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Lessons for mathematics higher education from 25 years of mathematics support

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INTRODUCTION

In 1995, the London Mathematical Society, the Institute of Mathematics and Its Applications and the Royal Statistical Society (the three leading professional and learned bodies in the mathematical sciences in the UK) issued the report *Tackling the Mathematics Problem* (LMS, 1995). This report introduced the phrase ‘the Mathematics Problem’ to describe the situation of an increasing number of new undergraduates, typically students of engineering or the physical sciences, arriving at university inadequately prepared for the mathematical demands of their course. The specific areas that the report identified as problematic were: lack of fluency and accuracy in numerical and algebraic calculations; decline in ability to solve multi-step problems; and a changed perception of the nature of proof.

This report was followed by other reports such as *The Changing Mathematical Background of Undergraduate Engineers* (Sutherland and Pozzi, 1995) and *Measuring the Mathematics Problem* (Hawkes and Savage, 2000); both published by the Engineering Council. Whilst much of the content of these reports was dependent on the judgement of academic staff, *Measuring the Mathematics Problem* did, as its name implies, seek to quantify the problem through the provision and analysis of relevant data. A vital contribution to this was the work of Lawson (2000). This work was based on analysis of the results of incoming undergraduates on a diagnostic test at Coventry University. The diagnostic test had been unchanged over the period under consideration. It covered a range of basic topics including arithmetic, basic algebra, lines and graphs, triangles, trigonometry, further algebra and basic calculus. These topics were all on the school mathematics syllabus and form a vital foundation for students entering engineering courses at university.

The results of students entering university with specific grades in A-level mathematics [1] were compared over the period from 1991 to 1999. These results showed that over this period of time the performance of students entering university with a specified grade in A-level mathematics declined. Furthermore, the analysis of the diagnostic test results revealed that students entering university in 1999 with a grade C (ie a middle ranking pass grade) performed at a similar level to those students who had entered university in 1991 with a grade N (a narrow fail grade). Lawson (2003) subsequently extended this work and showed that the average

performance of the 2001 A-level grade B cohort was almost indistinguishable from that of the 1991 A-level grade N cohort.

This evidence and further substantial lobbying by higher education institutions (HEIs) and professional bodies over subsequent years led the Government to commission an inquiry into post-14 mathematics education. The report of this commission *Making Mathematics Count* (Smith, 2004) identified a range of issues in mathematics education which could not be solved in the short-term and made a number of recommendations for resolving these issues, recognising that these would take several years to have an effect on universities. The report concluded that “In the short-term, the Inquiry believes that Higher Education has little option but to accommodate to the students emerging from the current GCE [2] process” (Smith, 2004, p. 95).

HEIs had reached this conclusion for themselves many years previously and started to make the required “accommodation”. A range of measures were introduced including bridging courses to be taken before starting on the university course proper and the modification of the university mathematics curriculum to include revision of key aspects of the school mathematics curriculum which experience showed were not well understood by many incoming students. Several institutions chose to tackle the Mathematics Problem through the introduction of mathematics support provision.

One commonly used definition of mathematics support, given by Lawson, Croft and Halpin (2003, p.9) is

A facility offered to students (not necessarily of mathematics) which is in addition to their regular programmes of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc.

In practice, the most common form of mathematics support was the drop-in centre. Various forms of drop-in centre were implemented in different institutions. Several variants of the drop-in centre model of mathematics support are presented in Marr and Grove (2010) and Lawson (2012).

The basic idea behind a drop-in centre is the provision of a location where students can “drop-in” (that is, come at a time of their own choosing) to receive assistance with mathematical difficulties. Such drop-in centres set out to have a welcoming, non-judgemental atmosphere, providing a “safe” location separate from the normal teaching and assessment process where students can ask even very basic questions without fear of this counting against them in some way at a later stage in their education. Such centres typically provide an array of resources such as handouts and textbooks; in addition there will often be computers for students to access video materials and take self-assessment diagnostic tests. However, the resource that is most valued by students is the provision of one-to-one interaction between the student dropping-in and a mathematics tutor (Lawson, Halpin and Croft, 2002).

The Mathematics Problem may have begun as a UK issue, however it has not remained so. Similar issues have been reported in many developed countries, for example Australia (Matthews et al, 2012), Ireland (Gill et al, 2010) and across Europe (Alpers, 2008). In response, mathematics support centres have been introduced at the majority of institutions in Australia (MacGillivray, 2009b) and Ireland (Cronin et al, 2016). In continental Europe, the introduction of mathematics support centres has been a little slower. A few institutions in Norway, Slovakia and Switzerland, supported by established practitioners from the UK and Ireland, have developed mathematics support centres. In Germany, a broader range of mathematics support initiatives have been introduced, including a small number of universities which have set up mathematics support centres (as reported in Liebendorfer et al, 2017).

