providers across the whole sector.

[4] From autumn 2012, all HEIs were able to charge a basic threshold of £6,000 a year for undergraduate courses up to a maximum charge of £9,000 a year.

6. Post-16 mathematics

6.1 The challenges facing institutions across the sector with regard to the provision of learning support for mathematics and statistics (as examined in detail in **Section 7**) are multi-faceted. There is the fact that only a small proportion of post-16 students continue with any form of mathematical education prior to entering HE; at the same time, universities are under increasing pressure to produce graduates who are capable of undertaking post-graduate study (often involving high level mathematics and/or statistics) and competing successfully in a global labour market where functional numeracy is regarded as a minimum entry requirement (Durrani and Tariq, 2012).

6.2 The issues associated with post-16 mathematics are long standing and well documented in the literature. A report by the Nuffield Foundation (Hodgen et al, 2010) for example, showed that England (along with Wales and Northern Ireland) has lower participation rates in mathematics after the age of 16 than all comparable OECD countries. It found that fewer than one in five students in England, Wales and Northern Ireland study any kind of mathematics after GCSE - the lowest levels of participation in the 24 countries surveyed. The Foundation's follow-up report (Hodgen et al, 2013) showed that unlike England, the countries with high levels of participation all offered more than one high-status option for post-16 students to continue with their mathematical education. That report recommended the development of a new mathematics qualification aimed at the large number of students for whom the traditional Mathematics AS/A level for whatever reason may not be the most appropriate option.

6.3 A third report published by the Nuffield Foundation (Hillman, 2014) pointed out that one of the most important factors in the debate about post-16 mathematics is that it is not simply *'a 'maths problem', nor one that affects only STEM subjects. It is an issue that cuts across different subjects and different stages of education. It is about ensuring that all young people have the quantitative skills necessary for further and higher education, for work, and for being informed citizens'* (p4). The report reiterated the fact that England, Wales and Northern Ireland have comparatively low rates of participation in mathematics at post-16, and that for those who do continue to study it AS/A level Mathematics is the dominant post-16 qualification. Even the increase in the numbers of UK participants in A-level Mathematics to 88,060 in 2013 needs to be considered alongside the fact that the size of the national year group cohort was over 600,000. It is from this restricted pool that universities from across the sector compete for the recruitment of standard entry students.

6.4 The reasons given in the report for the low participation rates in post-16 mathematics were as follows: the 14-19 qualification framework and the opportunities that this provides for early specialisation resulting in a narrowing of the curriculum and a small candidate group taking A-level Mathematics; the absence of alternative routes to A-level Mathematics (which according to some is likely to be exacerbated by the decision to end modularity, and to uncouple AS from A-level in England from 2015); the difficult transition from GCSE to A-level which leaves many potential students with sufficient grades and aptitude lacking the confidence to opt for Mathematics; limited access to alternatives to A-level Mathematics (such as the statistics with mathematical applications that is available in other OECD countries); and, the low take-up of alternative to A-levels such as the International Baccalaureate (IB) within which study of an element of mathematics is a required component. A new qualification, "Core Maths", which stands apart from the AS/A level structure is being introduced following a commitment to a goal of universal participation in post-16 mathematics made by the Coalition Government. It remains to be seen if this will help to ensure that the teaching and learning of mathematics and quantitative skills is embedded across all post-16 education provision in ways that will better prepare students for the transition into HE irrespective of their chosen programmes of study.

6.5 However, there is an extensive literature that suggests that the problems associated with post-16 Mathematics with regard to students' transition to HE run much more deeply than the relatively small proportion of the age cohort opting to study the subject at A-level. For example, Savage and Grove (2015) advance the view that many of the students recruited by universities to study not only the mathematical sciences, but also the other STEM subjects (e.g. chemistry, physics and engineering), often struggle to apply the mathematics they have previously learned when faced with unfamiliar problems. In particular, they note that incoming undergraduates (including those who have achieved the highest grades in A-level Mathematics) often lack experience of mathematical modelling and problem solving – skills they will need to develop in order to progress within their chosen programmes of study, and to make the transition to employment or research.

6.6 Hodgen et al (2014) drew upon commissioned work undertaken previously by subject experts in reporting on the mathematical and statistical needs of students undertaking undergraduate studies in seven university disciplines: Business and Management, Chemistry, Computing, Economics, Geography, Sociology and Psychology. The report also introduced some high-level contextual evidence from the pre-university sector, including data relating to trends in public examinations and policy developments in post-16 Mathematics education (particularly the planned introduction of 'Core Maths') that can be expected to impact on the students' transitions into higher education.

7. The challenges faced by students in relation to mathematics and statistics

7.1 The universities questioned for the purposes of the research identified a number of challenges their students face in relation to mathematics and statistics, which on the evidence would seem to be generic across the sector, whilst others were more closely associated with particular categories of institutions. Many of the challenges that they highlighted were in relation to a number of key themes identified as students' transition from school, college or the workplace into HE, whereas others were problems affecting their progression through their undergraduate courses, or transition to study at postgraduate level and/or into employment.

Student transitions into HE

7.2 Most of the challenges relating to the students' transition into HE identified by those questioned were attributed to sub-themes centred on: prior mathematical education; qualifications; levels of ability and self-confidence on entry relative to the demands of their undergraduate courses; widening participation; diversification and internationalisation. The reported challenges were distributed across programmes of study in a wide range of subjects – but their precise nature was found to vary considerably from one context to another. This can be illustrated by reference to how the challenges faced by undergraduate students in relation to mathematics and statistics within different subject disciplines were described by one of the University Alliance institutions. The individual questioned offered the following classification[5] around which different challenges were clustered:

- High level mathematics use (involving what was referred to as 'hard sums'[6]) in which mastery of advanced concepts and skills are an essential requirement because they form an integral part of the subject that is being studied, as in the case of the STEM disciplines.
- Medium or intermediate level use in which competence in mathematics and/or statistics is required in order to cope with the quantitative methods commonly used in such subjects as Business Studies, Economics, Education, Finance, Health Studies, Life Sciences, Management, Medicine, and the Social Sciences.
- Low level use when studying subjects such as Arts and Languages where little or no mathematics or statistics is required, but with the caveat that those who graduate in them will often be expected to pass employment tests of functional numeracy when seeking to enter the labour market.

7.3 In terms of the degree subjects that require the application of 'high-level' mathematics (as defined in **paragraph 7.2**) all the institutions questioned presently offer undergraduate courses in some or all of them, with some planning to increase what they provide in the near future. In recognition of the demands such courses make on students with regard to mathematics, there is now a shift towards stipulating higher levels of qualifications in that subject as an entry requirement. For example, one University Alliance institution said that it had recently conducted a review of its undergraduate courses in Engineering and concluded that in future all entrants to those degree programmes should be required to have an A-level in Mathematics (or its equivalent) – an AS in Mathematics no longer being sufficient. However, for reasons set out in **paragraph 5.2** and **paragraph 6.2**, it will undoubtedly face severe competition from other institutions in the sector – especially the 'high tariff providers' – when seeking to recruit students with A-level Mathematics.

7.4 It was noted however, by many of those questioned, that students who do have an A-level qualification in Mathematics are not necessarily well prepared to meet the demands of undergraduate study in HE. For example, such students at one of the non-aligned universities (a former member of the 1994 Group) were said to face two key challenges: that their experience of taking Mathematics at A-level had not prepared them for studying either Mathematics or one of the other STEM disciplines because they were unable to apply what they had previously learned in order to solve unfamiliar problems; and, that despite being well-qualified they still lacked confidence in their mathematical ability.

7.5 A second non-aligned university (another former member of the 1994 Group) reported that some of the well-qualified students it recruits to study Mathematics (including those with good grades in A-level Mathematics and Pure Mathematics) can still encounter difficulties when using those qualifications as a base from which to begin their undergraduate degree courses at university. In particular, they find the mathematical content of some Year 1 modules to be 'troublesome knowledge' (Perkins, 2006), and unless that problem is addressed at an early stage it can have an

[5] This thematic classification is not only referred to within **Section 7**, but also throughout the rest of the report.

[6] *'hard sums'* is terminology commonly used in some quarters to refer to advanced mathematical techniques though some believe this trivialises the nature of the subject, being much more than *'sums'*.

adverse impact on the students' learning as they advance through their course of study, in which case it becomes a transition within HE (or progression) problem.

7.6 It also emerged from the interviews that some undergraduate students in the Russell Group universities also experience problems with mathematics and statistics, despite the fact that in the main such 'high tariff providers' are capable of recruiting students with very good academic qualifications as measured by their GCSE, AS and A-level results. For example, at one of the Russell Group universities, the observation was made that many of the students who study subjects that require high level mathematics (e.g. Chemistry, Earth Science, Engineering and Physics) were so challenged by the mathematical components of those disciplines that they require extra support in their first year: *'These are students who previously have achieved very highly, getting As and A*s in Maths and Further Maths. However, there just isn't any part of their pre-university qualifications that helps them to build up their problem solving skills'*. It was added that whilst their first year Chemistry students are clearly able to demonstrate their ability to solve equations, they experience difficulties when asked to apply their knowledge to equilibrium-based problems (see Savage and Stripp, 2009). Thus overall, it is the acquisition of mathematical skills and the confidence to apply them in the context of the subjects they are studying, which presents these students with the greatest challenge. However, in subjects such as Life Sciences that do not require students to have a post-16 qualification in mathematics, it is now accepted that it is difficult for those students to cope with the quantitative aspects of their undergraduate courses without some form of learning support embedded in the curriculum or made available to them elsewhere by other means.

7.7 Similarly, another Russell Group representative said that, because of its status as a 'high tariff provider', it was in a position to 'cherry pick' its students (both undergraduate and postgraduate), which means they are all well qualified as measured by the UCAS points or honours degree classification they have achieved. They have also gone through the university's rigorous selection process involving the use of predicted examination results, references, admission tests, and interviews, the aim being to identify students with outstanding academic potential and the ability to benefit from the courses on offer irrespective of their socio-economic background. Nevertheless, all of the effort that goes into the selection process does not mean that all of those who are accepted are able to cope with the rigorous demands that will be placed upon them across a wide range of subject disciplines with regard to mathematics and statistics – even though they might well have already achieved the highest possible grades in A-level Mathematics, Pure Mathematics and even Further Mathematics. Hence the experience of that university, as reported in the interview, is that those students face a transition to HE problem that must be addressed across a wide range of disciplines that include the use of high and medium level maths within their degree programme (e.g. in Physics, Chemistry, Engineering, Biochemistry, Life Sciences, Earth Sciences, and Geography) as early as possible within the context of the chosen programmes of study, and then continually reinforced.

7.8 Positive outcomes from widening participation initiatives undertaken by many of the institutions interviewed were said to have resulted in the recruitment of more diverse cohorts of students than hitherto. In turn, the presence of more non-standard learners (i.e. mature, disabled and international students) has resulted in the emergence of further challenges in relation to mathematics and statistics. For example, one of the Russell Group universities indicated that the increased diversity of its undergraduates means that the range of prior knowledge and ability in mathematics and statistics is now much wider in first year teaching groups than was previously the case. The increased numbers of students in each annual intake has also resulted in larger teaching groups, which for some students can be an intimidating experience. It was noted that such a learning environment does not help those who are struggling to voice their concerns over the difficulties they are having with the mathematics and statistics they are required to study as an integral part of their undergraduate courses. A second Russell Group university reported that it too recruits mixed cohorts of home and international students, with some of the former being admitted with a BTEC rather than an A-level qualification in mathematics. One of the consequences of this policy is the disparity that exists between the two groups in terms of their mathematical qualification on entry – the overseas students already having achieved to a higher level in mathematics (e.g. via the IB) than those with a BTEC qualification – the latter needing more by way of learning support in order to facilitate their successful transition to HE. It was in this context, that one of the non-aligned universities suggested that the problem is exacerbated by a lack of awareness on the part of many of those who deliver teaching and learning in HE, of the levels of knowledge and understanding in mathematics required to achieve different entry qualifications (i.e. GCSE, BTEC, AS, A-level and IB).

7.9 The representative from one of the non-aligned universities questioned indicated that some of the students it recruits with disabilities are faced with particular challenges because they audio-record the lectures they attend. However, those students frequently find that it is difficult to study mathematics or statistics in this way *'because both subjects have often been taught very traditionally with the aid of a blackboard and chalk'*, adding that although the university has moved on since the time when blackboards were used, it can still be difficult for such students to make recordings of lectures that capture all of the information they need in order to fully understand the explanations that have been given during

a session. He went on to say that the presence of students within heterogeneous teaching groups, who for different reasons have difficulty coping with the mathematics or statistics that are embedded within their courses, highlights the need for more to be done in order to identify and address the learning needs of individuals as well as those of whole groups. Mature entrants to HE who have not studied any form of mathematics for many years (in some cases decades) were said to fall into this category – one of the University Alliance universities reporting that it is necessary for its MSSC (Mathematics and Statistics Support Centre) to provide additional learning support for such students, especially those taking its Nursing, Built Environment and Engineering courses.

7.10 Students who enter university without having studied any form of mathematics (or statistics) as part of their post-16 education were said by a wide range of institutions to face especially difficult transitions into HE. This was said to be the case in one of the non-aligned universities (a former member of the 1994 Group). Despite being a 'high tariff provider', many of the students it recruits have no post-16 qualifications in mathematics. The challenge faced by the university is to provide those students with learning experiences that will enable them to complete their degrees, and then progress on to study at postgraduate level or enter employment – in both cases in the face of severe competition. That challenge was said to be difficult to meet because a GCSE Grade C in mathematics (which is often set as the minimum entry requirement) is proving to be too low when it comes to coping with the quantitative aspects of many undergraduate programmes of study such as those in Environmental Sciences, Geography and the Social Sciences. Another non-aligned institution (and former member of the 1994 Group) also highlighted the fact that in some disciplines (citing in this case Economics and Psychology) that do not make a post-16 qualification in mathematics an entry requirement, students seem unaware that they will have to study quantitative methods to a high standard – even though the importance of mathematics and statistics is made clear to them at Open Days and in the literature on admissions. The resultant challenges facing those students were said to be such that they need to access learning support in mathematics and statistics in order to make a successful transition to HE.

