centre for excellence
sigma Σ
in mathematics & statistics support

evaluation of mathematics support centres

a review of the literature

National HE STEM Programme

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Section 1:

Executive Summary

Mathematics Support Centres (MSCs) have been established at universities in the UK and in a number of other countries elsewhere such as Australia and Ireland. Their chief functions are to address issues surrounding the transition to university mathematics and to support students' learning of mathematics and statistics across the wide variety of undergraduate courses that require an understanding of mathematical concepts and techniques.

There is a growing body of research studies, which have looked into a number of areas such as: the establishment of a MSC; the usage of MSCs and mechanisms for recording usage data; feedback from students and staff and ways to collect this; effects on achievement, pass rates and retention rates; and the prevalence of MSCs in the higher education sector. More recently researchers have begun to examine the effects of MSCs on undergraduates' mathematics learning experiences and mathematical confidence, and to address issues concerning students who are 'at risk' or underachieving and not engaging with the facilities offered by their MSC.

This report reviews and synthesises all the available published research evidence so that informed decisions can be made about the value of mathematics support activity and the targeting of future funding. The literature reveals that:

- a number of studies have been conducted concerning the prevalence of mathematics support centres in the UK, Australia and Ireland. These indicate that mathematics support has grown over the years and is now universally adopted by nearly all universities which have programmes requiring mathematical, statistical or other quantitative elements.
- the evaluation of mathematics support centres is taking place. In its simplest form, this may consist only of usage statistics or a description of what a support centre may offer or activities that take place to support students.
- increasingly rigorous studies are being undertaken to show the impact of mathematics support. These studies show through both qualitative and quantitative analysis that students who access mathematics support benefit in terms of achievement and confidence in their studies. These benefits are demonstrated through an improvement in academic results and a positive impact on progression and retention.
- methods employed for evaluation include regression analysis, diagnostic testing to identify students who should be accessing mathematics support and subsequent follow-up, comparisons of pass and/or failure results over several academic years of groups of students including those who do not access support.
- the evaluation of mathematics support is particularly challenging. The literature reveals why this is the case and shows how mathematics support practitioners are responding to the difficulties.
- an on-going issue with mathematics support is the group of students who should be accessing support and do not. The literature shows that research is being undertaken to determine the barriers to accessing support in order that these may be addressed.

The report concludes by identifying areas where further research would be helpful.

Section 2:
Introduction

In the epilogue to the 2010 report *Responding to the Mathematics Problem: The Implementation of Institutional Support Mechanisms,* Kyle wrote:

> *"...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."*
> (Kyle, 2010, 104)

This observation reflected not only the growth in the number of mathematics support centres which have been established in higher education institutions both in the UK and in other parts of the world, but also that the community had begun to look into ways of measuring the effectiveness of mathematics support initiatives. Whilst there may have been some limited activity in the UK prior to 1990, it was during the period 1990 – 2010 when institutions publicly acknowledged that they had recruited many students onto mathematically demanding courses for which they, the students, were not well-prepared and moreover, that universities were taking steps to address the challenges for both students and staff which arose as a consequence. Seminal to this willingness to acknowledge and respond was the report *Measuring the Mathematics Problem* (2000) which reported that *"acute problems now confront those teaching mathematics and mathematics-based modules across the full range of [UK] universities"* and recommended that *"prompt and effective support should be available to students whose mathematical background is found wanting"* (Hawkes & Savage, 2000). Such support is often provided through mathematics support centres. Whilst the term 'mathematics support centre' encompasses a wide range of provision, it should be interpreted in this report to mean *'a facility offered to students (not necessarily of mathematics) which is in addition to their regular programme of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc.* (Lawson, Croft & Halpin, 2003). In different institutions, it is known by different names such as *Maths Drop-in, Mathematics Learning Support Centre, Maths Café, espressoMaths* and in most but not all, there is a physical space and resources provided to carry out the activities of the centre.