DEVELOPMENT OF MATHEMATICS SUPPORT

In its early days, there were some who regarded mathematics support as rather peripheral and not a significant phenomenon in the learning and teaching of mathematics. Kyle (2010, p.103) reflects thus on his views about mathematics support:

Although I might not have put it in these terms at the time, I probably regarded mathematics support as a form of cottage industry practised by a few well meaning, possibly eccentric, individuals, who may themselves have been hard pushed to offer a credible rationale for this work.

However, such ambivalence towards mathematics support did not stop its development throughout the first decade of the 21st century.

In 2004, the Higher Education Funding Council for England (HEFCE) announced its largest ever teaching and learning development programme: Centres for Excellence in Teaching and Learning (CETLs). HEIs individually or collaboratively could bid to have elements of their practice recognised as a Centre for Excellence and receive substantial funding (amounts up to £4.5 million over 5 years were available for individual centres). At this time, two of the largest mathematics support provisions in England were the Mathematics Learning Support Centre at Loughborough University and the Mathematics Support Centre at Coventry University. Together these two centres submitted a collaborative bid to be recognised as a CETL. This bid was successful and the resulting Centre for Excellence was called **sigma**: Centre for Excellence in University-wide Mathematics and Statistics Support, or just **sigma** for short.

Individual CETLs had set out their plans of work in their bids and there was huge variation in the nature and focus of the CETLs. From the beginning, **sigma** set out to have an impact across the sector and did not focus its attentions primarily on activities within the two host HEIs, as was the case with many other CETLs. The original CETL bid had indicated that **sigma** would fully fund Leeds University to develop its own mathematics and statistics support (MSS) provision. The process of

establishing this provision at Leeds University would be closely monitored so that a blueprint for setting up MSS at other HEIs could be produced. Further funding (allocated on a matched-funding basis) would be made available through a competitive bidding process to enable other HEIs to establish their own MSS provision.

Over the 5 years of the CETL programme, **sigma** spent substantial sums of money on facilitating the development of MSS in other HEIs. This was not only through the direct provision of funds to other HEIs to establish MSS, as described in the previous paragraph. In addition, a range of other measures were funded including the development of thousands of learning resources for students that were made freely available through the website www.mathcentre.ac.uk and good practice guides for staff including: *How to set up a mathematics and statistics support provision*, *Gathering feedback on mathematics and statistics support provision* and *Tutoring in a mathematics support centre* [3]. Furthermore, **sigma** promoted professional development for those involved in the delivery of MSS through the provision of:

- training courses for those involved in tutoring in MSS centres;
- workshops focused on operational issues related to running MSS centres (such as evaluating the provision, publicising the provision, understanding the increasingly diversified pre-higher education mathematics curriculum);
- opportunities for secondments to **sigma** to work with Loughborough or Coventry colleagues on MSS projects;
- an annual conference, the CETL-MSOR [4] conference to enable the sharing of good practice and the development of scholarship in MSS.

By the end of CETL funding in 2010, **sigma** had been able to establish the **sigma** network, a free association of individuals in HEIs across England and Wales involved in the provision of MSS. In addition, **sigma** had worked with MSS providers in Scotland to help establish the Scottish Mathematics Support Network and with colleagues from Ireland to assist the on-going development of the Irish Mathematics Learning Support Network.

The success of **sigma** had been observed by the National HE STEM [5] Programme [6], a major HEFCE funding initiative aimed at increasing the number of graduates in STEM disciplines. This Programme commissioned **sigma** to continue its work of enabling the roll out of MSS in HEIs across England and Wales. Following the scheduled ending of the National HE STEM Programme in 2012, HEFCE directly funded **sigma** to maintain the development of MSS nationally and to enable the continuation of a sustainable network. Alongside continuing the initiatives described above, **sigma** focused on activities that would strengthen the network of MSS practitioners through the creation of a community of practice. **sigma** provided funding to revive the journal *MSOR Connections* (which had ceased due to the

demise of the Higher Education Academy Subject Centres), in which many practice-focused articles relating to MSS had previously been published. In addition, modifications were made to the by now well-established competitive bidding process for match-funding. This was extended to not just receiving bids from HEIs without any MSS provision but also to enable those with a small provision to bid for funding to enhance and extend their provision. All successful bids were allocated a mentor (an experienced MSS professional from another institution who was active within the **sigma** network). The role of such mentors was to provide assistance to the grant-holder in the delivery of their objectives. Furthermore, mentors encouraged the colleagues delivering the new or enhanced provision to themselves become active participants in the **sigma** network. This latter aim was further strengthened by the expectation that grant-holders would either present at the CETL-MSOR conference or write an article for *MSOR Connections*.