7.11 Understandably, the challenges students entering HE were said to face as a result of not having studied mathematics after the age of 16 were not uncommon in the 'low tariff providers' in the sample. One of those institutions (a member of the University Alliance Group) pointed out that it was not just the low levels of prior qualifications that was the source of the difficulties such students face in making the transition to HE, but the fact that in the interim many of them have forgotten much of the mathematics they had previously learned. A second University Alliance Group institution pointed out that much of its recruitment is from local low participation neighbourhoods. Such students are often first generation in HE and consequently cannot draw upon experience within the family to support the transition into HE. This university also identified that many of its students have a lack of confidence in their mathematical abilities. Although the entry requirements for all its programmes of study include a GCSE Grade C in Mathematics, the evidence from across the university is that many of those students have significant gaps in their knowledge, and lack confidence in their mathematical abilities. This is seen as a significant obstacle to their on-going success in HE, in contrast to the international students the university recruits, who generally were said to be much better qualified in mathematics.

7.12 One of the GuildHE universities was another to report that a high proportion of the students it recruits have no qualifications in Mathematics (or Physics) beyond a GCSE Grade C. At undergraduate level it was noted that there are two subject areas where this presents particular challenges with regard to mathematics and statistics, namely Sports, Health & Nutrition, and Psychology. In the former, the students often have difficulty with the underpinning mathematics (and Physics) in some modules (e.g. in Biomechanics), whereas in other modules they have problems coping with the statistics. In Psychology, the students have difficulty with the quantitative methods that are essential in degree level work in this subject, giving rise to the need for learning support in statistics in their case (but not in mathematics). The challenge with regard to quantitative methods used in Sports Science and Psychology was said to go *'well beyond the functional numeracy needed to draw and interpret pie charts, but to the advanced statistical approaches used in the conduct of the research, which underpins the subject content the students are studying'*. A similar point was made by one of the million+ universities, which attributed the challenges faced by its undergraduates in relation to mathematics and statistics to inadequate academic standards on entry – *'the students' UCAS points often having been acquired by means of A-level subjects that are 'not robust' combined with a Grade C in GCSE Mathematics'*. According to this particular university such entry qualifications do not provide a sufficient foundation for undergraduate study in faculties such as Health and Social Care and Social and Applied Sciences in which the students need to be able to read and understand the outcomes of research, and to be capable of conducting their own investigations using statistical methods.

Transitions within HE and into employment

7.13 The challenges said to be faced by students were not restricted to those relating to mathematics, their transition into HE or to learning experiences as undergraduates – they were extended to include transitions made within HE and into employment. Within that framework specific challenges facing students were identified including those relating to statistics, achieving functional numeracy, study at postgraduate level, and entry into employment.

7.14 A key theme running through the responses to this item was the challenges students were said to face in relation to statistics. According to one of the University Alliance institutions questioned, the problem does not usually manifest itself until the students reach their final year of undergraduate study, suggesting that this challenge may in part be a curriculum design issue: *'The students at this university have challenges in both maths and statistics with most being related to their entry into university in the first year. However, the problems differ according to subject areas e.g. the Social Science students don't have difficulties, particularly in terms of statistics, until they are working on their final year projects in which they are expected to use quantitative research methods'*. A second University Alliance institution elaborated on the challenges faced by its undergraduate students in relation to the use of quantitative methods in the Social Sciences. In this case it was suggested that: *'what the students need is a deeper understanding so that if they have a problem involving the use of statistics they will know why they need to use a particular test, and what the results really mean rather than the surface knowledge they have that tells them all they need to do is type certain numbers into the programme and they will get a t-value which they can then use'*. The absence of such a depth of understanding was said to have an adverse impact on the students' achievements as undergraduates, and hence on their progression to postgraduate study and future employability.

7.15 Seven of the universities questioned (1 Russell Group, 2 million+, 2 non-aligned – both former members of the 1994 Group - and 2 University Alliance institutions) indicated that their students face challenges not just with the mathematics and statistics that are integral to their programmes of study, but with achieving something much more fundamental i.e. functional numeracy[7]. One of the University Alliance institutions said that whilst students on its Health Studies programmes are required to have a GCSE in Mathematics, they often need additional support with those aspects of numeracy they will require in employment. Similarly, one of the Russell Group universities said that its students in the Biological Sciences often struggle with numeracy, attributing this to the fact that A-level Mathematics is not set as an entry requirement. A particular cause for concern was said to be the Biomedical students who in future will need to be able to accurately calculate the drug doses prescribed for their patients. In their case a good understanding of mathematics is not only important for transitions within HE, but also in future employment.

7.16 Attention was also drawn by a number of those questioned to the challenges faced by postgraduate students in relation to mathematics and statistics, one of the University Alliance universities stating that the difficulties associated with the latter become more apparent at this level because of the importance attached there to quantitative research methods. It was argued by one of the Russell Group universities that this was because: *'postgraduates are expected to use and understand statistics to a standard they have not been required to do in the past, which can lead to progression problems for them within higher education'*. A million+ university provided an example of this when reporting that its postgraduate students *'often find it difficult to use SPSS because they have not used it previously as undergraduates'* – perhaps because they had previously avoided engaging[8] with quantitative methodology by opting to study modules or to do projects that enabled them to adopt qualitative approaches. Three different universities (million +, GuildHE and non-aligned) identified a further challenge concerning the transition into postgraduate study – in this case about students' entry to initial teacher training (ITT). As a non-aligned university noted *'This problem is especially evident in Education – a particular issue for those who want to go on to do a PGCE being the need to pass the Skills Test for entry to teaching.'* The revised pre-entry professional skills tests (including a numeracy test) were introduced for students starting training from September 2013[9]. All three universities commented that this is a concern because although there are online resources provided by the Department for Education to assist new applicants, it still has implications for student support and recruitment.

[7] 'Numeracy' was being used in this context as a life skill i.e. not just being able to do simple calculations, but to have the confidence and competence to use numbers and think mathematically in everyday life including employment.

[8] See Savin-Baden (2006)

[9] See Department for Education (2011)

7.17 Finally, one of the GuildHE universities explained how the challenges faced by its undergraduate students in relation to mathematics and numeracy within HE have implications for their employability: *'Feedback in the form of graduate destination statistics indicates that much more needs to be done to help our students to enter employment after graduation. Both students and careers advisors see graduate entry tests in general, and numeracy tests in particular, as significant obstacles to the successful achievement of that objective. Giving students confidence in their ability to pass such numeracy tests will both improve outcomes and help raise aspirations'*. A million+ university reiterated this point in relation to its Health and Social Care and Social and Applied Sciences students, whose future employability would be jeopardised if they lack the necessary numeracy skills. Similarly, a Russell Group institution indicated that one of its on-going aims is to make more of its students *'mathematically literate and better prepared for the transition to employment'*. To that end, it was recognised by the university that this problem will need to be addressed with students who at present are not required to study any form of mathematics or statistics as part of their undergraduate courses i.e. *'students who might not need to use their knowledge of mathematics and statistics within a degree programme (e.g. English) need to see it as important that they become mathematically literate'*. However, it was acknowledged that *'developing transferable skills in numeracy by means of their degree programme would be a difficult challenge for many of those students'*. It was for reasons such as these that a University Alliance institution said that the learning support for statistics it provides is very popular with students – especially postgraduates from across a wide range of the disciplines.

8. Current provision of learning support for mathematics and statistics

8.1 Each of the institutions gave an account of the strategies it has adopted thus far in response to the challenges faced by its students in relation to mathematics and statistics as set out in **Section 7** - with none (irrespective of their 'tariff provider' status as defined by UCAS) reporting that they had no reason to act in this respect. The analysis of those responses shows that the support offered to students varies widely across the institutions in the sector. This ranges from that which is embedded into the design and delivery of certain modules in particular programmes of study, to comprehensive systems of learning support. These systems are well-established as an integral part of the core services that can be accessed by students from across the whole university according to their individual needs and circumstances. However, a second theme that is evident in the interview data is that the situation across the sector is not static, but is dynamic and subject to on-going change as individual institutions seek to develop and further improve their strategic response to the challenges their students face with regard to mathematics and statistics.

8.2 All three of the GuildHE universities indicated that they currently offer some form of learning support for mathematics and statistics to their students – though by and large that support has been located within specific courses where the need has become apparent. Current provision in one of those institutions was summed up as follows: *'At present learning support for maths is embedded within programmes of study as required, course tutors providing support according to need. This tends to be on a one-to-one basis where students seek advice from their tutors. The same model applies to the provision of learning support for statistics within postgraduate modules that involve research methods – the tutor providing any additional support that is deemed to be necessary'*. A similar strategy had been adopted at one of the other universities in this group, though in this case it was acknowledged that there was *'a need for the existing approach to the provision of support for mathematics and statistics to be further developed and strengthened in order to address the challenges faced by the students'*.

8.3 The third GuildHE institution said that until recently it had no formal structures in place to support its students' academic learning - including those relating to mathematics and statistics. However, it was reported that a 'Learning Hub' has now been established in order to address that problem (i.e. *'individualised support for numeracy and statistics is provided at the hub along with guidance on study skills, critical thinking, essay writing, and research methods'*). In addition, advisors have been appointed to *'deliver learning support at drop-in sessions or by working in the classroom alongside academic staff and their students'*. Since 2012-13 a student-mentoring scheme has also been developed by which Level 5 and 6 students have been recruited and trained to provide peer tutoring for Level 4 students[10] – particularly in relation to their transition into HE and to certain modules.

8.4 The strategies adopted for the provision of learning support for mathematics and statistics by the two million+ universities were found to be in marked contrast to each other. In one of those institutions its approach bears similarity to those of the two GuildHE universities as described in **paragraph 8.2** i.e. within its undergraduate programmes of study *'the strategy is based on embedding mathematics and statistics into the curriculum from an early stage – in Year 1 modules onwards. Module specifications have been changed to incorporate the new content, new teaching-learning resources have been created, accompanied by staff development activities to enhance delivery of the new curriculum – all led by the Learning and Teaching Enhancement Unit'*. Over and above that, it was said that the university now offers students a programme of study focused on developing their core study skills. This is complemented by a 'peer mentoring' scheme, which provides learning support, but not specifically in relation to mathematics and statistics.

8.5 The strategic response in the second university from the million+ group was found to be more complex with a combination of university-wide and faculty-based learning support for mathematics and statistics. The former was said to consist of a generic learning and teaching support centre offering drop-in sessions for mathematics and statistics and a 'Study Hub' that provides students with access to online guidance and learning resources. In addition, the faculties were said to have tailored their provision of learning support for mathematics and statistics to meet the particular needs of their students. In the university's Faculty of Business & Law for example, in programmes for which there are professional examination exemptions, there is an obligation to satisfy external professional body requirements with regard to mathematics and statistics. To ensure that those standards are met, most courses incorporate supplementary sessions and provide one-to-one tutoring aimed at enhancing the students' learning in mathematics and quantitative methods. In 2013/14, a peer mentoring scheme was introduced that combines learning support for statistics with other forms of guidance. In the Faculty of Life Sciences & Computing the focus in terms of the provision of support is on mathematics

[10] These levels refer to the Framework for Higher Education Qualifications in England, Wales and Northern Ireland: http://www.qaa.ac.uk/en/Publications/Documents/Framework-Higher-Education-Qualifications-08.pdf

delivered by means of: 'clinics' offered to students on a drop-in basis; e-learning resources; additional lectures and tutorials on the more complex aspects of mathematics such as calculus; and, 5-minute video vignettes of chosen topics.

8.6 Of the seven University Alliance institutions questioned, six indicated that they now have well-established systems of learning support for mathematics and statistics including the provision of drop-in centres. The university in this group with the longest experience of offering mathematics and statistics support said that *'in relation to some programmes of study support is embedded within the delivery of teaching and learning'*. This targeted assistance is supplemented by a long-standing MSSC, which was said to *'offer students access on a drop-in basis to one-to-one tutorial support, online and other resources and a place where it is safe for them to think mathematically and have the confidence to seek practical help and guidance'*.

8.7 By way of contrast, a second University Alliance institution, which claimed that it too had a comprehensive system of learning support for mathematics and statistics, said that it was only recently that it had developed a MSSC through an initiative led by a senior manager (i.e. a PVC). The centre is located in a dedicated space within one of the main buildings where it offers face-to-face learning support in mathematics and statistics to students from all faculties as part of the university's learning enhancement strategy. The MSSC also provides workshops for students preparing for numerical psychometric tests, which hitherto have been a significant obstacle for those seeking to make the transition to graduate-level employment. In addition to supporting student learning, the centre has an important role in the implementation of the university's outreach and public engagement strategies.

8.8 All four of the other University Alliance institutions with established systems of learning support for mathematics and statistics indicated that they too have developed MSSCs in order to supplement the guidance already embedded in the frontline delivery of teaching and learning. One of those universities said that its centre now operates on two sites and is open for approximately 14 hours per week during term time. However, at times of peak demand, those hours are extended and use is made of satellite locations within libraries. The MSSC at one of the other institutions in this group was said to offer its students *'one-to-one tutorial support, access to online resources and peer mentoring in which some novel approaches have been developed and researched'*. In addition, some departments in this university were said to *'provide learning support for mathematics and statistics by means of a maths or research skills unit designed to meet the needs of the subject area'*.

8.9 The two remaining institutions from the University Alliance group with well established support for mathematics and statistics (as noted above) also offered full accounts of what they provide within the context of the wider systems of learning support that have been developed for their students. At one of those universities support was said to *'consist of a dedicated facility in a new library building which provides a confidential study advice service for anyone who wants tutorial guidance on: statistics or mathematics; study skills; planning and writing essays; assignments and dissertations; and, time management. Students can either 'drop in' for that confidential advice or book a 30-minute tutorial by email from one of 8 tutors (with specialist skills including a Dyslexia Tutor) who are routinely available. The support is provided on a one-to-one basis and there is no 'naming and shaming' to their departments of those students who have sought it. Access to such support for students varies according to demand'*. Of the provision of learning support for mathematics and statistics at the sixth institution in this group it was said that *'In theory any student should know that if they have a problem with maths and stats they should be able to walk into the university library on the ground floor to the support centre area and there will be someone there to answer their queries'*. In this case, the services provided by the MSSC are complemented by the work of the university's 'Learning Development Unit', and by introductory mathematics and statistics courses that are integrated into the delivery of certain programmes of study. The seventh University Alliance institution indicated that it was currently seeking to enhance the learning support it makes available to its students – a process that includes the development of a support centre for statistics.