During this twenty year period, audits of provision have been carried out in the UK, Australia and in the Republic of Ireland (see Section 3), which substantiate the claims of substantial growth in activity. MacGillivray & Croft (2011) note that a recurring theme in the audits is that centres often exist precariously and lack security, often staffed by very willing, but part-time, fixed term or casual staff or postgraduate students. Although the audit of current provision in the UK (Perkin *et al*, 2012) found that the number of institutions offering some form of mathematics support had increased substantially, it also found a few instances of a reduction in mathematics support services in some UK universities due to restructuring of departments, retirement of key staff or insufficient funding. MacGillivray & Croft *(op cit)* emphasize the importance of collecting and analysing information to provide evidence of the contribution of support centres to improving student performance and reducing attrition. However, few centres have the resources to gather large quantities of data and some centres report that they do not have the expertise to analyse it. MacGillivray & Croft note that many who work in support centres do so in order to spend their time teaching and supporting students, not researching, analysing data and reporting findings. Data collection has often, for understandable reasons, been scant. Nevertheless, as this report will show, there are now examples of centres where effort has been expended on *systematically* gathering data, analysing it, and publishing findings. In the three parts of the world previously mentioned - the UK, Ireland and Australia - there are individuals and groups carrying out this activity. Evaluation and associated issues have been discussed at conferences, for example *CETL-MSOR* held annually in the UK and the *Irish Workshop on Mathematics Learning and Support Centres* organised annually by the Irish Mathematics Learning Support Network. Furthermore, we have found research about the effectiveness of mathematics support centres within postgraduate theses – Whitehead (1992), Perkin, (2007), Liston (2008), Symonds (2009) and Patel (2012).

In the UK, from 2005 – 2012, mathematics support was given additional momentum through national funding for **sigma** – a centre for excellence in mathematics and statistics support – based at Loughborough and Coventry Universities, and for the **sigma** network that acted to share practice, disseminate findings, and act as a stimulus to support activity in other institutions.

The original impetus for mathematics support was the recognition in the early 1990s that many students embarking upon mathematically-based university courses such as engineering and physical sciences were not sufficiently well-prepared. Furthermore, as a consequence of curriculum changes in 2000 (House of Commons Education and Skills Committee, 2003, 7) the number of students taking AS and A2 level mathematics dropped significantly as many found the transition from (the new) GCSE mathematics to AS/A2 too demanding (Porkess, 2003, 12). Following a further review the school

mathematics curriculum was revised and major national initiatives e.g. *Further Mathematics Network* (http://www.fmnetwork.org.uk), *More Maths Grads* (http://www.moremathsgrads.org.uk) were put in place to encourage more students to study mathematics post-16. By 2012 the numbers of students studying AS/A2 mathematics had recovered to pre-2000 levels (JCQ, 2001-2012), testament to the success of these initiatives. It might, therefore, be thought that the *'Mathematics Problem'* of 2000 has been solved and there is no longer a need for extensive provision of mathematics support at university level. Unfortunately, this is not the case. In June 2011, the Advisory Committee on Mathematics Education produced a report *Mathematical Needs – Mathematics in the workplace and in Higher Education* (ACME, 2011) which drew further attention to the difficulties faced by students on an exceptionally wide range of courses. The report states:

> *"We estimate that of those entering higher education in any year, some 330,000 would benefit from recent experience of studying some mathematics (including statistics) at a level beyond GCSE, but fewer than 125,000 have done so. This places those responsible for many university courses in an impossible position. They cannot require an appropriate level of mathematics of their applicants and hope to fill their places, and in many cases they are unable to design courses with the level of quantitative demand that would be appropriate for their disciplines."* (ACME, 2011, 1)

Increasingly, quantitative elements are found in a wide range of university courses, such as biological sciences, social sciences, business and nursing, and yet many students remain inadequately prepared. Even when students are not required to study mathematics as part of their higher education curriculum, challenges are faced by mature students or those taking employers' numeracy tests. These difficulties may be exacerbated by the fact that it may be some years since any form of mathematics was encountered particularly when the study of mathematics terminated at 16. Research (Hodgen *et al*, 2010) conducted by the Nuffield Foundation addressing participation in upper secondary mathematics in 24 countries, found that