By the end of the final tranche of HEFCE funding in 2016, **sigma** had directly helped facilitate the establishment of 36 new MSS provisions at HEIs across England and Wales. In addition, the **sigma** network was firmly established as a valuable community which could be sustained through contributions of time and expertise from those involved in MSS at HEIs across the sector. MSS had become a firmly established part of the HE infrastructure throughout the UK and Ireland. As Youdan (quoted in Fletcher, 2013, p. 49) put it

Mathematics and statistics support has now attained a critical mass and overcome the significant hurdle where universities worry whether offering such support is an indication of modest aspirations. The accepted position is now that it is a student's right to receive support with the mathematical content of their degree.

Surveys of the extent of provision of mathematics support across universities in the UK (Lawson, Croft and Halpin, 2003; Perkin and Croft 2004; Perkin, Croft and Lawson, 2013; Ahmed et al, 2018, Grove, Croft and Lawson, 2019) have shown that the number of institutions providing mathematics support has increased significantly during the 21st century.

MSS had also gained academic credibility. The previously held view of mathematics support as a 'cottage industry' had changed. Kyle's (2010, p. 104) previously quoted appraisal of MSS continues

Now only a few years on, we see that the concept of mathematics support has not only become firmly embedded in UK Higher Education, but colleagues have moved on to gather data on the way students use such resources and look for optimal strategies for the delivery of this support, and this is perhaps the most convincing evidence of acceptance. Mathematics support came of age in the first decade of the 21st century. What might once have been described as a cottage industry now plays a respected and widely adopted role in Higher Education.

The growing maturity of the MSS community has led, amongst other things, to an increase in the volume of research and scholarship relating to MSS. A recently published literature review (Lawson, Grove and Croft, 2019) surveying publications since 2000 contains 117 references.

INCREASED DEMAND FOR MATHEMATICS AND STATISTICS SUPPORT

Whilst **sigma** played a significant role in establishing MSS as “respected and widely adopted”, there were also external factors which contributed to this. The most important of these was the increasing quantification of many disciplines brought about by technological advances in data collection. As a consequence of this, the Mathematics Problem was no longer the preserve of engineering and the physical sciences. Professional bodies and learned societies from an ever expanding range of disciplines highlighted both how their disciplines were becoming increasingly quantitative and also how students studying their disciplines were inadequately prepared for such quantitative material since the majority of them had not studied any mathematics since the age of sixteen.

The Biotechnology and Biological Sciences Research Council strategic plan for 2010-2015 (BBSRC, 2010, p. 15) identified that

“As bioscience becomes increasingly quantitative there is also an urgent need **to raise the mathematical and computational skills of biologists** [original emphasis] at all levels.”

The British Academy, a national body for social sciences and the humanities, issued a position statement *Society Counts* (British Academy, 2012) which highlighted weak quantitative skills in their disciplines, identifying a shortage of academic staff able to teach such skills. The Royal Society of Arts, in a report *Solving the maths problem* (Norris, 2012), whose title invoked previous reports from engineering and mathematical sciences bodies, concluded that (*ibid*, p.11)

English universities are side-lining quantitative and mathematical content because students and staff lack the requisite confidence and ability.

The nature of higher secondary education in the UK is such that mathematics is not compulsory after the age of 16. This makes the UK an outlier in terms of educational provision in developed countries. Hodgen et al (2010), in a study of 24 educational jurisdictions, found only six where the study of mathematics was not compulsory after age 16. The six were Australia (NSW), England, Ireland, Northern Ireland, Scotland and Wales. In all six of these educational jurisdictions, mathematics support provision in higher education is widespread. A report by the UK’s Advisory Committee for Mathematics Education (ACME, 2011) has sought to quantify the problem caused by the optionality of mathematics post-16 in the UK. Their report estimates that in any given year around 330,000 students enter higher education for the first time taking courses where there would be benefit from studying mathematics or statistics at a level beyond GCSE [7]. However, only around 125,000 students per

year undertake such study. The 205,000 students who comprise the gap between these two figures are likely to be in need of MSS once at university.