8.10 The responses to this item of the three non-aligned universities that were formerly members of the 1994 Group indicated they are at very different stages with regard to the development of the learning support for mathematics and statistics offered to their students. In the first of those institutions such assistance has long been an established part of a comprehensive system of learning support available to its students, whereas the other two are both currently engaged in a process of improving their provision. In one of these two universities, the aim thus far has been *'to put learning support close to where it is actually needed by integrating it into courses rather than in a separate support centre'*. In the second, the representative questioned said that the university had some experience of providing learning support for mathematics and statistics through a recently established MSSC, which offers *'a drop-in tutorial service to students, and online learning resources designed to address their different knowledge gaps'*. In addition, learning support is provided within subject departments by means of mathematics or quantitative methods 'surgeries' and tutorials in which students are helped to acquire the knowledge and skills they need in order to succeed and to progress on their chosen pathways.

8.11 The member of the former 1994 group with a long history of developing learning support in mathematics and statistics and of collaborating with others in the sector in order to further research and disseminate effective practice offered a detailed account of the guidance available to its students, and how that is integrated into university-wide systems of support. In this case, the MSSC was said to be *'the main source of learning support for mathematics and statistics, its services being available to every student so that in 2012-13 it had over 7000 visits by students from 21 departments'*. The centre now operates from *'two well-resourced bases, which students are encouraged to use as study spaces, along with the one-to-one drop-in help that is provided by experienced mathematics lecturers'*. Learning support for statistics is available in the afternoons in one of the two centres, and *'for final year and postgraduate students, a Statistics Advisory Service with bookable half-hour appointments is also available'*. Experienced mathematics lecturers offer one-to-one drop-in help according to published timetables. The MSSC also runs workshops that allow students to revise, practise and develop basic mathematical and statistical skills, and works closely with the Counselling and Disability Service and Student Support Centre.

8.12 The system of learning support for mathematics and statistics at one of the other three non-aligned universities questioned reflects the fact that it has long established links with **sigma**. Like others in that network it too has a MSSC that is open to all students studying at the university where they can access drop-in help, online resources, a statistics advisory service, and mathematics study skills workshops. In addition, peer mentors provide tutorial guidance for first-year mathematics students, and a 'Maths Café' enables students to practise and develop their mathematics skills in an informal atmosphere. The MSSC was also said to be collaborating with the university's Disability Services in order to establish how best to provide learning support in mathematics for students with disabilities. Finally, the centre is working collaboratively with others to develop an academic learning centre, which will ultimately provide students with access to a range of learning support (e.g. in mathematics, statistics and English Language) by means of a co-ordinated service across the whole university. In addition, the university offers learning support to those students who are about to make the transition into HE in subjects such as Mathematics, Computer Science and Engineering by making available online resources and providing courses on campus over the summer period prior to their entry to university.

8.13 One of the other non-aligned universities reported that the strategy it has adopted for the provision of learning support for mathematics and statistics is to integrate it into the delivery of programmes of study according to need. However, the university also said that it now has *'a 'Skills Team' that provides support for students in developing their academic writing and numeracy skills'*. Support with regard to the latter is provided by means of *'face-to-face tuition and online support, often using external resources, including those of the **sigma** Network and the Kahn Academy[11]'*. Finally, it was noted that the university uses the Foundation Year as a means of developing students who are otherwise well qualified, but lack the knowledge and understanding of mathematics they need in order to make a successful transition into Year 1 of a degree in subjects such as Engineering, Physics and Mathematics.

8.14 The final institution in the non-aligned group in the research sample indicated that it too had a learning support centre for mathematics, but in this case it is not a university-wide facility rather it is run by one of the STEM discipline faculties *'for use by its own students'*. The centre is situated in a learning space that is dedicated for the purpose, and the support it provides *'is based on a self-help package called HELM[12])'* – a learning resource said to *'cover virtually all the Mathematics needed at level 1 and level 2 of a degree in engineering'*. During semester time students seeking guidance can book one-to-one tutorials with a postgraduate tutor who will provide help with the problems in HELM or any other mathematics problems. The centre also provides timetabled classes and group tutorials during semester time in addition to timetabled 'tutorial periods' when postgraduates, appointed by their departments, are available to provide tutorial support for undergraduates. The university was also said to have a learning support centre for statistics, which *'provides advice on the statistical tasks associated with dissertations undertaken by master's degree students and with research projects conducted across the University'*.

8.15 Of the five Russell Group universities in the research sample only two reported that they provide various forms of learning support for mathematics and statistics by means of a MSSC. One of those universities said that its centre: has been established since 2010; operates independently from the subject departments; and, offers support on two sites to all undergraduates, postgraduates (on taught courses and research programmes) and in some cases to academic staff. The learning support it provides was said to include: 'drop-in' tutorials at which students can discuss their concerns with a tutor; one-to-one appointments (hour-long and made via an on-line booking system) with a tutor to talk through more involved problems or dissertation queries; and, statistics workshops for postgraduates required to undertake quantitative analysis. Students can also use the centre to access guidance sheets, booklets, reference books, and online resources. The second university in the Russell Group to have a MSSC said that this had been established only recently, and that the intention was that it would be used as *'a means of providing learning support that goes beyond that offered in individual programmes of study'*. Within those programmes learning support for mathematics and statistics was currently said to include: specialist modules; introductory modules; customised resources; personal tutoring; and, even some 'drop-in' support.

[11] https://www.khanacademy.org

[12] Developed by a consortium led by Loughborough University.

8.16 The three remaining Russell Group universities in the research sample all indicated that they find it necessary to provide a substantial amount of learning support in relation to both mathematics and statistics despite the fact that in all three cases they are 'high tariff providers' with regard to recruiting students. However, none of these institutions said that they deliver that assistance by means of support centres like the ones used elsewhere in the sector. Nevertheless, it was reported that as many as 60% of all the undergraduates entering one of those Russell Group universities *'need to enhance their knowledge and understanding of mathematics and statistics in order to succeed on their chosen programme of study'*. That enhancement is currently provided by means of *'supplementary learning through service teaching delivered in house by the university's Mathematics Department'*. In addition all first year students at this university, irrespective of their subject specialisms, are required to study a course, which enables them to *'develop their methodological skills including those relating to the evaluation of statistical data'*. According to need, as many as 50% of first year students from across the undergraduate programmes also take a course in mathematics or statistics – though students on some programmes of study are exempted. It was said that whilst every effort is made to provide the high quality inputs of mathematics and statistics support that the students require in order to progress on their chosen pathways, it is sometime necessary to offer additional learning support by means of a 'drop in' facility run by the university's Teaching and Learning Support Unit.

8.17 The other two Russell Group universities questioned have both developed an approach to the provision of learning support for mathematics and statistics which gives precedence to embedding that support into the design and frontline delivery of the curriculum. In one of those institutions it was argued that this is relatively easy for them to do because of *'the lack of diversity in the students'* it currently recruits. Even though many of those students enter the university with A-level Mathematics it does not necessarily mean that they have the confidence or mathematical ability to apply that knowledge to solve problems in their chosen STEM subject. Consequently, *'in the first year all students take a unit in mathematics the purpose of which is not to teach any new mathematics, rather to get them to apply their knowledge to solving real problems in context'*. The equivalent for students studying Social Science subjects was said to be a first year unit in quantitative methods.

8.18 The final institution from the Russell group questioned indicated that its response to the challenges faced by its students in relation to mathematics and statistics was to embed mathematics and statistics into the design and delivery of each programme of study, and for that core content to be delivered throughout by subject specialist staff who have the necessary qualifications, experience and interest in mathematics or quantitative methods. In addition, new Year 1 students receive a booklet (which can also be accessed on line) prior to entry which sets out a baseline statement that makes explicit what they will be expected to know and be able to do in mathematics and statistics at the outset of their course in October, and provides examples for them to work through in the interim. Many of the subject departments then go on to provide two one-hour lectures per week in Year 1 on the mathematics/statistics needed to cope effectively with the course requirements in Years 2 and 3. These tend to be organised around problems set in context with carefully selected postgraduate students (who are being mentored by the academic staff) providing tutorial support. In assessing the students' work arising from these sessions the emphasis is formative i.e. no grades are allocated but each individual is provided with feedback aimed at enhancing their future learning.

9. Extent to which mathematics and statistics support is established and embedded

9.1 Given the composition of the research sample, there are wide variations in the challenges faced by students in those institutions in relation to mathematics and statistics. There are also variations in the different ways in which those challenges are currently being addressed. It is therefore reasonable to expect that there is evidence of significant differences from one university to another in the extent to which learning support is an established and embedded part of their university-wide provision, and that its presence will vary markedly in the degree to which it is visible. The accounts provided by those questioned also show that the current situation with regard to the provision of mathematics and statistics support is subject to on-going transformation as institutions seek to enhance their students' experience of HE (and in doing so improve retention rates), their achievements and employability.

9.2 All three of the GuildHE universities indicated that by and large the learning support they offer for mathematics and statistics is currently to be found within specific courses as and when it becomes apparent that it is needed, and as such cannot be said to be an established and visible part of their overall core provision. No explicit references were made to support for mathematics and statistics in the OFFA Statements of two of those institutions – though detailed reference is made to the organisational strategy for enhancing learning support in general in the OFFA Agreement (2014-15) of the third of the GuildHE universities. In that particular instance a decision by the senior management team was said to have resulted in the provision of learning support for mathematics and statistics via its 'Learning Hub'. Consequently, that support is in the process of becoming established as an integral part of the university's core provision – the website demonstrating that the availability of support for its students' academic learning is now being made explicit.

9.3 A marked difference occurred between the responses of the two million+ Universities to this item. At one of those institutions, no explicit reference was made to mathematics and statistics support in its OFFA Agreement (2014-15); and, that it was also absent from the information provided for students on the university's website. In addition, unlike those universities with established MSSCs, it was also noted that there was no dedicated physical space where students could access learning resources and support from qualified staff (or trained student mentors). However, in the second million+ institution, learning support for mathematics and statistics was found to be better developed, and as such to form a clearly discernible part of its established core provision. This is evidenced by: a statement in its OFFA Agreement; and, the presence in the university of a centre for the enhancement of learning and teaching. The latter provides a range of learning support aimed at developing the students' academic study skills by means of 'drop-in sessions' for mathematics and statistics, and regular 'writing clinics'. This is complemented by the provision of a dedicated website, which offers students access to online guidance and resources.

9.4 By way of contrast, the responses of the seven University Alliance Group institutions along with those of the six non-aligned institutions presented a different picture of the extent to which learning support for mathematics and statistics is well established and hence a highly visible part of their university-wide core provision. Two of those institutions have played an important role in the development of learning support for mathematics and statistics, and others have used external funding to establish MSSCs and have been active in the **sigma** Network. It is not surprising therefore, to find in the interview data derived from this group of institutions accounts of well-developed, firmly established, rigorously evaluated and highly visible systems of learning support for mathematics and statistics for both undergraduate and postgraduate students. That support is over and above that which is embedded at appropriate points in the delivery of the curriculum in programmes of study such as those in the STEM disciplines and the Social Sciences. As shown in **Section 8**, the support provided usually takes the form of on-line and other resources, drop-in facilities at MSSCs, access to well qualified staff and to trained student mentors. The provision of such specialist support for mathematics and statistics does not exist in isolation, but is often an integral part of a wider system of support aimed at enhancing not just the students' academic learning, but their whole experience of HE over the life cycle. One of the University Alliance institutions questioned expressed this as follows: *'the university's MSSC is certainly well embedded as part of its core provision and as such is available to all students. It is part of 'learning development support' and runs parallel to the provision of the 'writing café', which offers support for students' academic writing. Learning support for mathematics and statistics therefore, is part of a wider range of provision aimed at improving student retention, achievement and employability'*.

9.5 Given the importance attached to learning support for mathematics and statistics in those institutions that have invested heavily in its provision over a number of years, it is not surprising that its presence is now highly visible. The individual questioned from one of the University Alliance institutions summed up the situation in this respect as follows: *'The MSSC has a very prominent visual presence and is so positioned that everyone studying at this university will have to walk past the centre. It is outlined very clearly on the website, in the OFFA Agreement and in every students' handbook (electronic and hard copy). It is now well established and is viewed as being an integral part of the university's 'core provision' for learning support and student experience. It is now funded through library core funding. Specialist staff are employed at the Centre (with more planned in the short and medium term), and there are resources available online*'. A very similar account was offered by one of the non-aligned institutions questioned i.e. it was noted that: *'support for mathematics and statistics is very visible – it is on the website and is easily accessible within it. It is also advertised heavily on campus using electronic noticeboards with e.g. 'Maths Café' advertised on them. There are also signs in the Mathematics Department saying 'MSSC is here' and it is also heavily advertised within the Student Union particularly the 'Maths Cafes', so it is visible and also, used a lot by students'*.

9.6 However, not all of the University Alliance and non-aligned institutions have been as committed to the provision of learning support for mathematics and statistics as those that now have such support firmly established within their core provision, and in this respect would seem to be at different stages in their development. Two of the non-aligned institutions (both former members of the 1994 Group) indicated that they are at an early stage in that development process. In one of those universities the existing provision was said to be *'well-established and embedded, but in quiet and subtle ways and much less visible than it is in other HEIs'* i.e. there is still no reference to it in the university's OFFA Agreement, no presence on the website and no physical space that is dedicated to its use. The second university in this group noted that: *'at the present time learning support for mathematics and statistics is becoming embedded in institutional provision and it is also becoming increasingly more visible', and that 'following the successful application for funding, the university is now in the process of developing the forthcoming OFFA statement and the business model for its implementation'*. However, despite having learning support for mathematics and statistics that is embedded and well established as part of their core provision, two of the other non-aligned institutions questioned said that no explicit references are made to that support in their OFFA Agreements.