> *"England, Wales and Northern Ireland recorded lower levels of participation in upper secondary mathematics education than any other country surveyed. They are the only countries in the survey in which 20% or fewer of upper secondary students study mathematics."* (Hodgen *et al*, 2010, 5)

The House of Lords Select Committee on Science and Technology report *Higher Education in Science, Technology, Engineering and Mathematics (STEM) Subjects (2012)* states that there is still evidence of a skills gap between the mathematical skills of students when they enter Higher Education and the mathematical skills needed for STEM first degrees (House of Lords Select Committee on Science and Technology, 2012, 15). In addition they report they had received evidence that graduates often lack the numeracy skills to succeed in the workplace.

To address these problems and their widening participation remit, many higher education institutions are expanding their mathematics support and citing this in their Access Agreements, which state how a university will provide fair access to lower income and under-represented groups following the introduction of higher tuition fees in 2006/7 (http://www.offa.org.uk). An example of this may be seen in the Access Agreement from the University of York.

> *"5.2 Maths Support Development*
>
> *The York Maths Skills Centre has been set up to provide University-wide support for elements of maths learning, independent of departments, but in conjunction with what departments already provide. A pilot programme providing support for first year students from subjects (in the sciences and economics) whose modules include, or require, elements of algebra and calculus, has been very well utilised and we are expanding this service to meet some additional areas of identified need. The successful establishment of the Mathematics Skills Centre to support students across a wide of range of disciplines was specifically identified as a 'Feature of Good Practice' for which the University was commended by the QAA in its very recent Institutional Review."* (Offa, 2012, 12-13)

Mathematics support in the UK is likely to remain part of the academic support landscape of higher education for the foreseeable future.

In the current financial climate many of the community wide sources of funding for mathematics support initiatives such as the National HE STEM programme have dried up and it is likely to be increasingly difficult to develop new centres or enhance existing provision. Consequently, it is very timely to take stock of the research evidence available that looks critically at provision and tries to measure its effects. The purpose of this report is therefore to review and synthesise all the available published research into the effectiveness of mathematics support activities to enable informed decisions to be made regarding the development of such services and the targeting of future funding.

> *"Although its punch can far outweigh its size, such learning support must not be "lost" within other frameworks even if it may be associated with them. It needs sufficient security to attract, train and retain staff, and to play its part in the on-going and longitudinal data collection and analysis that should be an integral part of its contribution to the university. All universities should ensure that such data collection and analysis are undertaken and performed correctly to provide vital information for university academic management. However, as reported, few of the facilities currently have the resources to undertake this important work."* (MacGillivray, 2008, 26)

This report will describe and discuss evidence of the evaluation of mathematics support centres in each of the following areas:

- the prevalence of mathematics learning support centres
- data collection for the evaluation of mathematics support, what mechanisms are used and the difficulties and challenges that are presented. This will include data for both quantitative and qualitative studies as well as information that is available to institutions and is in the public domain
- analysis of data that demonstrates mathematics support centre usage and activities
- the impact of mathematics support centres on students, staff and the institution.

The report will conclude by identifying areas where further research would be helpful.

Various acronyms are used throughout to refer to mathematics support centres – MSC (mathematics support centre), MLSC (mathematics learning support centre), MLC (mathematics learning centre). Many papers referenced are not specifically addressing the subject of evaluation of mathematics support but have elements that are of interest. A method of referencing has been adopted which points the reader to the relevant section or page in a paper where appropriate. In addition, literature has been omitted where the focus of the paper is the establishment of a MSC and the evaluation of facilities is not addressed. This report does not make any attempt to categorise particular studies in terms of their rigor, academic excellence or good practice. It does however seek to highlight elements of studies that would be useful to consider for the evaluation of the effectiveness and impact of mathematics support centres.