The introduction of the Teaching Excellence Framework (TEF), compulsorily in England and voluntarily in other countries in the UK, has caused HEIs to pay increasing attention to student retention rates since this is one of the key metrics that is assessed in determining the outcome of a TEF assessment (DfE, 2017). A National Audit Office report into student retention in higher education (NAO, 2007, p.32) identified the fact that “Many students require some additional academic support, especially in mathematical skills” and throughout the report inadequate preparation in mathematics is identified as a major contributor to students not completing their courses. Because of the capacity of MSS to make a difference to retention and drop-out rates, increasingly MSS provision is being viewed by institutional senior management as a strategic issue for the institution and not a local issue for the mathematics department (Tolley and MacKenzie 2015).

Although evaluation of the impact of MSS is not straightforward, there is substantial and growing evidence of its effectiveness. A literature survey of evaluation of mathematics support centres was published by Matthews et al (2013); subsequent work by Dzator and Dzator (2018), whilst not a literature survey, cites several studies that have taken place since 2013, as does Lawson, Grove and Croft (2019). One of the most important studies in this area is O’Sullivan et al (2014). They report on a multi-institutional large-scale student evaluation of mathematics support across the island of Ireland, presenting both quantitative and qualitative data. The qualitative data includes feedback from students reporting the difference that engaging with MSS has made to them in the following terms (O’Sullivan et al, 2014, pp. 38, 42 and 75):

Made me see that it is not impossible to grasp a particular mathematical task, but that it takes practice and time.

Maths isn’t scary any more.

I am even starting to enjoy maths now.

Students who had engaged with mathematics support were asked if they had considered dropping out because of difficulties with the mathematical elements of their course. Those students who answered this question affirmatively were asked a follow-up question of whether the availability of MSS had influenced their decision not to drop out. 22% of the students surveyed reported that they had considered dropping out and of these 64% indicated that the availability of MSS had been a factor in their decision to remain on course.

At its conception, MSS was designed to provide support to ‘at risk’ students ie those in danger of failing their course of study because of difficulties with the quantitative components of the course. The original aims could have been classified as remedial.

However, MSS has not been restricted to ‘at risk’ students and the voluntary nature of engagement with this support (for example, students choose to attend a drop-in centre, they are not compelled to do so) has made the provision available to all. MSS has not been promoted as a remedial service. Instead, MSS has sought to engage with all students who wish to improve their learning of mathematics and statistics. As a consequence, many of the students who avail themselves of MSS are not ‘at risk’ students but able students who are seeking to improve their performance in mathematics and statistics from good to excellent (Pell and Croft, 2008).

Several quantitative studies, such as those of Gallimore and Stewart (2014), Dzator and Dzator (2018) and Jacob and Ni Fhloinn (2018), have consistently shown that students who engage frequently with MSS achieve better outcomes (in terms of pass rates and average marks on mathematics and statistics modules) than students with similar characteristics (typically entry qualifications) who do not use MSS. This raises the question about why some students do not engage with MSS, particularly those who are in danger of failing their mathematics or statistics modules. When such non-users of MSS are asked for their reasons for not engaging, the most commonly given reasons are such things as “Not being aware that MSS was available” or “Not knowing where the MSS support provision was located” (Symonds, Lawson and Robinson, 2008). Other studies of non-engagement with MSS, such as Mac an Bhaird et al (2013), O’Sullivan et al (2014) and Grehan et al (2016) report similar findings.

Whilst most MSS providers devote considerable energy and resources to publicising their provision (using a range of ‘marketing’ methods such as information in course packs, presentations during induction week, posters, branded merchandise, lecture shouts outs, prominent links on the institutional virtual learning environment, social media, etc.) it is of course possible that some students are unaware that they can access MSS. However, reasons such as “not knowing where the MSS provision is located” perhaps indicate that additional factors are influencing their non-engagement. If such students were motivated to engage with MSS, it would not be difficult for them to find its location (in many institutions it has a prominent position in the library or some other central student facility). A small number of students indicate that their reasons for non-engagement are due to deeper reasons such as feeling that they had too many problems (ie were beyond help), feeling demoralised or fearing embarrassment. It seems likely that such reasons may underlie the more superficial reason of “not knowing where the MSS provision is located”. Securing engagement of such students will always be difficult where the model of MSS provision is one which requires students to ‘opt-in’ (such as a drop-in centre).