9.7 Of the five Russell Group universities questioned, only two indicated that any reference was made to learning support for mathematics and statistics in their OFFA Agreements. However, one of those institutions went on to explain that learning support was not yet firmly established as part of its core provision *'because at the present time what is available does not translate clearly into a coherent offer of mathematics and statistics support for all students*'. The situation in the second of these two institutions was said to be very different and was summed up as follows: *'The University Teaching Committee has designated the MSSC as a permanent resource in the University for which funding is embedded in its OFFA agreement. The budget allocated to the MSSC provides funds for 1.6 FTE staff, a number of paid postgraduate tutors, books and stationery, advertising materials and necessary equipment. The MSSC has a webpage on the university's website making its services highly visible to students'*.

9.8 Despite making no reference to learning support for mathematics and statistics in their OFFA Agreements the other three Russell Group universities questioned all asserted that, to varying degrees, such support was well established and firmly embedded into the design and delivery of teaching and learning across a wide range of subject disciplines i.e. within those programmes of study where the evidence indicates that it is needed in order to facilitate the students' transitions into and/or within HE. One of those universities also reported that it had experimented with *'the provision of learning support for mathematics and statistics by means of a drop-in facility in a student friendly environment (a 'maths café') run on the principles of self-referral and confidentiality, but the take up was low – the conclusion being reached that the needs were being addressed effectively by other means as evidenced by feedback from student satisfaction surveys and the very low wastage rates'*. In one of the other universities, the support for quantitative methods that is routinely integrated into the design and delivery of the curriculum is complemented by the provision of a drop-in centre run by the Teaching and Learning Centre. The provision of such support was said to be highly visible to students through its presence on the university website. In the final Russell Group University interviewed it was said that: *'learning support for mathematics and statistics is a well-established and very visible part of core provision in some subject areas, but not in others'*. In addition, it was noted that some staff time is allocated to supporting student learning in mathematics and statistics, and that the online resources available to students via the website are also highly visible.

10. Needs, priorities and intentions with regard to the provision of mathematics and statistics support

10.1 It is evident from the responses of all those interviewed, that institutions across the sector find themselves in a dynamic and challenging situation – one in which their operating environment is changing in ways to which they feel compelled to respond in order to remain competitive and maintain (or better still improve) their status. To that end the provision of learning support for mathematics and statistics is just one of a range of initiatives, which indicate that priority is being given to enhancing the quality of the students' experience, either through a process of consolidation and the continuous improvement of what is currently being offered, or by means of new strategic initiatives that will impact on their institutional cultures, how they are managed and the identity they choose to project.

10.2 All three of the GuildHE universities indicated on the basis of their analysis of their current situation it was necessary for them to enhance the learning support offered to their students in mathematics and statistics. Having reached that conclusion one of the GuildHE universities said that it was currently *'advertising for (initially) two mathematicians to be responsible for: the delivery of the mathematics and statistics components of a series of six UG degree programmes (e.g. Mathematics and Biology, Mathematics and Computing); and, provide mathematics and statistics support across the university in a range of other subject disciplines'*. In addition, the expectation is that *'the provision of learning support for mathematics and statistics will be further developed as this small group of mathematicians expands over the next few years'*.

10.3 The second GuildHE institution questioned said that it now recognised that there is *'a growing need for some basic entitlement to provision of mathematics and statistics support that is open to all students across the university'* – not least because it did not want to be in a situation in which its students fail because that support had not been made available to them. Efforts in that institution, therefore, are being directed towards developing and establishing a consistent form of learning support as part of a centralised co-ordinated approach that is accessible to all students who need it from across the whole institution. Work is also being done on resource development including the creation of online learning materials in the form of 'self-help' packages, which students can use alongside the tutorial support that is integral to the delivery of individual modules. The third GuildHE institution indicated that it has recently acquired research degree awarding powers status as a result of which it was busy recruiting research students – students who will require training and on-going learning support in quantitative research methods. The intention (in the short and medium term) is to develop the institutional capacity to provide those students with that support.

10.4 Of the two million+ universities in the sample, one indicated that its draft strategic plan (2015-20) envisages growth in student numbers in the sciences, technology and mathematics, which will have *'implications for the provision of learning support for mathematics and statistics that have yet to be addressed'*. In the second million+ institution questioned the aim in the short term was said to centre on providing students with quality learning support for mathematics and statistics – perhaps by means of carefully planned foundation courses. In the medium and long term the intention is to promote an institutional commitment to the provision of extra-curricular support for the learning of mathematics and statistics for undergraduates studying a range of disciplines including those offered by the Faculty of Life Sciences and Computing and Social Sciences and Humanities.

10.5 By and large the seven University Alliance institutions were found to have well-established systems of learning support for mathematics and statistics. However, that did not prevent them from identifying new needs or new developmental priorities in the light of experience or changing circumstances. There is evidence therefore, of a commitment to enhancing the student experience by providing them with on-going support with a view to improving levels of satisfaction, achievement and employability. This can be illustrated by reference to one of those institutions, which said that it plans to increase the amount of funding it spends on mathematics and statistics support, and to work on finding ways of increasing the number of students[13] using the 'drop-in' facility and on-line resources available via its MSSC. It was said of a second university in this group that its *'immediate aim is to provide the students it recruits with both access to HE and future success in terms of completion of their courses, achievement and employability'*. To that end learning support for mathematics and statistics (along with support for critical thinking and academic reading and writing skills) will be increased with the employment of new designated staff. In the medium and longer term, it was said that *'there is strong support for the MSSC, and for mathematics and statistics support as part of wider institutional initiatives aimed at enhancing the student experience by improving retention, completion, achievement and employability'* (as articulated in the university's OFFA Agreement (2013-14).

10.6 A third institution from the University Alliance group said that it has been investing heavily in STEM disciplines by creating new Schools all of which have a strong emphasis on the need for high levels of competence in applied mathematics. The university is currently looking critically at how its approach to the provision of support for mathematics will have to change in response to these developments in terms of coping with the increased numbers of students, the nature of their learning needs and how best they might be addressed. A short-term priority at one of the other universities questioned in this group of institutions was said to be *'increasing awareness among undergraduates of the services offered by the MSSC in order to increase the footfall to something closer to that seen in comparable institutions, and to create a second support centre to focus on statistics'*. With regard to the former, the university said that it is working closely with the Students' Union to determine the optimum times when, and places where, that support should be made available. The strategic goal for the medium term is to draw upon practice elsewhere in the sector by involving students (e.g. as mentors) in the provision of learning support for mathematics and statistics.

10.7 The fifth of the University Alliance institutions questioned indicated that the immediate intention is to provide learning support across the university by building on the work of its Q-Step Centre[14]. The medium term development plans were said to include the training of students to act as peer mentors (or 'data buddies') by the Staff Development Unit, and *'the setting up of a 'Maths Café' is under active consideration as a way of making it easier for students to seek support'*. It was also said that the university intends to audit the learning support for mathematics that is currently being provided for undergraduates studying the STEM disciplines in order to gather examples from practice that can be used as the basis of staff development workshops.

10.8 The sixth institution in the University Alliance group questioned reported that in the short-term it would have to respond to the increased demand for learning support for mathematics and statistics coming from a number of sources including *'Arts' and Social Science students who need it in order to cope more effectively with the demands of their courses – and improve their employability skills'*. Expansion in student numbers over the next five years (including an additional 500 in the STEM disciplines) is expected to result in increased demand for mathematics and statistics support. The expectation is that this will be provided within the existing organisational structures using the methods of delivery that have already proved to be effective. However, the final University Alliance institution indicated that the provision of learning support for mathematics and statistics had not been identified as a development priority in its most recent strategic plan. The reason given for this was that it is no longer seen as being a problem that needs to be addressed because the necessary support systems are already well established and in position to further the students' transitions into, and within HE.

10.9 One of the non-aligned institutions (in this case a former member of the 1994 Group) indicated that a key area of immediate concern was the transition into HE of undergraduates who enter with BTEC qualifications to study STEM subjects. In the short term, the intention is to pilot an approach which involves using the outcomes of a diagnostic test to allocate students to tutorial groups where they will be provided with learning support tailored to meet their individual needs. The introduction of new degree programmes and a projected expansion of student numbers in Engineering are expected to increase the need for learning support in mathematics, which will have to be addressed.

10.10 A second non-aligned institution (and former member of the 1994 Group) said that in the short- and medium- term the intention is to conduct an analysis across the whole institution in order to determine what types of learning support for mathematics and statistics are needed, and the modes of delivery (including pre-session learning activities for students) that might be used. The outcomes will then be used to develop a plan for the provision of learning support for mathematics and statistics that is part of a coherent organisational strategy aimed at improving student achievement and employability across the whole university. The third former 1994 Group university said that if it *'wishes to maintain its high academic standards and continue to deliver teaching and learning experiences that are highly rated by its students, it will have no alternative but to continue to implement the support systems for mathematics and statistics it has already put in place'*. Hence, the intention is to improve the delivery of the learning support offered to students – not just in mathematics and statistics, but also in English language and to those with special needs. On-going improvement will be facilitated by feedback from students and staff, and by having systems in place for reviewing provision and planning evidence-based changes.

10.11 One of the other non-aligned institutions offered a similar response to this item when stating *'I do not think the university has officially formulated any future intentions with regard to learning support for mathematics and statistics – other than to continue with the support that it currently provides'*. One of the other universities in this group was more forthcoming, indicating that: *'the provision of learning support for mathematics and statistics is seen as being part of a broader set of development priorities for the university that include widening participation, retention, achievement and employability.*

[13] Over 10,000 students were said to have used the university's drop-in centre in 2013-14.

[14] Q-Step is a £19.5 million programme designed to promote a step-change in quantitative social science training in the UK: http://www.nuffieldfoundation.org/q-step

The intention therefore, is to improve the learning support the university provides – and to achieve that through planned changes that are evidence based'. The final non-Aligned institution indicated that despite having well-established systems of learning support for mathematics and statistics in place it still had needs that would have to be addressed in future including: getting more support embedded into the delivery of programmes of study; making sure that learning support is better advertised and used by those students who need it; providing additional statistics support for the university's growing number of PhD students; and, prioritising the provision of support for international students and those recruited through the university's widening participation initiatives.

10.12 In responding to this item, one of the Russell Group universities stated that it was *'in the process of developing a new Learning and Teaching Strategy for 2015-19, and that clear medium- and long-term plans have yet to emerge'*. However, one need that had been acknowledged was for *'the development of learning support for Quants for students on programmes of study in the Social Sciences'*, so that *'in terms of priorities and intentions, the Social Sciences cluster of departments is currently discussing how to strengthen the teaching and support for quantitative methods and skills across the curriculum'*.

10.13 A second Russell Group university indicated that its *'mission over the short-, medium- and long-term is to put in place rigorous systems of learning support for mathematics and statistics' that will enable it 'to maintain the very high academic standards it sets itself in all of the subject disciplines it offers'*. The third institution from this group stated that like all other HEIs it was seeking as a matter of priority to broaden participation, and in so doing make a contribution to increasing social mobility. However, in order to achieve this objective over the medium term, the university is working on the idea of a two step programme that involves the development of: a new transition pathway for entrants from schools and colleges to HE that builds upon the ideas already embodied in a core module from Year 1; and, progression pathways through to graduation and on into employment. The provision of learning support for mathematics and statistics will be integral to both of those progression routes.

10.14 The fourth university from the Russell Group questioned indicated that the establishment of a MSSC was at the heart of its development strategy with regard to learning support for mathematics and statistics, and as such was an immediate short-term priority. That major development will be accompanied by other medium-term initiatives including: an analysis of non-continuation rates beyond Year 1 looking especially at students from BTEC and IB backgrounds and the implications this has for the provision of learning support; and, to draw upon the pool of expertise in quantitative methods across the university in order to formulate a coherent plan for learning support for statistics. The intention for the longer-term in this university is to develop an overarching strategic plan that will not only address the provision of a wide range of learning support, but also seek to embed the development of skills for employability into the curriculum. In the final Russell Group University in the research sample the provision of learning support for mathematics and statistics was caught up in a wider set of deliberations under the aegis of the Education Committee and involving all Faculties. At this stage therefore, it is difficult to say what the future development priorities will be until an overarching strategic plan has been formulated.

11. Means by which needs, priorities and intentions have been determined

11.1 The question in the interview about the means by which needs and priorities and intentions with regard to the provision of learning support for mathematics and statistics (as discussed in **Section 10**) have been determined, provided an opportunity to explore with senior managers the processes by which strategic decisions concerning the students' experience of HE are reached in a wide range of institutions across the sector, and in so doing begin to establish where responsibility lies for such matters, and to gain some insights into the evidence that is taken into consideration in arriving at these decisions. The responses show how strategic decisions concerning the provision of learning support for mathematics and statistics are seldom taken in isolation, but are frequently linked to a wider set of considerations such as those relating to outreach, access, and increasingly to student recruitment, retention, achievement and employability.

11.2 Responsibility for decision-making with regard to the provision of all forms of learning support in one of the institutions in the GuildHE group was said to rest with its senior management team. That group was said to be in the best position to see support for academic learning in its wider context i.e. within the university's strategic plan for student recruitment, retention, achievement and employability. In this instance senior management was said to be *'committed to evidence-based decision-making'* with regard to development initiatives such as the provision of support for mathematics and statistics. By way of contrast, at the second GuildHE institution a small working group (led by a head of department) was said to have identified the needs and made recommendations to the 'University Executive'. It was that group that had decided to give priority to the provision of support for mathematics and statistics and to that end had initiated a capacity building process. In the third of the GuildHE institutions, the need for mathematics and statistics support was said to have been made apparent by evidence derived from a variety of sources including: end of module questionnaires; monitoring of assessment; deliberations of Programme Boards; and, engagement with students by means of the 'Learning Advice Team'. Senior management has begun the process of collating and analysing this information, the outcomes of which will be used by them to determine development priorities and actions.