Although this report makes reference to aspects of the evaluation of mathematics support from a wide range of sources, the following studies, given in chronological order, are the principal sources of discussion of methods of evaluation of the effectiveness of mathematics support:

- *Action Research into Effective Student Support in Mathematics* (Challis *et al*, 2004). This report from a Conference Working Group considered how mathematics support may be evaluated and evolved a methodology incorporating all current forms of evaluation of mathematics support. The paper does not report on evaluation that has been conducted.
- *Measuring the effectiveness of a maths learning support centre – The Dublin City University experience* (Dowling & Nowlan, 2006). This study addressed the effectiveness of the Maths Learning Centre by studying usage statistics, student feedback, and pass rates of at-risk students comparing those who attended the centre with those who did not. The study found the Centre had made a positive contribution to student retention.
- *Investigation of completion rates of Engineering students* (Cuthbert & MacGillivray, 2007). This Australian study found that students who used optional support for first year engineering mathematics available through the QUT Maths Access Centre were twice as likely to complete their course as those who did not.
- *Justifying the Existence of Mathematics Learning Support: Measuring the Effectiveness of a Mathematics Learning Centre* (Gill & O'Donoghue, 2007). This study at the University of Limerick examines various ways of measuring effectiveness. The authors suggest metrics that may be used for evaluation namely student numbers/uptake, department and college participation, independent reviews, external department reviews, retention/grades, research output, development and expansion, associated projects, and links with other MLCs.
- *Mathematics Support – support for all?* (Pell & Croft, 2008). This study analyses data from first year engineering cohorts and seeks to differentiate between students who would have failed had they not accessed mathematics support, those who fail but do not access support and those competent frequent users who wish to do better. They propose a methodology for evaluating the effectiveness of mathematics support initiatives.
- *Towards a culture of data collection & analysis in mathematics support centres* (Croft, 2009). In this paper, Croft highlights the challenges in evaluating mathematics support such as: difficulties with funding resources for analysis; longitudinal studies being problematic due to evolving nature of university education such as changes in entry requirements; changes to syllabi and staffing; access to data such as prior qualifications. A classification is made of two types of evaluation – 'soft' measures such as usage data and feedback from students and 'hard' measures which are tangible measures of improvement in performance. The need for mathematics support providers to balance time and resources between student support and evaluation of services is emphasised.
- *The impact of the mathematics support centre on the grades of first year students at the National University of Ireland Maynooth* (Mac an Bhaird, Morgan & O'Shea, 2009). This study considers the influence of the Mathematics Support Centre on the grades of first year students who attended the centre. Students were identified as 'at-risk' from either their prior mathematics qualifications or a diagnostic test and the centre was found to have a positive influence on the most 'at-risk' students. It also found that a high percentage of this group do not attend the centre.
- *Learning support and students studying mathematics and statistics* (MacGillivray, 2009). This paper reports an overview of mathematics and statistics support in Australia including evaluation, which demonstrates the impact on grades and progression.
- *The Origins, Development and Evaluation of Mathematics Support Services* (Gill, Mac an Bhaird and Ní Fhloinn, 2010). This study addresses the development of the provision of mathematics support at third level (higher education) institutes in Ireland and discusses how these services are evaluated.

- *Evaluation of the University of Limerick Mathematics Learning Centre* (Carroll, 2011). This study sought to examine the impact of the mathematics learning centre on students' mathematics education and their attitudes to mathematics. The study obtained qualitative and quantitative data through questionnaires administered to past or current users of the centre.
- *Measuring the effectiveness of a mathematics support service: an email survey* (Gillard, Robathan & Wilson, 2011). This study incorporates data from responses to an email survey from 21 institutions – 19 UK universities, one Australian and one Irish. Information is provided on the nature of mathematics support provision with a focus on how universities measure the effectiveness of the support that is available, what techniques are used for evaluation, and offers opinion on what makes an effective MSC.
- *Understanding Evaluation of Learning Support in Mathematics and Statistics* (MacGillivray & Croft, 2011). Discussed here is the need for data collection and analysis set against the aims and objectives of mathematics support. A framework for evaluation is suggested.
- *An innovative approach to evaluating the University of Limerick's Mathematics Learning Centre* (Carroll & Gill, 2012). This paper reports analysis from the study conducted at the University of Limerick. Findings reveal positive indicators that demonstrate that the MLC improved students' confidence, attitudes, study habits and affected retention.