MATHEMATICS AND STATISTICS SUPPORT AND SPECIALIST MATHEMATICAL SCIENCES STUDENTS - PART 1

Although the definition of MSS (Lawson, Croft and Halpin, 2003), **quoted on page 2 of this chapter**, states that mathematics support is for “students (not necessarily of mathematics)” it might have been a more accurate representation of the original intention had it said that mathematics support was for “students (not primarily of mathematics)”. Drop-in centres originally targeted engineering and physical sciences students and, for the reasons described in the preceding section, the expectation is now that students from a much wider range of “user-disciplines” will avail themselves of MSS. Particularly given the original focus of MSS on students at risk of failure because of weaknesses in quantitative skills, it was not anticipated that many students studying for degrees in the mathematical sciences would engage with MSS. After all, such students have chosen to study mathematics or statistics and will have had to demonstrate a comparatively high level of competence in these disciplines to have been admitted to the course. However, experience has shown that students studying the mathematical sciences are often those most likely to engage with MSS. ~~Usage data of Loughborough University’s Mathematics Learning Support Centre [8] show that in a typical year over 25% of the visits to the drop-in centre are made by mathematics students. They are the biggest users of the Centre, with over twice as many mathematics students engaging with MSS as the next largest group (Mechanical and Manufacturing Engineering).~~ This phenomenon has been reported at ~~other~~several universities, for example by MacGillivray (2009a), Solomon, Croft and Lawson (2010) and Grove, Guiry and Croft (2019). Indeed both MacGillivray (2009a) and Solomon et al (2010) report that mathematics students “colonised” the physical space of the drop-in centre in the universities in question.

This raises the question as to why specialist mathematical sciences students should make such extensive use of MSS provision, and in particular, the drop-in centre. One answer to this question may be found in the results of the National Student Survey.

THE NATIONAL STUDENT SURVEY AND MATHEMATICAL SCIENCES STUDENTS

The National Student Survey is an annual survey of all final year undergraduates at all publicly funded HEIs. The survey presents students with a sequence of statements relating to a range of different aspects of their experience at their university. Students are asked to indicate their level of agreement with each statement using a five point Likert Scale: Strongly agree, Agree, Neither agree Nor disagree, Disagree, Strongly disagree. The statements cover aspects such as the teaching students have received, assessment and feedback, student support, learning resources and course organisation.

The results from the NSS feed into grading and ranking systems for universities including official measures such as the Teaching Excellence Framework (DfE, 2017)

and unofficial (but nonetheless influential) ones such as league tables produced by The Guardian and The Times/Sunday Times newspapers. In such gradings, NSS data is typically analysed by measuring the percentage of students showing some level of agreement with a particular NSS statement (ie respondents selecting the first two items on the Likert scale – strongly agree and agree – are combined into a single category and, by default, those selecting the other items are also combined into a single category). The complete set of NSS data is made publicly available by the Office for Students [9].

The results of the NSS give a way to compare students experience in studying different subjects in higher education in the UK. The Joint Academic Coding System (JACS) [10] is a way of classifying subjects. In this classification there are 21 high level subjects such as Medicine & Dentistry, History & Philosophical Studies, Engineering & Technology and Mathematical Sciences. The analysis that follows takes the NSS results from 2016 and breaks them down by the 21 subjects at the highest level of JACS.

In the 2016 NSS there were 22 statements with which students were asked to indicate their level of agreement (this has since changed and the current version of the NSS contains 28 statements). With four of these statements, students from the mathematical sciences showed a higher level of agreement than students from any other subject. These statements are set out in Table 1.

Statement	Level of agreement
Assessment arrangements and marking have been fair	87%
Any changes in the course or teaching have been communicated effectively	88%
The course is well organised and running smoothly	89%
I am satisfied with the Students' Union at my institution	71%

Table 1: Statements where Mathematical Sciences students have a higher level of agreement than students from any other high level JACS subject

The fourth statement in this list is not related to students' experience in learning and teaching but is more to do with the social side of university. It has been suggested that mathematical sciences students have the highest level of agreement with this question because they have lower expectations in this sphere than students of many other subjects.

The other three questions relate to what might be classified as process-focused statements. The second and third statements reflect the administrative efficiency of the course. These statements are not directly related to learning and teaching, but do relate to the environment in which such learning and teaching takes place. Since assessment is a major driver of student learning, the first statement is directly connected to learning. In part, mathematical sciences' high score here may be due to the nature of the discipline. Many assessment tasks taken by mathematical sciences students have a correct answer and students may therefore be more likely to perceive the marking of such tasks to be fair than students whose assessment tasks are more essay-based where students often feel that there can be elements of subjectivity in the marking and that the final mark awarded can be affected by who actually marks the work.

A set of statements on the NSS explores students' views of their experiences with teaching at their institution. With these statements, the level of agreement of mathematical sciences students is lower than for students of most other subjects. Table 2 shows the position of mathematical sciences in an ordered list of the 21 subjects for the three teaching related statements.