11.3 In one of the million+ Group institutions, the university's senior management team was said to be in the process of producing a strategic plan for the period 2015-20 in consultation with other senior staff. Consequently, the needs, priorities and intentions with regard to future provision of learning support in mathematics and statistics by the university have not yet been finally determined. At the second million+ group institution in the sample, individual faculties were said to make decisions in the first instance with regard to such matters as entry requirements, the design and delivery of the curriculum and, the provision of additional learning support for mathematics and statistics. However, their decisions with regard to needs, priorities and future action are overseen at institutional level through established organisational structures and processes such as those associated with course validation, the annual monitoring of taught courses, and the university's 'Undergraduate and Postgraduate Education Committee', on which all faculties and the centre responsible for the enhancement of teaching and learning are represented.

11.4 The interview data from the seven University Alliance institutions indicate that they too have formal organisational management structures through which important decisions about development needs, priorities and intentions are made. In the university in this group that has pioneered the development of learning support for mathematics and statistics its MSSC reports to a 'Learning and Teaching Committee' – a working group that ensures that the quality of teaching, the students' experience and learning support provision is maintained. It is that committee that determines needs, priorities and intentions with regard to learning support for mathematics and statistics. In so doing, it was said to adopt a pragmatic approach involving consultation with students and staff, and the formative evaluation of action research by which *'new things are tried and if they work they continue and if not, they stop and then something else is tried'*.

11.5 A second institution in the University Alliance group indicated that in its case the needs and priorities with regard to on-going planning were identified using a variety of means including: evaluative feedback from students; inputs from academic staff; comments made by external examiners; and, outcomes from a development project on employability. The annual OFFA Agreement process was said to have focused attention on the need to link outreach and public engagement activities with a strategy for enhancing the students' experience as a result of which support for academic learning (including mathematics and statistics) has become a key priority for the university under the leadership of the PVC. Similarly, one of the other universities in this group reported that its priorities and intentions with regard to support for mathematics and statistics are currently *'being developed by senior management and are driven by the desire to optimise the student experience and enhance their employability'*. Determining priorities in this area of activity at the institutional level was said by the individual questioned at another university in this group to be *'the responsibility*

of the Academic Enhancement and Standards Committee' and that *'it is this in association with other high level committees, which scans the horizon, formulates policy, makes the necessary strategic decisions and then monitors the implementation of changes that have been planned'*.

11.6 The responses of the three remaining institutions in the University Alliance group offered further insights into the decision-making process with regard to the provision of support for mathematics and statistics. One of those said that because it has been setting up new departments, *'high-level strategic discussions have been taking place in which curricula have been reviewed on a regular basis and benchmarked against national standards. Such evidence is then taken into account and acted upon – learning support for mathematics and statistics being provided upon this basis'*. The individual questioned went on to add *'the university's Director of Education ran a project over some time to provide maths support and part of that has involved an evaluation of the support mechanisms and what the students need to support their academic learning'*. Seemingly, the evidence from that project is now being used to inform developments within individual departments with regard to the provision of support for mathematics and statistics.

11.7 The two remaining institutions in the University Alliance group also indicated that their senior management teams have adopted rigorous evidenced-based approaches to decision making with regard to mathematics and statistics support. The first of those universities said that its decisions had been *'based a lot upon work with students and immediate graduates in terms of understanding their needs and priorities over and above what could be derived from the NSS and first and second year programme of study surveys'*. That work with students was said to include a research project involving in-depth interviews with 800 undergraduates who entered the university in 2013 in order to determine what learning support is likely to be needed by those who enter in future via the National Scholarship Programme. Similarly, senior managers in the second of these two institutions were said to have determined the needs, priorities and intentions with regard to the provision of learning support for mathematics and statistics. It was also noted that those decisions were *'data driven and made in the context of seeking to develop an institutional strategy for improving student retention and progression'*. This was said to be part of an on-going process by which barriers to progression (including modules where students seem to struggle and under-achieve) are being identified and analysed.

11.8 There were some marked contrasts in the responses of the three non-aligned institutions that were formerly members of the 1994 group. In one of those universities strategic decisions with regard to the provision of support for mathematics and statistics were said to have been arrived at through: *'the mechanisms you would expect to find in a well-run university, with each faculty having in place procedures by which the quality of its teaching and learning is evaluated, but ultimately system-wide matters are discussed and policy formulated at senior management level'*. The second of these three institutions indicated that the decisions had not been made on the basis of evidence drawn from across the whole institution, or informed by a strategic plan for the provision of support for mathematics and statistics. A much fuller picture emerged from the interview with the third institution. According to the individual questioned this matter comes under the brief of the PVC (Learning and Teaching), and *'in determining needs, priorities and forward plans the provision of mathematics and statistics support has to be put into a wider context of the whole system of support the university has put in place for the benefit of its students'*. That system was said to *'include the frontline delivery of high quality teaching and learning, library provision, English language support, residential accommodation, finance, health care, along with mathematics and statistics support'*. The interviewee went on to explain how *'each of these has its own sub-committee which is responsible for the planning and delivery of the services it provides – but to work effectively as a system those have to be aligned to the goals of an overarching strategic plan'*. Once determined plans for developing learning support have to be resourced, which means that *'a well-argued case has to be put to the university's Operations Committee that controls the budget and allocates funds'*.

11.9 The other non-aligned institutions all provided detailed accounts of the means by which needs, priorities and intention with regard to support for mathematics and statistics are determined. The representative from one of those universities indicated that the decisions had been arrived at through far-reaching discussions about what the students' needs might be over the next ten years, not just in terms of mathematics and statistics but support for academic learning in general. Those discussions were said to have been headed by one of the PVCs and to have involved the Teaching and Learning Committee, Deans with responsibility for Teaching and Learning, and the Director of the Learning and Teaching Enhancement Office. At the second university from the Non-Aligned group, it was stated that in some subjects it is the relevant professional bodies (e.g. those connected with Engineering) and employers (e.g. the NHS) that indirectly determine needs and priorities through the requirements they impose on programme specifications by means of accreditation. In others subjects it was said to be *'more ad hoc, with the annual planning process allowing all departments to indicate to senior management where there is a need for additional support and to make a case accordingly'*.

11.10 The final university from the Non-Aligned group in the sample said that in 2011 its whole approach to widening participation and outreach had been reviewed with a view to adopting a more co-ordinated, targeted and evidence-based approach. Following that review, a department for widening participation and outreach had been created, which is located within the Division of the Deputy Vice-Chancellor (Academic Affairs) alongside the departments of HE and technology enhanced learning. These now work closely together in developing attainment-raising programmes, and in creating an inclusive learning environment. A university committee with responsibility for learning and teaching has also been created, with sub-committees to ensure that planned improvements (such as those relating to learning support for mathematics and statistics) are delivered according to plan.

11.11 The responses of the five Russell Group universities when asked about this matter made fewer detailed references to institutional management structures and their related procedures. In one of those universities, decision-making about needs and priorities with regard to the provision of support for mathematics and statistics was said to be *'a straightforward matter because they are established and addressed by the departments themselves – each department working autonomously but within the wider framework of the Strategic Plan 2013-18'*. In a second instance, those decisions were said to rest with the PVC (Learning and Teaching), though in *'determining needs and framing operational plans inputs are sought from the faculties and other interest groups from across the university, and from students via the formal procedures set up for the purpose'. It was also stated that 'all this has to be done within the wider framework of the university's forward planning procedures, and mindful of its public commitment to outreach and widening participation'*. In the case of a third university in this group, it was reported that consideration of these matters at a senior level had been prompted by a bid for funding to set up a statistics support centre. Although that bid had been unsuccessful it had acted as a catalyst for bringing different interest groups together from across the university to discuss the provision of learning support not just for statistics but also for mathematics. However, in terms of developing an institutional strategy for such provision those discussions were said to be ongoing.

11.12 Of the two remaining institutions from the Russell Group, one indicated that teaching and learning in every department is subject to an annual review, which in all cases includes consideration of needs and priorities with regard to supporting students' academic learning. In addition, students are represented on various committees where they can voice their views about what they think is needed in terms of learning support – including that provided by the university's MSSC. Ultimately, it is senior management that determines institutional priorities from the recommendations it receives, and is responsible for integrating them into a development strategy, which in turn can then be used to plan future actions. In the final institution from this group, consideration of learning support for mathematics and statistics was said to have been *'caught up in wider discussions about embedding transferable skills across the curriculum'*, and that at this stage efforts were being directed towards identifying where that support was most needed and how best it might be provided.

12. Plans for developing mathematics and statistics support provision

12.1 There is clear evidence of the need to provide various forms of learning support for mathematics and statistics from institutions across the sector. In addition, there is a drive to be ever more competitive in an operating environment that continues to pose new challenges. Therefore, it is perhaps to be expected that many of the universities are in the process of reviewing their existing provision and formulating new strategic plans for its on-going improvement with a view to enhancing the satisfaction, retention, achievement and employability of their students.

12.2 Two of the GuildHE universities questioned indicated that as yet they had no definite plans in place to develop new learning support for mathematics and statistics or for that matter to extend existing provision – one saying that all it had at the present time was *'ideas under discussion'*. The development of resources was said to be a key requirement at this stage in both institutions, and in one of them it was noted that *'active consideration is being given to providing a summer foundation course for students about to enter some of its courses, particularly those in Applied Physics and Applied Sciences'*. That university also said that it was looking at the team responsible for the provision of learning advice to see if it could stretch its resources in order to offer specialist mathematics and statistics support to students in addition to the other forms of learning support it already provides.

12.3 In the case of the third of the Guild HE universities, it was said that learning support for mathematics and statistics would continue in areas where it proves to be necessary (e.g. for undergraduates studying Sports, Health and Nutrition and Psychology, and for postgraduates doing research degrees). It was also stated that the university's senior management team will continue to respond positively to evidence which indicates that difficulties with learning mathematics and statistics are having an adverse impact on student satisfaction, retention and achievement. In this context, it was said that the aim is to identify and address those difficulties as early as possible, and to do so by determining what resources are needed, and by what methods support will be delivered and by whom. It was noted that integral to this approach is the on-going work that is being done with the academics in subject departments to improve the design and delivery of the curriculum by embedding as much support for mathematics and statistics as possible into mainstream teaching and learning, in order to address potential problems as early as possible in a module or programme of study.

12.4 In one of the two million+ universities it was said that *'no plans are currently in place because of the stage the university is at in the planning cycle'.* The reason given for this was that *'the strategic plan under discussion has yet to be accompanied by decisions about the actions that will have to be taken'*. However, it was also noted that what is envisaged in terms of the expansion of provision in the STEM disciplines, and the on-going need to address weaknesses in mathematics, statistics, and functional numeracy of its new entrants, plus the drive to improve the students' employability all mean that increased attention will need to be given to the provision of on-going support for student learning. For its part, the second Million+ university indicated that in 2014-15 it plans to: implement a new academic mentoring scheme in which students will act as peer mentors; and, develop a cross-institutional 'peer-assisted study session' scheme based upon core modules in first year programmes of study.

12.5 Of the seven University Alliance group institutions, one reported that: *'there are no plans in place for new provision, rather the intention is to extend and improve what is already being done'*. However, in the second of those universities questioned it was stated that *'resources are being made available for the provision of additional learning support for mathematics and statistics as part of a wider strategy aimed at enhancing the student experience'*. This was said to be an integral part of an initiative led by the DVC to provide skills support within each Faculty (including drop-in facilities for mathematics and statistics). The intention is that the MSSC will: provide workshops for programme leaders; promote discussion of such topics as the use of diagnostic testing and the implications for teaching and learning in HE of changes to the curriculum and examinations at 16+; and, work closely with other university student support services (e.g. guidance and employability, and wellbeing).

12.6 A third University Alliance institution said that whilst it already had various forms of learning support for mathematics and statistics in place, the opening of a new School of Mathematics and Physics and a MSSC means that it is now in a very different position in terms of both resources and expertise. Consequently, over the next two years consideration will be given to how the existing provision can be improved and extended. The situation was also said to be changing at a fourth university in this group – in this case by getting its plans in place for piloting a new statistics support centre from September 2014.

12.7 The theme running through the response of the other institution from this group was on making improvements to their existing provision. For example, it was said of one of those that it would be seeking to: *'investigate the times of the week and places around its campuses where learning support is best provided; and, establish a peripatetic 'Maths Café', the use of which it had already piloted on a small scale'*. Similarly, one of the other universities said that it had *'no plans for extending support for mathematics and statistics other than continuing to develop what is already in place'*. That response was echoed by what was said by the final institution in this group, which already has well-established systems of support for mathematics and statistics: *'the current plan involves the provision of more of the same by building on what is already in place and demonstrably working well in terms of structures and processes'*. The individual questioned went on to add: *'our current practice is underpinned by a strong conviction that support provided by means of one-to-one tuition is preferable to anything currently on offer via stand-alone e-learning; it may be labour intensive and time consuming but it is much more effective'*.

12.8 The replies of the three non-aligned former 1994 Group institutions to this item all indicated that the provision of learning support for mathematics and statistics would continue to present challenges that would have to be addressed. At one of those universities it was suggested that future provision by means of a MSSC would be on the agenda for its new PVC (Education). Similarly, at the second of the institutions from this group the indication was that provision of learning support would be extended via its new MSSC. The third institution in this group already has well-established and highly visible learning support for mathematics and statistics embedded in its core provision. However, the view was expressed that such support *'will continue to be an issue affecting students' transition to HE and their pathways through it and on into a world of work dominated by the needs of a knowledge economy'*. It was argued therefore, that the university *'could not afford to relax its academic standards or reduce the support it provides in order to enhance student learning across a wide range of subject disciplines that require mathematics and statistics to a very high level'*. Within that context, it was said that whilst no new provision was planned, priority would continue to be given to mathematics and statistics learning support as part of a wider system of support services offered to all students.