This report will now consider research evidencing the prevalence of mathematics support (Section 3), definition of mathematics support centres (Section 4) followed by data collection (Section 5) and analysis for evaluation (Section 6). Further research that may be desirable is identified in Section 7.

Section 3:

The prevalence of mathematics support centres

A number of studies have been conducted over the years to determine the prevalence of mathematics support both in the UK and elsewhere. The interpretation of exactly what constitutes mathematics support and whether this takes place in a mathematics support centre is not always clear. In earlier studies, the use of the term 'drop-in workshop' has been assumed to indicate the existence of a MSC. Clearly this will not always be valid as 'drop-in' support may indicate the possibility of a student visiting a lecturer during office hours or prior to examinations and not the establishment of a MSC. Some studies have been more extensive and have tried to capture the nature of mathematics support. As technology has evolved, the method of capturing the data has moved from postal and telephone surveys to email questionnaires. Some of the early studies included further as well as higher education institutions. Chronologically, the studies are:

- *Maths Support Survey: An Examination of Maths Support in Further and Higher Education* (Beveridge & Bhanot, 1994). A questionnaire was sent to 800 further and higher education institutions in the UK to ascertain practice in mathematics support. All responding institutions (142 replies HE(42), FE(100)) had some form of mathematics support and 76% offered drop-in workshops.
- *SURVEY: Learning Support for Mathematics in FE and HE* (Beveridge, 1997). A second UK survey was conducted in 1996 which canvassed all institutions from each of the following groups: traditional university, new university and HE colleges together with a random sample of FE colleges which had mathematics departments. The initial survey was by telephone to determine the person responsible for mathematics support or the Head of Mathematics. This was followed up by a postal survey, which was in turn followed by a telephone survey to 80% of the sample group. 200 responses were received out of 201 institutions with 56% (111) offering drop-in workshops.
- *A Tale of Two Surveys* (Beveridge, 1999). A third UK survey was conducted in 1999 on the support needs of lecturers delivering mathematics as a service subject in HE and all parts of FE. Comparison was made to the 1996 survey but no methodology was given and there is no indication of the number of HE and FE institutions surveyed. It shows 77% of responding institutions offering drop-in support in 1999 and 56% in 1996.
- *Undergraduate Mathematics and the Role of Mathematics Learning Support* (Taylor, 1999). Mathematics support was examined in Australia. A review of accessible university websites was conducted to seek evidence of the existence of mathematics support initiatives. This showed that 46% of Australian universities offered drop-in support (data based on a sample size of 26). The paper also refers to a 'proliferation' of learning centres in1994 that were staffed by mathematics/ statistics experts.
- *After the diagnostic test: What next? Evaluating and enhancing the effectiveness of mathematics support centres* (Lawson, Halpin & Croft, 2001). In 2001 an email and online questionnaire followed up by a telephone interview was used to survey the extent and nature of mathematics support centre provision at all UK universities. 95 institutions responded and eight were visited to conduct interviews with three groups – students who used the centre, students who did not use the centre and staff who tutored in them. 48% (46) of institutions who completed the survey had support provision.
- *Mathematics Support Centres – the extent of current provision* (Perkin & Croft, 2004). In 2004, 106 universities in the UK were surveyed and 95.3% responded. Web sites were trawled for evidence of mathematics support and, where none was found, contact was made by email to the Head of Mathematics, Heads of Engineering/Computing/Business or central support staff. 62.3% (66) offered some form of support, 33% (35) did not with 4.7% (5) not responding.
- *An Audit of Mathematical Support Provisions in Irish Third Level Institutes* (Gill, O'Donoghue & Johnson, 2008). CEMTL, the Regional Centre for Excellence in Mathematics Teaching and Learning conducted an audit of 13 mathematics support centres across the Republic of Ireland examining the nature of the provision, institutional support, resources used and challenges. Drop-in clinics were provided by all but one institution. In addition Centres reported on their measures of success and recordkeeping.