Statement	Position of Mathematical Sciences
Staff are good at explaining things	15
Staff have made the subject interesting	18
Staff are enthusiastic about what they are teaching	14=

Table 2: Position of mathematical sciences in a list of 21 subject areas ordered by level of agreement with the statement

Table 3 shows the last five subjects, with their level of agreement, in the ordered list for the statement "Staff have made the subject interesting".

Posⁿ	Subject	Level of Agreement
17	Mass Communication and Documentation	81%

18	Mathematical Sciences	78%
19	Business and Administrative Studies	77%
20	Computer Science	77%
21	Engineering and Technology	76%

Table 3: Subjects with the lowest levels of agreement with the statement “Staff have made the subject interesting”

It can be seen from Table 3 that the gap between the Mathematical Sciences in 18th position and the subjects below it in the list in positions 19-21 (two percentage points cover all four subjects) is smaller than the gap upwards (three percentage points) to the subject in 17th position. This suggests that there is very little difference between these last four subjects in the list and there is a clear gap then to the next subject up (Mass Communication and Documentation). At the other end of this ordered list, in equal 1st position, 91% of students from Veterinary Sciences and 91% of students from Historical and Philosophical Studies indicated agreement with this statement. Academic staff who teach mathematical sciences would say that mathematical sciences is an extremely interesting subject but they are not managing to communicate this interest to their students as effectively as staff in most other subjects.

There are two statements in which the level of agreement of mathematical sciences students was lower than in any other subject. These are shown in Table 4.

Statement	Level of Agreement
The course has helped me present myself with confidence	69%
My communication skills have improved	68%

Table 4: Statements where Mathematical Sciences students have a lower level of agreement than students from any other high level JACS subject

Across all subject areas, the average level of agreement with the two statements shown in Table 4 were 81% and 84% respectively. The highest level of agreement with the first statement was 89% amongst students of both Medicine & dentistry and Teacher Education and for the second statement was 95% amongst students of Medicine & dentistry. These statements are related to personal development and cover areas that are important in terms of employability following university.

In summary, when comparing the experience of mathematical sciences students with those of students from other subjects, using data from the 2016 NSS (which is

entirely student self-reporting), we find that their experience in process-related areas is excellent, in teaching is unsatisfactory and in personal development is very poor. These results echo the findings of Hewson (2011) who analysed the 2010 NSS results. His analysis showed that students of mathematical sciences had the highest levels of agreement of all subjects with the statements relating to the fairness of marking and course organisation, was below all subjects other than computer science for the statement relating to making the subject interesting and below all subjects for the statement about presenting oneself with confidence. In other words, over this six year period, mathematical sciences has maintained its strengths but not improved its weaknesses.

MATHEMATICS AND STATISTICS SUPPORT AND SPECIALIST MATHEMATICAL SCIENCES STUDENTS - PART 2

The results of the NSS outlined above, particularly those relating to the teaching of the mathematical sciences, perhaps throw some light on to why students from the mathematical sciences have a tendency to “colonise” mathematics support drop-in centres. The work of Solomon et al (2010) and Solomon, Lawson and Croft (2011) reveals some of the reasons behind the comparatively low opinion that mathematical sciences students have of their teaching at university.

Relationships with lecturers and tutors are very important to many students. Their experience in the traditional lecture and tutorial settings is often not satisfactory for them. They report being too embarrassed or intimidated to ask questions in a lecture setting, which could often be in front of hundreds of other students. Even in smaller group tutorials, they have a fear of being patronised by being told that the answer to their question is ‘obvious’ or that something they are struggling with is ‘simple’. They have reservations about visiting staff in their offices even during times which have been publicised as ‘office hours’; such consultations take place in ‘their space’ and the visit is either interrupting them from doing something else (if no other students are present) or is constrained by there being a queue of students who need to be seen during the available hour.

Research evidence shows that mathematics support centres completely alter the power dynamic (Solomon et al, 2010). Support centres are viewed as neutral ground that does not belong to either the tutor or the students. A tutor on duty in the support centre is away from his/her desk and clearly is there in order to be asked questions and so the sense of interrupting them from doing something else is not present. Perhaps because of the way MSS tutors are trained, certainly because of the intended ethos of MSS where no question is regarded as too basic, students should not experience discouraging remarks such as ‘this is easy’ when seeking help in a drop-in centre.