12.9 The answers given by the representatives from all three of the other non-aligned institutions to this item were very similar. At one of those universities it was stated that because it had already increased the number of staff at its MSSC and established a 'Maths Café', provision of support had already been extended. Nevertheless, future plans were said to include: *'examining the learning support needs of a more diverse student intake, and the adoption of new approaches to the delivery of that support including the use of MOOCs and blended learning'*. The other two institutions indicated that what was planned was *'more of the same'* – though in one case it was said that the performance of its *'Skills Team will soon be reviewed in order to determine what further steps are needed to enhance learning support in areas like mathematics and statistics'*.

12.10 The responses of the five universities from the Russell Group indicated some significant contrasts between them in terms of the stages they have reached in providing learning support for mathematics and statistics and the strategies they have adopted. According to one of those institutions the plan is to *"plug the gaps"* in the provision of support for mathematics and statistics and to bring it up to the level that already exists for the development of students' literacy and academic writing. A second university said that it was planned through its MSSC to offer wider institutional support for mathematics and statistics, including (if the funds can be made available) one module of mathematics or statistics for all undergraduates. The areas of development with regard to mathematics and statistics support identified by a third Russell Group institution included *'more coherent recruitment, training and support for postgraduate tutors'. In addition, the plan for its MSSC was said to be 'to continue to evaluate and refine its activities in the light of feedback and changing demands, and to be receptive to offering new and innovative ways of reaching new users through on-line support materials and the use of VLE'*.

12.11 The fourth university from this group indicated that it had *'no plans in place for major developments with regard to the provision of learning support for mathematics and statistics'*. However, the trend was said to be for more subject departments (e.g. Earth Sciences, Geography and Biosciences) to recognise the need to require A-level Mathematics as part of their entry requirements for their undergraduate courses. Having done that it is also necessary for them to *'put in place teaching in Year 1 that enables all of their students to acquire the foundation they need in order to make a successful transition from school or college to HE and to be able to progress from there on their chosen pathways'*. The final Russell Group institution responded to this item by saying that *'It is perhaps better to say that serious consideration is being given to developments that will impact on the learning support needed for mathematics and statistics than firm plans being in place'*. One possible option said to be under consideration is for a four-year undergraduate course, which would include a Foundation Year followed by three years of subject specific programmes of study. The Foundation Year would provide students from diverse backgrounds with a transitional experience (i.e. from school or college to HE) and in so doing better equip them for advanced study at degree level in a research-intensive university. Mathematics and statistics would be strong elements in the curriculum of the proposed foundation year.

13. Assistance needed by HEIs

13.1 The institutions in the sample offered a range of views about how they might be better assisted in order to further develop and embed learning support for mathematics and statistics in ways that would be sustainable in the longer term. In addition to calling for further sharing of experiences derived from practice, there were requests for online learning resources for mathematics and statistics that have been contextualised for use in the delivery of subjects such as the STEM disciplines and the Social Sciences, and for the provision of opportunities for continuing professional development and recognition for those staff who work in mathematics and statistics support.

13.2 One of the GuildHE universities began by suggesting that whilst there are no 'simple solutions' or 'quick fixes' to the long-term, deeply rooted challenges its students faced there was *'much that institutions from across the sector can learn from the experiences of those who are more advanced in the approaches they have already developed in the learning support they provide for their students – both undergraduate and postgraduate – in mathematics and statistics'*. The individual questioned went on to add that the university was aware that *'there are national groups including the **sigma** Network that are working to enhance the teaching and learning of mathematics and statistics across the sector'*, and that this was regarded as being *'hugely important and relevant to us, especially where those groups are seeking to address pedagogic issues relating to students' transition into HE'*.

13.3 A second university from the GuildHE group also suggested that the pooling of learning resources would be an effective way forward: *'Because it is a waste of effort if we are putting a lot of time and money into developing online resources when someone down the road has already done so'*. It was pointed out however, that the provision of support for mathematics and statistics is also *'about having staff capable of communicating effectively, and who understand the pedagogic principles that underpin the design and delivery of effective learning support that is embedded within the curriculum'*, adding that *'at present there are a number of staff in the university with the knowledge and skills needed to provide effective learner support of this kind, but there are others who will probably need extra help from elsewhere in the form of CPD if they are to offer such support within their own subject specialisms'*.

13.4 Whilst two of the GuildHE universities indicated that external support particularly with regard to the development and sharing of learning resources would be advantageous, the third suggested that within a marketised HE system whilst competition is a major driving force for change, it can also inhibit collaboration between different institutions across the sector. The individual questioned from that university went on to add: *'it is also difficult to build collaborative communities of practice with academics in HEIs that vary markedly from each other[15] because the problems that need to be addressed are perceived of as being different according to their institutional context. Hence anything that can be done to facilitate sharing of experience and collaboration, not just with other Guild HE universities but also with others in the sector, would be welcome'*. In addition, it was suggested that this university and others in the sector would benefit from the availability of diagnostic tools that would enable them to be more proactive in identifying and addressing at an early stage the challenges their students face in relation to mathematics and statistics.

13.5 The two million+ universities also indicated that support from other institutions across the sector would be helpful, and offered suggestions about the forms that collaboration might take. For example, one of those institutions said that it would welcome: *'access to the frameworks, models and toolkits for, and successful case studies of, sustainable embedding of learning support for mathematics and statistics, in addition to the updating and further development of existing online resources made available via a meta website'*. However, the second of the million+ university indicated that whilst it *'recognised the need to be outward looking, it also has to be self-sufficient'*. The individual questioned went on to develop this point as follows: *'In addition to help in developing their own institutional capacity to manage change by identifying and analysing the needs for learning support, in general as well as for mathematics and statistics, HEIs need to collaborate with and learn from the experiences of others'*.

13.6 Five of the seven University Alliance institutions indicated that in their opinion support was needed for the development of high quality learning resources, especially those aimed at helping students to make successful transitions into and within HE - one of those universities suggesting that what was required was more guidance materials like those produced by the RSS. Two specific areas of need were identified with regard to external support in the form of learning resources: for work with students entering HE who have been *"turned off"* mathematics to the extent that, in some cases, they have strong emotional barriers to the subject; and, to help students become more confident in mathematics and statistics in order to raise their awareness of how numeracy plays a key part in everyday life including employment. With regard to the former, one of those questioned from this group reported that a colleague claimed that many students are 'terrified of maths' – an idea that has been substantiated by the work of Tariq (2005) in connection with Biological Science and Stokes (2006) in relation to the Geography, Earth and Environmental Sciences (GEES) subjects.

[15] Notwithstanding this quote, **sigma** has succeeded in developing a collaborative community of practice comprising individuals from markedly varying institutions.

13.7 By way of contrast, the other two University Alliance institutions gave priority to support for training and CPD for their staff over more access to learning resources. They suggested that amongst other things this would raise awareness of the different models that currently exist with regard to the provision of learning support for mathematics and statistics, and help their academic colleagues to embed innovative methods into the design and delivery of their courses. In their view, the overall aim should be to help individual institutions to improve the learning experiences of their students in their chosen courses of study as a first step in providing learning support for mathematics and statistics. To that end, it was said that guidance is needed on how to make the experience of learning mathematics and statistics in university programmes of study much more effective (even enjoyable) for students in the context of the day-to-day delivery of teaching and learning – backed up with access to other forms of support such as that provided by MSSCs.

13.8 Three of the universities from this group also indicated that there is a need to ensure that support for mathematics and statistics continues to be developed and made available to students in ways that are sustainable. One of those universities suggested that whilst there is ample evidence of good practice in terms of developing and embedding that support, *'it is likely that the need for such provision will grow rather than diminish as a result of the numbers of students entering higher education and their entry qualifications, combined with the drive to improve the quality of the student experience as well as meeting the demands of employers with regard to employability'*. Hence the challenge now facing institutions across the sector is *'to increase both the quantity and quality of support they provide for mathematics and statistics along with other aspects of student learning'*. To one of those interviewed, therefore, *'sustainability is to a large degree a question of the on-going provision and appropriate use of resources over time'*. Specific areas in which further help would be welcomed by these three institutions included: advice on embedding learning support for mathematics and statistics within the delivery of different subject disciplines; mentoring for support centre and other staff; guidance on how we can get more students to fully engage with the learning support made available to them; and, examples of how to scale up the drop-in support provided by means of one-to one tutorials.

13.9 The individual questioned from one of the former 1994 Group universities (now non-aligned) emphasised the importance of support being directed towards helping institutions to develop practices and resources that have been customised for use in their own situation when stating: *'this university is full of academic researchers who like to be creative about teaching and learning, and who prefer to fabricate their own solutions to problems relating to teaching and learning in their own institutions, rather than import them from outside'*. Nevertheless, it was said that they would be willing to access and use high quality online resources such as those being developed by Epigeum[16]. A similar view was expressed by another non-aligned university (formerly in the 1994 Group) i.e. *'If ever there was a case for access to shared resources this is it',* adding that *'there must already be a lot of resources developed within institutions targeted at commonly-used mathematical skills and statistical methods so many institutions are in effect reinventing the wheel'*. It was concluded that *'whilst it might be hard to make a case for open education resources within a marketised HE system, in the area of learning support for maths and statistics it would be beneficial to use a collective approach'* adding that *'it seems a very obvious way forward and the use of MOOCs would be very good in this area as well not least because an institution could justify the expense of developing a MOOC on the grounds that it would also act as a pre-sessional resource for students'*.

13.10 The individual questioned from the third former member of the 1994 Group that is now a non-aligned university with a well established MSSC, offered a different perspective on the usefulness of a development strategy based on sharing resources and good practice, arguing instead for the adoption of a more holistic approach to developing and embedding learning support for mathematics and statistics. This was expressed as follows: *'much good work has already been done by individual universities to establish well-founded systems of learning support for mathematics and statistics – especially by those leading the **sigma** Network and strong communities of practice have now been established, from which others across the sector can learn. However, those support systems and the ways in which they are structured, resourced and implemented will tell those seeking guidance little about how, when and why they were developed – and who within their respective HEIs was responsible for driving the development process forward'*. These comments indicate that it would be too easy to focus on disseminating the 'products' (the systems and resources) relating to mathematics and statistics support, and not on the wider 'processes' including the leadership, strategic thinking, brokerage, and engagement with staff and students by which they were developed within those institutions that have led the way. In order to further enhance and embed mathematics and statistics support in a sustainable manner therefore, the focus needs to be on helping institutions to develop their own capacity for curriculum innovation and organisational change, and to do so by drawing upon the experiences of those who have already begun to do so.

13.11 Two of the other non-aligned universities responded by reiterating points made elsewhere about the value of access to learning resources in helping to develop sustainable learning support for mathematics and statistics. One of those questioned expressed this as follows: *'we need to take advantage of learning technology in order to provide resources that address a large-scale system-wide problem, but in so doing the university needs to make available to its staff and*

[16] 'Epigeum' [http://www.epigeum.com].

students resources that have been tailored to particular subjects and their requirements, rather than general resources on numeracy, maths and statistics'. The representative from the second of these institutions identified the need for assistance in training its staff to deliver effective learning support i.e. *'a lot of training and CPD will be needed to move forward with learning support for mathematics and statistics, and it would be good if that experience could lead to some form of professional accreditation'*. Whilst being in agreement with much of what had been said elsewhere in response to this item, the final Non-Aligned institution focused attention on the challenges arising from the students' transition into HE by suggesting that universities across the sector would benefit from help being given to the schools and colleges from which they recruit their students. This was seen as being a matter of *'encouraging pupils to know how important maths is in day-to-day life as well as at university, and building their confidence in using it'*.

13.12 Those interviewed from the Russell Group universities highlighted the need for support in developing the systems and processes that would enable them and others to do as one said i.e. *'to share resources and best practice across the sector'* and in so doing *'stop us from having to re-invent the wheel'*. However, it was widely recognised that support systems and learning resources developed elsewhere need to be customised in order to meet the requirements of individual institutions and become sustainable – a process likely to require the provision of staff training and CPD. The view of one of the universities from this group was that what was needed was external support aimed at building the capacity of institutions across the sector – especially amongst those academic staff responsible for the design and delivery of programmes of study to undergraduate and postgraduate students – to analyse their own needs in context with regard to the provision of learning support for mathematics and statistics. The outcomes of such a situational analysis could then be used as the basis for building their own sustainable strategies for meeting the challenges their students face in relation to mathematics and statistics. What is being advocated here bears many similarities to the suggestions put forward in response to this item by the individual questioned from a university with a long-established MSSC (see **paragraph 13.10**).

14. How external assistance might be provided nationally

14.1 The responses to this the final item in the interview schedule were underpinned by a shared assumption that there would be no large scale injection of external funding to provide learning support for mathematics and statistics, and that the emphasis in future would have to be on building capacity on what has already been achieved, working with existing organisations such as the HEA, subject associations, professional bodies and the **sigma** Network, closer collaboration with like universities in the sector, and on a substantial degree of institutional self-reliance.

14.2 All three of the GuildHE universities made positive suggestions about how the **sigma** Network might continue to provide the assistance they and other institutions across the sector need in relation to the future development of learning support for mathematics and statistics. However, they all stressed the importance of any guidance they are offered being customised to meet the particular needs and circumstances of their individual institutions. They also indicated that, whilst priority will continue to be given to mathematics and statistics support wherever it is shown to be needed, expansion of that and other forms of support for academic learning will be contingent on factors such as the growth in student numbers.

14.3 It was said of one of those universities that its primary aim was to improve the frontline delivery of teaching and learning across a range of undergraduate programmes, and to that end there was an expectation that its: *'members of staff will engage with others through **sigma** and any other networks that are able to provide advice and access to resource materials'*. In addition, it would also be looking to the same sources for guidance on how to supplement that by providing other forms of learning support for mathematics and statistics.

14.4 A second GuildHE university indicated that it intended to take advantage of opportunities offered through the **sigma** Network and other agencies such as the HEA for *'sharing experiences about the institutional processes by which the needs for learning support are identified, diagnosed and addressed'*. In particular it called for access to *'case studies of how to be more preventative with regard to the need for learning support for mathematics and statistics as well as guidance and resources on how best to deliver it'*. However, it was also said that whilst seeking to draw upon the experience of others in the sector, institutions *'need to be self-reliant and encouraged to fashion solutions to their own problems'*. It was in this context that it was suggested that if funding was to be made available it could be used to good effect by appointing *'peripatetic advisors to provide guidance on matters relating to learning support in mathematics and statistics to individual institutions across the sector'*.