- *Learning Support in mathematics and statistics in Australian Universities: A guide for the university sector* (MacGillivray, 2008). In 2007, a study (ALTC – funded leadership project "Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian Universities") into the nature of learning support in Australian universities identified that 33 out of 39 (85%) had some form of mathematics support. Information was obtained through a combination of searches, phone interviews, surveys and direct input at the Delta Symposium in 2007 as part of the study.
- *Mathematics Learning Support in Higher Education: the extent of current provision in 2012* (Perkin *et al*, 2012). The email study conducted by Perkin & Croft in 2004 was updated in 2012. 119 UK universities were contacted by email and 88 (85% of the 103 who responded) have some form of mathematics support.

Section 4:

Aims and objectives of a mathematics support centre

Whilst a definition of mathematics learning support centres has already been given above for the purposes of determining what literature has been considered for inclusion in this report, a more detailed examination is useful as a backdrop for thinking about what data collection and analysis may or should take place. As may be seen from some of the statements below, the aims and objectives of individual centres, whilst broadly similar, differ in the detail.

> *"The primary objective of the Mathematics Learning Support Centre (MLSC) is to raise the level of student proficiency in the use of basic mathematical skills. Success in achieving this objective will help reduce student wastage rates and enable students to achieve better grades on their undergraduate programme."* (Patel, 1998, 1)

> *"To contribute to learning in mathematics by the provision of support, the creation of opportunities and the understanding of research to increase positive outcomes in student learning."* (Central Queensland University) (Taylor, 1999, 3)

> *"To develop and provide academic programs and resources to enhance learner independence."* (The University of Southern Queensland) (ibid)

The operational objectives of the Queensland University of Technology's Maths Access Centre (QUTMAC) go beyond day to day student support.

- *"Support for skills and understanding, and in developing student confidence and lifelong learning across all mathematics and statistics service and core units*
- *Provision and fostering of an environment of partnership and openness in mathematical learning – within and between all student cohorts and staff"* (Cuthbert & MacGillivray, 2007, 2)

In their UK-based study, examining mathematics support across a number of institutions, Lawson *et al* (2001) found that the aims of many institutions were similar and the differences related more to who was permitted to access the support.

> *"'To provide non-judgmental support for students outside their teaching departments.'*

> *'To ease the transition of all students to HE courses with a significant numerate component.'*

> *'To provide a GP surgery for any type of difficulty in mathematics or statistics.'*

> *'To provide one to one support for any member of the University with mathematics difficulties no matter how small.'*

> *'To offer extra help (i.e. outside formal classes) for any student taking any maths module.'"* (Lawson *et al*, 2001, 20)

They reported one case where the aim was somewhat different

> *"To provide a pleasant environment where students can work, study and support each other."* (ibid)

Taylor (1999) concurs with Lawson *et al* saying

> *"The specific aims of mathematics learning support differ between universities but the essence is the same.* (Taylor, 1999, 214)

In addition to aims relating to student learning support, the aims of the Maths Support Service (MSS) at Cardiff University include:

> *"To monitor the provision of mathematical support across UK institutions, endeavour to apply examples of good practice and develop innovative approaches to further enhance the service provided."* (Wilson & Gillard, 2008, 95)

Clearly when examining the evaluation of mathematics support, the individual aims and objectives of centres will need to be considered. An example relating to usage statistics is useful. Many authors show high usage of their centres as evidence of success of their mathematics support. In contrast an aim of the mathematics support at St Andrews is to seek to resolve students' difficulties in one appointment as much as possible.