As the NSS results show, mathematical sciences students have the lowest level of agreement with the statement “The course has helped me to present myself with

confidence”. Although this question is probably more focused on students’ ability to make oral presentations (a graduate employability skill which should be developed in all undergraduate courses), it also raises the issue of confidence. Whilst mathematical confidence is different from more general personal confidence, a learning experience which undermines the mathematical confidence of students who previously identified themselves as good at mathematics is likely to impact on their more general confidence. Mathematical confidence is a major issue for some undergraduates in the mathematical sciences who find unsettling the transition from school mathematics, where the focus is on process and algorithmic exercises, to university mathematics with its emphasis on proof and rigour. In the study of Solomon et al (2010), 26% of the mathematics undergraduates who participated in their survey reported that since coming to university ‘I realised that I am not very good at maths’ compared to 80% who reported ‘I was better at mathematics than most in my class at school’.

For students whose mathematical confidence is low, the MSS drop-in centre can provide a safety that they do not experience in lectures or tutorials. The one-to-one interaction with a tutor removes the sense of public exposure that is present in a group learning situation such as a lecture or tutorial, where students with low confidence would not ‘risk’ asking a question. There is safety too in that the MSS tutor is (usually) not going to be involved in the summative assessment process and so students are more likely to reveal areas of lack of understanding knowing that this is not going to ‘be held against them’ at some stage in the future.

A commonly held caricature of a mathematics student is a male loner who is striving to be better than his contemporaries. This caricature does not resonate with many mathematics students, not only female ones, whose natural approach to learning is far more collaborative than competitive. In very simple ways, mathematics support centres facilitate students in adopting a collaborative approach to learning. It is a physical space that is set aside for study rather than social activity, but it is not one where silence or even quiet is expected. The furniture is often round or hexagonal tables which make it easy for a small number of students to work together. These practical factors can lead to the formation of undergraduate student communities of practice, as demonstrated by the following comment by student “Roz” quoted in Solomon et al (2010, p.428):

I used it [the mathematics support centre] a lot because a group of us who tend to get fairly good marks used it a lot. Other people sort of came in to work with us and got the help and so on and so ... and it developed a real upspin, it was really kind of in a sense the place to be, and there was a lot of people, there was a lot of use.

It is not necessary to have a MSS drop-in centre to provide many of the attributes that students of the mathematical sciences indicate are valuable to them. Waldock et al (2017) describe the development of a purposefully designed informal learning space for mathematical sciences students which has many of these characteristics.

However, the availability of such spaces is rare in HEIs and drop-in centres are much more prevalent. It is therefore not surprising that many mathematical sciences students tend to gravitate towards them. As Solomon et al (2011, p.580) conclude

Support centres appear to have a significant impact on discourses of ability and learning; they lead in particular to an appreciation of, and emphasis on, collaborative work and, in consequence, to a shift in attitudes towards university mathematics as a community of enquiry as opposed to an individual performance-oriented pursuit.

Most MSS providers seek to support all students from across their institution - the original, full name of **sigma** was 'Centre for Excellence in University-wide mathematics and statistics support'. Therefore supporting mathematical sciences students lies within the remit of MSS. However, where disproportionate use is made of MSS by such students steps may need to be taken to address their needs in other ways. Students of other disciplines, particularly those where the level of mathematical content is relatively low, can be intimidated from engaging with MSS if it seems to always be dominated by specialist students engaging in discussion about advanced topics. The two institutions studied in MacGillivray (2009a) and Solomon et al (2010), where it was reported that mathematical sciences students had "colonised" the MSS provision, both introduced separate rooms solely for the use of such students. Such a measure is a short-term solution. There is a need for those teaching the mathematical sciences to reflect on and enhance their own practices, in the light of the NSS results and high levels of demand for MSS.

CONCLUSIONS

MSS has become a well-embedded feature of the HE infrastructure in many countries, notably the UK, Ireland and Australia. In other countries such as Germany, Norway, Slovakia and Switzerland, MSS is in its infancy but support centres have been established with assistance from colleagues in the UK and Ireland. In most institutions where MSS is established there is no shortage of students wanting to engage with the provision. Indeed, one of the most common responses received on student evaluation questionnaires, when asked if they have any suggestions for how the MSS provision can be improved, is that it should be available for more hours than it currently is.

As well as the growth in potential users due to the increasing quantification of many subjects, described in Section 3, in recent times MSS has seen increase in demand from another source. The origins of MSS were in facilitating the transition into university; the latest new demand comes from enabling the transition out of university. Many employers now use numerical reasoning tests as part of the selection process for graduate level jobs. For students who have not formally studied any mathematics since the age of 16, such tests can be extremely daunting and they look for MSS to help to prepare them.

Although MSS as it is currently delivered in HEIs around the world has many positive features, it should not be regarded either as ‘the finished article’ or as a panacea – the final solution to the Mathematics Problem. The MSS community is aware that delivery of MSS will always be ‘a work in progress’ and means and methods of delivery will need to adapt to both address existing shortcomings (such as securing engagement from those who seem not to be motivated to engage) and to respond to new demands (such as providing support for graduate selection tests).