14.5 The third GuildHE institution questioned could see no further than the **sigma** Network as the main source of the support it needed, and expressed the hope that it would *'continue to support the setting up of MSSCs through the provision of guidance and resources'*. It went on to suggest that from its perspective, future engagement should be directed towards learning support and development staff (who it said *'are often unaware of **sigma**'*), and academics from different subject disciplines who nevertheless need guidance on providing student support for mathematics and statistics. With regard to the latter, it was suggested that wherever possible **sigma** should work in close collaboration with the networks associated with established subject organisations such as the IoP and RSC.

14.6 Both of the million+ universities stressed the importance of on-going collaboration between different institutions across the sector. Their preference was for this to be facilitated by the **sigma** Network and its regional hubs working in collaboration with other agencies such HEFCE, the HEA, subject associations and professional bodies, especially those directly related to subjects such as the STEM disciplines and the Social Sciences i.e. those in which a knowledge and understanding of mathematics and statistics are essential.

14.7 With many of the University Alliance universities already having well-established forms of engagement with the **sigma** Network they were able to offer well-informed views about how it might continue to support them and others across the sector with regard to the provision of support for mathematics and statistics. The individual questioned from one of those institutions expressed this as follows: *'the support that the **sigma** Network provides is invaluable, but there is still a lot to be learnt from others and how they work. So, meetings and networking opportunities provided by **sigma**, staff mentoring and training are all invaluable and these can only be done effectively at a national or regional level as it is simply beyond the capacity of an individual institution to provide such a service'*. In addition, a case was made for the continuation and further development of the mentoring scheme offered by **sigma**, which was said to be especially important in the case of *'universities in the process of establishing new support centres'*.

14.8 A second University Alliance institution with long experience of learning support for mathematics and statistics suggested that *'the wider provision of high quality resources online would be very helpful to many institutions across the sector'*, and that *'whilst these could be provided by **sigma** this is usually something that is best developed on the ground within an institution'*. Nevertheless, it was acknowledged that there is much to be gained through the exchange of ideas between institutions by means of meetings of small groups of practitioners – either face-to-face or through the use of communication technologies such as Skype. This was thought to be especially important in respect of those working in new support centres, who have much to learn from the experiences acquired by the staff of established MSSCs, and those who because of geographical location feel isolated. Finally, it was suggested that new support centres will only be sustainable if they are financially well supported beyond the initial start-up phase, in order to be able to employ enough well qualified staff to meet the growing demands for learning support from students at times when they most need it, and to deliver it in well-resourced accommodation.

14.9 A third institution in the University Alliance group indicated that there was an on-going need for collaboration in relation to the provision of support for mathematics and statistics built up in institutions linked to the **sigma** Network's regional hubs. It was argued that whilst the CETL-MSOR annual conferences are an important meeting place for mathematics and statistics support practitioners, an issue going forward is to build new forms of collaboration with others in HE who are involved in providing support for other aspects of students' academic learning. Given the resources to do so, it was said that **sigma** has the knowledge, experience, networks and reputation to be able to take a lead role in developing much-needed initiatives of this kind.

14.10 Two of the University Alliance institutions also indicated that whilst there is ample evidence that many universities across the sector have developed (or are in the process of developing) strategies for addressing the need for mathematics and statistics support, in many cases the approaches they have adopted have not been thoroughly evaluated. It was suggested that the **sigma** Network along with the HEA (e.g. in association with its NTF scheme) could play a valuable role in this respect by encouraging rigorous evaluation of practice in mathematics and statistic support, and in disseminating the outcomes of those studies to institutions across the sector. It was also pointed out that in mathematics and statistics there are many learned societies[17] with an interest in the provision of learning support to HE students, which means that it is not always easy to navigate a way through the guidance and the resources that are available. According to one of those questioned: *'practice transfer between institutions across the sector in relation to mathematics and statistics support would be made easier if the messages were communicated through a single 'go-to organisation' – the **sigma** Network'*. Similarly, the other institution argued that *'using the **sigma** Network and other relevant sources as a central resource, or 'hub' for all resources relating to learning support for mathematics and statistics would be helpful'*.

14.11 Three of those questioned from the University Alliance group suggested that there was a need for more work to be done at the interface between schools and colleges and HE through the agency of individual institutions working in association with the **sigma** Network, the HEA, subject associations and professional bodies. For example, at one of those institutions an NTF is *'working in schools at a secondary level as part of the outreach programmes as well as with colleagues in the university, and as a result is gaining useful knowledge about the curriculum at 16-19 and about what help and support those students will need when they make the transition into HE'*. One of the other universities in this group advanced the idea that online resources should be developed targeted on GCSE and A-Level students for use in connection with outreach activities, the aim being *'to provide potential students with information before they enter HE about the sort of mathematics and statistics they will be studying as undergraduates in different subjects'*.

14.12 One of the non-aligned universities (formerly a member of the 1994 Group) also advanced the view that *'a national network like **sigma** is the obvious way forward with regard to how resources and knowledge can be shared across the sector'*. However, the individual questioned went on to say that whilst not being too familiar with the work undertaken via its regional hubs the sense was that *'a regional approach is probably unhelpful because regions contain a range of institutions that are quite different from each other in terms of types, sizes and missions. In this region for example there is one university that is very large with several smaller institutions that have little in common with each other. However, nationally there are other institutions with which a university like this has many similarities'*. Like three of the University Alliance institutions, the representative of this university went on to suggest that the institutions from across the sector along with the **sigma** Network should play a key role by engaging with post-16 education with a view to developing a better understanding across the sector of the curriculum particularly with regard to the delivery and assessment of A-level Mathematics.

[17] The examples cited included: The Institute of Mathematics and its Applications (IMA); The Mathematical Association (MA); and, The Royal Statistical Society (RSS).

14.13 A second non-aligned university (one of the former 1994 Group) stated that *'the reputation and strengths of the **sigma** Network in terms of its knowledge and understanding of how effective support for mathematics and statistics can be designed and delivered means that it is in a good position to provide on-going advice and guidance to institutions across the sector at different stages of development with regard to the provision of such support'*, adding that *'other organisations also have the potential to provide external inputs to that process including the Leadership Foundation for Higher Education, the Higher Education Academy, and the National Union of Students'*.

14.14 One of the remaining non-aligned universities questioned advocated various on-going roles for the **sigma** Network in relation to the provision of support for mathematics and statistics, starting with the suggestion that it could take a lead in the development work that needs to be done in collaboration with universities and schools and colleges to better prepare students in mathematics for their transition into HE. This was combined with the idea that *'**sigma** could fulfil a central role in the provision of CPD for staff working in maths and statistics support enabling them to become more aware of best practice and what works or what doesn't'*, adding that there is *'a need for a national forum of this kind to collate and distribute resources for maths and statistics drop-in centres to raise their awareness about how different the BTEC system is from the IB and from A-levels'*. There was a similar response from the other two non-aligned institutions, one suggesting that it would welcome the provision by **sigma**, working in association with other agencies, of *'bespoke on-site training, intensive short courses off site, and post-training support through mentoring for a fixed period of time, say six months'*. The final university from this group, unlike a number of others questioned, suggested that such support could be provided more effectively through the network's regional hubs rather than nationally.

14.15 Of the five Russell Group universities in the research sample only one was of the opinion that its needs for assistance in relation to the provision of support for mathematics and statistics could be served through participation in activities associated with the **sigma** Network's regional hubs. Of the others, one was very strongly of the view that its interests and those of others would be better served through working, not with a diverse set of institutions in a geographical region, but with other research intensive universities on the grounds that they would have *'problems in common in relation to both mathematics and statistics that need to be addressed, and could build upon previous collaborations opening up more opportunities to work together on matters of mutual interest such as sharing facilities, student learning, staff training, curriculum development and on-line resources'*. It was acknowledged however, that the **sigma** Network was in a strong position to facilitate the creation of such partnerships, to provide them with on-going support and disseminate their outcomes (including resources) to others in the sector.

14.16 The university from the Russell Group that envisaged a future role for regional hubs in the provision of support for institutions across the sector made a number of suggestions about other contributions **sigma** might make. First, the individual questioned advocated the further rolling out across the sector of MSSCs on the grounds that *'they have cleverly found a way for students – who can often find it quite difficult to ask their tutors when they are struggling – to seek help'*, adding *'we find that they are more often inclined to speak to fellow students in their departments rather than the professors, and if they get behind, it is a constant struggle in maths. So the provision of a discrete drop in centre with a mixture of short course provision is the right model for us – and probably for others'*. In addition to collaborating with other HEIs via the **sigma** Network's regional hubs in order to develop resources that could be shared, a case was also made for seeking inputs from learned societies and professional bodies especially those with an interest in the STEM disciplines and the Social Sciences, and for building linkages between outreach activities and providing learning support – not just for mathematics and statistics, but for other aspects of academic study in HE as well. Finally, it was suggested that PVCs who are not themselves mathematicians or statisticians, would welcome any support directed at them that was forthcoming from the **sigma** Network, especially if it was from a strategic leadership and management perspective.

14.17 Two of the other Russell Group universities questioned offered similar responses to this item. Of the first of those it was said that *'despite being a large research-led university that has the capacity to analyse problems relating to teaching and learning such as the need to provide support for mathematics and statistics, and then fabricate its own 'home grown solutions', we are fully aware that much can be learned from other institutions. Hence the value to the sector as a whole of an organisation like **sigma** that can be a 'first port of call' for information, guidance and other forms of assistance for those seeking to improve the provision of mathematics and statistics support'*. However, despite being aware of the benefits that can be derived from collaboration by means of partnership arrangements, that was said to be something that *'needs to be managed carefully'*. The second of these universities also indicated that external assistance from sources such as the **sigma** Network should be directed towards: *'building the capacity of those institutions across the sector (especially amongst those academic staff responsible for the design and delivery of programmes of study to undergraduates and postgraduates) to analyse their own needs in context with regard to the learning support they provide for mathematics and statistics. The outcomes can then be used as the basis for building their own strategies for meeting the challenges that have been identified'*. The individual being questioned went on to add: *'Whilst staff can benefit from networking with (and learning from) those who are successfully tackling the problems associated with the provision of learning support in mathematics and statistics, there are no easy 'off-the shelf' solutions to be had'*.

14.18 The final Russell Group university argued for 'more of the same' with regard to the guidance it had been able to derive from **sigma** and the HEA in relation to the provision of learning support for mathematics and statistics. However, in looking to the future it suggested that priority should be given to a programme of training and staff development for postgraduate tutors leading to some form of recognised status such as 'Associate Fellow of the HEA'. Similarly, *'the provision of top-up training in Stats/Quants for academic staff would help to address a gap in what is currently available to the sector'*. The indication is therefore, that external assistance in the form of new initiatives may be needed to aid the development of the professional identities of staff working in maths and statistics support (Rowland, 2006; Naidoo, 2005).

15. Conclusions

15.1 The adoption of a qualitative research method based on in-depth, semi-structured interviews with senior managers from a carefully constructed sample of HEIs from across the sector in England produced a detailed body of evidence, which when analysed in the light of the research questions, produced a wealth of insights into the challenges faced by students with regard to mathematics and statistics, the learning support currently provided, the strategic plans for the development of that support and the means by which they were determined through to the assistance institutions themselves will need going forward and how it might be provided through **sigma** and other agencies.

15.2 Without exception all of the HEIs questioned indicated that they have students who are challenged to a greater or lesser degree by mathematics and statistics. Whilst the precise nature of those challenges varies in detail both within and between different types of university, in general they can be related to the students' ability to make effective transitions into HE, within HE (including their progression to postgraduate study), and to employment.

15.3 The challenges experienced by students are not confined to the mathematical sciences and the STEM disciplines, but extend to subjects such as Economics, Business and the Social Sciences, which make use of quantitative methods, and even to Arts, Humanities and Languages courses in which little or no use is made of mathematics or statistics, but whose students are likely to face a graduate numeracy test when seeking entry to employment.

15.4 The challenges students encounter in making the transition into HE were attributed to the small proportion of those now entering universities who have studied any form of mathematics as part of their post-16 education, to the difficulty many of those with an A-level qualification in mathematics have in applying their prior knowledge to solving problems in unfamiliar contexts, and to the negative attitudes some students have previously acquired towards studying any form of mathematics and/or statistics.

15.5 It is recognised by all of the universities questioned that unless the challenges students face with regard to mathematics and statistics are addressed through the provision of appropriate forms of learning support, it is inevitable that they will have an adverse impact on their ability to make successful transitions both within and beyond HE i.e. on their satisfaction, retention, progression through their chosen programmes of study, and ultimately on their levels of achievement and employability.

15.6 The learning support for mathematics and statistics currently offered to students, and the means by which it is delivered, varies widely across the institutions sampled, ranging from that which is restricted in scope and highly targeted through to comprehensive systems of university-wide support. The former is likely to be embedded in the design and delivery of selected modules within particular programmes of study and limited to relatively small numbers of students, whereas the latter consists of more extensive provision including on-line resources and drop-in facilities located in MSSCs, which can be accessed by students from across the whole institution according to their individual needs and circumstances.

15.7 The extent to which the learning support for mathematics and statistics has been established and become embedded as a visible part of the core provision also varies across the institutions questioned, being a recent small-scale innovation in some, and university-wide and long established in others. Its presence in the former can only be detected through careful scrutiny of the evidence available in module and programme specifications; in the latter it is highly visible through the physical spaces (MSSCs) where it is located, pages on the website through which its services are advertised (to both current and prospective students), the availability of on-line and other resources, access to qualified staff tutors and trained student mentors, and through explicit references to it in annual OFFA access agreements.