> *"In the drop-in model students can effectively set up their own study groups whereby clusters of them taking the same course regularly congregate and work through tutorial sheets together, ironing out queries both amongst themselves and with the help of staff working in the Centre. For these models, a measure of success is the number of repeat visits by each student. By way of contrast, a measure of success for the appointment-based model is how quickly the tutor is able to "clear" the problem encountered by the student: this corresponds to a low average number of visits per student, at least in a given time period... Surprisingly, records over the first two years have indicated that, on average (and with a very long tail!), we are able to clear problems within one or two sessions demonstrating that the one-to-one model is, in fact, both cost-effective and time-efficient."* (Marr, 2010, 24-25)

In this case, a low number of repeat visits would possibly be an indication of success of the mathematics support services.

Section 5:

Evaluation of mathematics support centres

In order to show evidence of the effectiveness of mathematics support centres, studies have considered their impact on different areas and stakeholders. Gillard *et al* (2011) write

> *"When considering the effectiveness of such services we might consider the following three groups, each of which have their own set of (not necessarily distinct) measures, considerations and perspectives. These are:*
>
> - *the student requiring the support;*
> - *the centres providing the support; and*
> - *the governing institution."*
>
> (Gillard *et al*, 2011,44)

Evaluation to support or justify the activities of a mathematics support centre will need to consider the services provided from the viewpoints of the different stakeholders. For example, students may avail themselves of mathematics support to gain understanding during their course and/or knowledge and confidence for examinations and future employment. The mathematics support centre will be interested in the success of their support, the marketing of their services, the availability of support, the resources they use or provide, staffing and methods of delivery. The governing institution may be seeking to justify funding, establish direct academic impact, and assess the effect of mathematics support on the retention of students. Those engaging in evaluation must therefore determine what evidence will show that the mathematics support provided by the mathematics support centre contributed to any of these.

Whitehead (1992, 158) suggests that the reasons for evaluation include enabling *"decisions for course improvement, decisions about individuals, decisions as part of administrative regulations – accountability and cost effective components, appraisal of value."*

In an Australian context Taylor (1999) provides an example where staff conducting the evaluation, are developing systems to address both the student and the institution perspective.

> *"Staff have developed a framework that allows both student centred and institutional perspectives to be considered in the development of a program. This framework involves the ranking of programs on a bivariate continuum which looks at program development from a student's and the institution perspective. This framework is still evolving but tries to consider the fact that just because a strategy involves a short contact with a student, as might occur in a Drop-in Centre, this does not mean that from a student's perspective they have not had a successful outcome. Student and institutional measures of success are often different."*
> (Taylor, 1999, 215)

The studies described in this report seek to evaluate mathematics support from the perspective of one or more of the stakeholder groups. Other considerations may also be included.

It is evident from the literature that those conducting the evaluations are aware of the need for rigorous evidence-based research, for example

> *"Continuous and thorough evaluations of mathematics support services is of critical importance to the establishment of best practice and the maintenance of these services for the students who need them."*
> (Gill, Mac an Bhaird & Ní Fhloinn, 2010, 56-57)

However such evaluations may be problematic. Whitehead (1992,163) highlights two issues – timing of evaluation and the voluntary nature of participation. She explains that whilst the aims of mathematics support may be long term, evaluation after a short space of time may fail to show effects which are significant at a later date. In addition, students choose whether to avail themselves of support and the extent to which they will engage with the support offered. In discussing the analysis of data relating to improved module passes, Patel & Little (2006) point to potential bias in the data,

> *"There are two possible sources of bias here arising from the voluntary nature of mathematics study support: weak students seeking help to pass (by far the majority) and strong students wishing to get the best possible grade (a small minority)."* (Patel & Little, 2006,133)

The papers referenced here will show that even when studies are able to demonstrate that students who use mathematics support centres outperform those who do not, it is often not possible to prove that the improvement is due to the activities of the centre.