With regard to solving the Mathematics Problem, it should also be remembered that MSS was part of universities’ response to the conclusion of the Post-14 Mathematics Education Inquiry that “In the short-term, the Inquiry believes that Higher Education has little option but to accommodate to the students emerging from the current GCE process” (Smith, 2004, p.95). An implication of this statement was that in the medium-term external actions, such as those recommended in the Inquiry’s report, would alleviate the mathematics problem. MSS has clearly become something more than short-term, but this does not remove the need for others to play their parts too. Many incoming undergraduates would benefit from being better mathematically prepared on entry to university, particularly by choosing to study some mathematics post-16. The mathematical demands of courses could be made more explicit to prospective students, although for universities this is double-edged. On the one hand, it might influence students in their choice of subjects at school so that more of them do study mathematics post-16; but on the other hand, it might deter potential applicants and make it harder for universities to recruit to certain subjects. Improved communication about the Mathematics Problem to teachers and parents, as well as applicants, could tend to push students to the former rather than the latter of these courses of action.

The authors of this chapter do not suggest that MSS should be introduced in every university. We believe that the need (or not) for MSS is dictated by local circumstances and that there should be very clear reasons for introducing MSS and such provision should have specific aims. As set out above, at universities throughout the UK, there is a very clear need brought about by the widespread underpreparedness of many undergraduate and postgraduate students for the mathematical demands of their courses.

There are those who would criticise the provision of MSS. Some suggest that “*We don’t have the kind of student who needs support at our institution*”. If this is the case, then we would agree that establishing MSS is not necessary. However, Mackenzie et al (2016), who interviewed senior managers from 23 institutions from across all sectors of UK higher education, found that in all institutions there was an awareness that there were many students who were struggling with the mathematical demands of their studies.

Others opine that “*If students do not know **that** [a piece of elementary mathematics], then they should not be at university*”. Whilst this may be their opinion, the reality is

that there are many students who are at university and who do not know “*that*”. MSS is about dealing with this reality.

Still others suggest that the provision of MSS is a collusion with the inappropriate school curriculum and those who teach badly in higher education; they suggest that if there was no MSS then something would have to be done to remedy these failings. The authors reply to this is that changing the school curriculum and improving poor teaching in higher education are laudable aims, but ones that will not be achieved quickly. As was quoted previously, the Smith Inquiry concluded “In the short-term, the Inquiry believes that Higher Education has little option but to accommodate to the students emerging from the current GCSE process” (Smith, 2004, p.95). In the meantime, there are students who are struggling and it is our belief that they should not be regarded as collateral damage in the process of bringing about larger-scale system change. Today’s students need help today, not an improved system in five or ten years’ time.

Finally, we would repeat the findings of Solomon et al (2011, p.580) quoted earlier that

they [support centres] lead ... to a shift in attitudes towards university mathematics as a community of enquiry as opposed to an individual performance-oriented pursuit.

This is surely something to be welcomed. This does not mean that MSS is a panacea, but the outcomes of MSS have benefitted hundreds of thousands of students worldwide over the last 25+ years and have led to MSS becoming firmly established in many HEIs around the world. All the indications are that it will remain so for many years to come.

NOTES

1. A-levels are national qualifications in the UK typically taken at age 18 ie at the end of secondary education. In the 1990s, these qualifications were graded A-E (pass grades), N (narrow fail), U (unclassified).
2. At this time, most students took GCE (General Certificate of Education) qualifications (most frequently A-levels) as a means of qualifying for entry into university.
3. These guides, and several others, are available from the **sigma** network website www.sigma-network.ac.uk.
4. CETL-MSOR = Continuing Excellence in Teaching and Learning in Mathematics, Statistics and Operational Research.
5. STEM = Science, Technology, Engineering and Mathematics.
6. See <https://www.birmingham.ac.uk/university/colleges/eps/STEM/National-HE-STEM-Programme/national-he-stem-programme.aspx> (Accessed 17 March 2019) for further details.
7. GCSE level is the qualification taken at age 16 ie at the end of compulsory education in mathematics.
8. ~~<https://www.lboro.ac.uk/departments/mcc/about/stakeholders-reports/> (Accessed 17 March 2019).~~

9-8. <https://www.officeforstudents.org.uk/advice-and-guidance/student-information-and-data/national-student-survey-nss/get-the-nss-data/> (Accessed 17 March 2019).

10-9. <https://www.hesa.ac.uk/support/documentation/jacs> (Accessed 17 March 2019).

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