15.8 When asked to detail the needs, priorities and intentions of their institution with regard to the provision of learning support for mathematics and statistics those questioned indicated that the situation across the sector in this respect is far from static. This is because all of the institutions recognise the need to develop what they currently offer with a view to extending its scope and/or improving its effectiveness. In some cases the intention is that this will be achieved by building on previous experience and existing organisational structures (e.g. by developing online resources, implementing new mentoring schemes and getting more students to access the learning support available via established MSSCs). In other instances the need to make transformational changes has been recognised and priority is now being given to developing and implementing plans for university-wide systems of support including the setting up of MSSCs that are in use elsewhere in the sector.

15.9 The means by which strategic decisions concerning the provision of learning support for mathematics and statistics are made were found to differ across the HEIs in the sample. In instances where the support is targeted on particular programmes of study and groups of students, needs, priorities and intentions are largely determined at School or Faculty level working within existing organisational structures and procedures. However, in cases where university-wide systems of learning support for mathematics and statistics have been (or are in the process of being) established, strategic decisions are made at the highest managerial level (usually led by a PVC with responsibility for teaching and learning, or the student experience) and linked to a wider set of considerations such as those relating to outreach, fair access, student recruitment, retention, achievement and employability.

15.10 There was tacit agreement across the HEIs that the challenges posed by mathematics and statistics will continue to be a major factor affecting students' transition into HE and their pathways through it and on into a labour market that is dominated by the demands of a knowledge economy. Universities therefore, are committed to the ongoing provision of learning support for mathematics and statistics, and this is reflected in their forward planning. For those institutions with well-established university-wide learning support systems, the aim is to improve the delivery of current provision based on evaluative feedback, and if necessary to extend it in order to serve newly identified areas of need. In other instances, a decision has already been reached, or is under active consideration, to develop comprehensive systems of learning support including the establishment of MSSCs based on the principles developed by **sigma**.

15.11 The institutions offered a range of views about how they might be better assisted in order to further develop and embed learning support for mathematics and statistics in ways that would be sustainable in the longer term. In addition to calling for further sharing of experiences derived from practice via **sigma** and other established networks, there were requests from those interviewed for additional online learning resources for mathematics and statistics that have been contextualised for use in the delivery of STEM subjects and the Social Sciences, and made available to the sector via a single 'go-to website'. There were also calls for the provision of opportunities for CPD for staff working in mathematics and statistics support, (coupled with improvements in the systems by which their contributions are recognised and rewarded), and for guidance targeted on the needs of senior managers in HEIs (such as PVCs) with responsibility for strategic planning with regard to the students' experience.

15.12 There was a shared assumption amongst the HEIs questioned that it is unlikely that there will be an injection of funding from external sources for new initiatives aimed specifically at improving the provision of learning support for mathematics and statistics. The emphasis in their responses therefore, was on self-reliance coupled with how best to build on the support that is currently available to institutions via the **sigma** Network, the HEA, subject associations, and the professional bodies. Further collaboration between HEIs was also advocated with some in favour of this sharing of experience being facilitated through the **sigma** Network's regional hubs, and others expressing a preference for groupings of 'like universities' on the grounds that the latter would have more problems in common that needed to be addressed, and would be able to build on existing partnership arrangements.

15.13 It was evident from the responses of all of those questioned that the intellectual capital that has now been accumulated by the **sigma** Network is highly respected and valued by institutions across the sector irrespective of their type and 'tariff provider' status. That intellectual capital includes both the high levels of knowledge and understanding **sigma** has acquired about learning support for mathematics and statistics in HE through its research and development activities, and its established networks of collaborating institutions, organisations and communities of practitioners. The **sigma** Network also has the human capital (as reflected in the status and reputation of those closely involved in its activities) and organisational structures to continue to play a leadership role in the development and dissemination of effective practice in the provision of learning support for mathematics and statistics in HE.

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Appendix 1:
Email to Pro-Vice-Chancellors

Dear Professor ...

Thank you for agreeing to support the high level sector needs analysis we are undertaking on behalf of the sigma Network. The aim of the research is to gather evidence that can be used to inform sigma's activities, and to offer HEFCE an analysis of the requirements of the higher education sector in England with regard to mathematics and statistics support. To that end we would welcome your response to the following questions from a University of …….. perspective.

1. What challenges do your undergraduate and postgraduate students face in relation to mathematics and statistics in different subject disciplines across the whole institution?

2. What support for mathematics and statistics is currently offered to those students within your institution?

3. To what extent is mathematics and statistics support well established and embedded in that it forms a visible part of your core provision (e.g. through explicit reference to it in your OFFA statement or by having resources such as staff time allocated to it)?

4. What are the needs, priorities and intentions of your institution with regard to mathematics and statistics support in the short-, medium- and longer-term?

5. By what means have those needs, priorities and intentions been determined at the institutional level?

6. Are plans in place for the development of new mathematics and statistics support provision (or if applicable an extension of provision that already exists)?

7. How can institutions across the sector be better supported in their attempts to further develop and embed mathematics and statistics support in a sustainable manner?

8. How might the external assistance institutions such as yours require with regard to mathematics and statistics support be provided nationally (e.g. through the sigma Network and/or by other means)?

We will send a separate message to your PA setting out the dates and times over the coming weeks when one of us will be free to talk to you by telephone.

We will of course be grateful to receive any supporting documents from you that would help to clarify the situation at the University of …….. with regard to mathematics and statistics support – though we note that your website is a rich source of background information. Anything you say or provide will be treated in the strictest confidence and we undertake to use it solely for the purposes of the research. Care will be taken over the storage of the data we collect, and access to it will be restricted to the small team responsible for the research.

We look forward to hearing from you and to finding out more about mathematics and statistics support at the University of ……..

Kind Regards,

Professor Harry Tolley & Dr Helen Mackenzie

Appendix 2:
Interview questions and prompts

1. **What challenges do your undergraduate and postgraduate students face in relation to mathematics and statistics in different subject disciplines across the whole institution?**

   For example:
   - *By programmes of study/subject disciplines*
   - *'Troublesome knowledge' in Mathematics degree courses.*
   - *Undergraduate students (Year 1 transition from school/college to HE, Year 3 dissertations).*
   - *Postgraduate students (e.g. Masters and PhD dissertations statistics).*

2. **What support for mathematics and statistics is currently offered to those students within your institution?**

   For example:
   - *Tutoring (or 'peer mentoring') for Mathematics students to deal with troublesome knowledge/modules.*
   - *Learning support centres (for mathematics and statistics alone or as part of a generic learning support centre).*
   - *How such support centres operate (drop-in, booking system for tutorials, confidentiality, on-line resources etc).*

3. **To what extent is mathematics and statistics support well established and embedded in that it forms a visible part of your core provision (e.g. through explicit reference to it in your OFFA statement or by having resources such as staff time allocated to it)?**

   For example:
   - *References to learning support for mathematics and statistics In OFFA statement.*
   - *Visible on website.*
   - *Part of core provision of wider (generic) learning support/enhancement of the student learning experience.*
   - *Availability of on-line and other 'customised' resources.*
   - *Presence of staff with the necessary skills/ expertise to provide learning support for mathematics and statistics.*

4. **What are the needs, priorities and intentions of your institution with regard to mathematics and statistics support in the short-, medium- and longer-term?**

   For example:
   - *On-going commitment to it as part of the drive to enhance the student experience and further graduate employability.*
   - *Formalise and enhance existing provision such as creation of a mathematics and statistics (or a generic) learning support centre.*

5. **By what means have those needs, priorities and intentions been determined at the institutional level?**

   For example:
   - *Where does responsibility lie for strategic 'horizon scanning', formulating strategic plans and putting those plans in to action? Name of the group/committee?*
   - *Does it feed up to the top from below?.*
   - *What part is played by feedback from NSS, visibility of position in league tables?*

6. **Are plans in place for the development of new mathematics and statistics support provision (or if applicable an extension of provision that already exists)?**

   For example:
   - *More of the same or investment in new provision for learning support?*

7. **How can institutions across the sector be better supported in their attempts to further develop and embed mathematics and statistics support in a sustainable manner?**

8. **How might the external assistance institutions such as yours require with regard to mathematics and statistics support be provided nationally (e.g. through the sigma network and/ or by other means)?**

   For example:
   - *Role for* **sigma** *Network – leading source of research, guidance, resources etc.*
   - *Provision of generic support nationally and/or through regional hubs?*
   - *Provision of support targeted on the needs of particular types of HE (such the Russell Group or GuildHE Group)?*

Appendix 3:
Thematic analysis

Research Question	Key Analytical Themes
What challenges do your undergraduate and postgraduate students face in relation to mathematics and statistics in different subject disciplines across the whole institution?	Challenges identified connected to a thematic 'transition pathway': • Into Higher Education • Within Higher Education • Into Employment
What support for mathematics and statistics is currently offered to those students within your institution?	Levels of support: • Organisational and centralised – support provided across the institution for all students. • Maths and Statistics Support Centres. • 'Add on' support - drop in centre or student services. • Departmental support – embedded within programmes 'targeted' at particular students
To what extent is mathematics and statistics support well established and embedded in that it forms a visible part of your core provision (e.g. through explicit reference to it in your OFFA statement or by having resources such as staff time allocated to it)?	Levels of established / embedded maths and statistics support: • High – well established / committed e.g. staff provision (within departments / or across the institution), high visibility e.g. website / signposted on campus • Medium – some support provision emerging and becoming more visible. • Low – Little provision of support with low visibility • Reference / no reference in OFFA statement
What are the needs, priorities and intentions of your institution with regard to mathematics and statistics support in the short-, medium- and longer-term?	• Enhancement – consolidation • Continuous review • Improvements / new initiatives
By what means have those needs, priorities and intentions been determined at the institutional level?	• Responsibility for decision making – Senior management team / University Executive • Evidence base / drivers: Engagement with students, programme boards / departmental staff / annual reviews/ assessment outcomes/ committees/ overarching strategic plans
Are plans in place for the development of new mathematics and statistics support provision (or if applicable an extension of provision that already exists)?	Level of planning: • No plans • Plans to enhance provision • Plans to extend current support • Evidence base / drivers: Enhancing student satisfaction, retention, achievement, and employability
How can institutions across the sector be better supported in their attempts to further develop and embed mathematics and statistics support in a sustainable manner?	Types of support required: • Online resources (contextualised)/ resources to help the transition into HE • Continuing professional development for staff / professional accreditation • Support through collaboration / sharing resources
How might the external assistance institutions such as yours require with regard to mathematics and statistics support be provided nationally (e.g. through the **sigma** Network and/or by other means)?	External assistance: • **sigma** Network and its regional hubs • HEFCE • HEA • Other means - via subject associations & professional bodies

Appendix 4:
sigma Network letter to Pro-Vice-Chancellors

Dear Colleague,

We are writing to invite you to participate in a high level sector needs analysis relating to mathematics and statistics support of both undergraduate and postgraduate students, being undertaken as part of a major HEFCE-funded initiative. The purpose of the needs analysis is to inform Funding Council policy and also the direction of travel of the **sigma** Network, the national organisation promoting the provision of mathematics and statistics support in HEIs.

For many years, well-documented concerns have existed regarding the mathematical skills and preparedness of both undergraduates as they commence their university studies and of graduates moving into the workplace. These concerns are not primarily in relation to those studying courses in the mathematical sciences or going into highly mathematical jobs, but more in relation to those studying in other disciplines and entering what might be termed "general graduate employment". In a recent CBI survey, only 21% of employers reported being "Very satisfied" with graduates' basic numeracy skills.[18]

In 2005, the **sigma** Centre for Excellence in University-wide Mathematics and Statistics Support 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, and there now exists a wealth of free publications and learning materials available from the **sigma** Network and **math**centre websites[19]. Research undertaken has demonstrated that by 2012 the majority of HEIs were providing additional mathematics and statistics support.

In 2013, HEFCE funded the **sigma** Network to establish a three-year follow-on programme to maintain and further embed mathematics and statistics support across English HEIs. Whereas previously the work of **sigma** was focused upon supporting practitioners, a 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 HEIs might welcome from the Funding Council, and how the **sigma** Network can aid senior management within HEIs in ensuring the provision continues to meet institutional needs in a sustainable manner.

Professor Harry Tolley and Dr Helen McKenzie are working on our behalf to undertake this analysis and are keen to solicit the views of university senior managers on the future development of mathematics and statistics support at both an institutional and sector-wide level.

We would be delighted if you were able to participate, and we anticipate that the primary means of doing this would be through a short telephone or email interview. If you are willing to participate please respond to Professor Duncan Lawson (Pro-Vice-Chancellor for Formative Education, Newman University) by email to d.lawson@newman.ac.uk.

We look forward to hearing from you.

[18] Changing the pace: CBI/Pearson Education and skills survey 2013.

[19] www.sigma-network.ac.uk and www.mathcentre.ac.uk

Appendix 5

BERA	British Educational Research Association
BIS	Department for Business Innovation and Skills
BTEC	Business and Technology Education Council
CBI	Confederation of British Industry
CETL	Centre for Excellence in Teaching and Learning
CPD	Continuing Professional Development
FE	Further Education
GCE A-level	General Certificate of Education Advanced Level
GCE AS	General Certificate of Education Advanced Subsidiary Level
GCSE	General Certificate of Secondary Education
GEES	Geography, Earth and Environmental Sciences
HE	Higher Education
HEA	Higher Education Academy
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HELM	Help Engineers Learn Mathematics
IB	International Baccalaureate
IoP	Institute of Physics
MOOC	Massive Open Online Course
MSOR	Maths, Stats & OR Network (OR = Operational Research)
MSSC	Mathematics and Statistics Support Centre
NHS	National Health Service
NTF	National Teaching Fellow
NUS	National Union of Students
OECD	Organisation for Economic Co-operation and Development
OFFA	Office of Fair Access
PVC	Pro-Vice-Chancellor
QAA	Quality Assurance Agency for Higher Education
RAE	Royal Academy of Engineering
RDAP	Research Degree Awarding Powers
RSC	Royal Society of Chemistry
RSS	Royal Statistical Society
SPSS	Statistical Package for Social Scientists
STEM	Science, Technology, Engineering and Mathematics
VLE	Virtual Learning Environment

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