> *"Some institutions have tried to analyse the performance of regular centre users and compare them to the overall student body or to groups with similar entry qualifications who do not use the centre. Such comparisons usually show that regular users perform significantly better overall than the non-users. However, even where these data exist it is not conclusive that the centre has made the difference. It can be argued that regular users are better motivated students who would have found another source of help had the centre not existed."* (Lawson, Croft & Halpin, 2003, 17)

Taylor (1999) highlights another issue which relates to the publication of evidence of the impact of mathematics support. When evaluation is conducted, it is important that this work is published such that all stakeholders are aware of the evidence – the students who may access the support, staff in the institution and the governing institution.

> *"Once the pitfalls of evaluation have been overcome then promotion is the next step. It is not unusual to discover that members of the mathematics departments know little or nothing about the mathematics support programs that operate in their universities, especially if they are outside that department. Management often know even less, even though issues of student retention are receiving high profile in senior management circles. The needs of students drive mathematics support staff but in the long term we can only help those students by arming ourselves with convincing evaluation and research publications."* (Taylor, 1999, 217)

There is clearly agreement that evaluation of mathematics support centres needs to take place. Ní Fhloinn (2009) describes the type of analysis that may take place through both quantitative and qualitative studies:

> *"Evaluating mathematics support is challenging and a multi-faceted approach is undoubtedly the most accurate means of doing so. A combination of quantitative data, based on detailed records maintained by the MLC, with qualitative data from an anonymous student questionnaire provides valuable insight into the daily operation of the centre and possible improvements that are needed. In addition to this, anecdotal evidence is also important, such as that gathered by regular communication with tutors working in the MLC, and discussion with students who use the service, as well as observations of the director, who works regularly in the centre."* (Ní Fhloinn, 2009, 98)

Many studies reflect these two types of data collection. Quantitative usage data which as Croft (2009, 7) says, are relatively easy to collect and analyse and, over a period of time, will show trends and indicate a measure of demand. He continues that this type of data however, does not show what goes on in a centre, provide insights into the quality of teaching and learning, measure student gain or performance improvement. Further distinction is made between evaluation using hard measures, which include tangible objective improvements in performance such as improved grades and retention and soft measures, which provide usage data and feedback from students. Croft (2009, 5) guards against overvaluing feedback as students will always be happy to receive one-one support.

Some studies also refer to the costs and time requirement of collecting and analysing data. Institutional resources need to be made available for this to happen. Dowling & Nolan (2006) comment that it was the appointment of a full-time member of staff in the support centre that enabled a large-scale data collection and analysis study.

> *"The presence of a whole-time Manager in the MLC has enabled the collection and analysis of data on first year mathematics in DCU on a scale not possible before."* (Dowling & Nolan, 2006, 54)

This report will now consider evidence of data collection firstly for usage statistics and secondly for feedback from students, tutors and other interested parties. Analysis of this data for the purposes of demonstrating effectiveness and impact will be considered in section 6.

5.1 Mechanisms of data collection for usage statistics

Most mathematics support centres are interested in knowing who uses their facilities and how often. Almost all studies refer to usage data. Systems for collecting and recording this data range from simple manual systems to those that incorporate automatic scanning technology, which over the years has reduced in cost and become more accessible.

As the following references show, data collected focus on details relating to the users of the centre, the support delivered and the activities conducted in the centre. Some writers report administrative problems with data collection and how they were addressed. Some institutions collect data on how users learnt about the mathematics support centre to inform their publicity strategies. There is little point in a mathematics support centre if potential users are unaware of its provision and, as these studies will show, one of the on-going issues with mathematics support provision is that there is a significant group of students who could be availing themselves of mathematics support, but do not.

The mathematics learning support centre (MLSC) at Loughborough University was operational from October 1996. Students were encouraged to sign a logbook recording the nature of their difficulty and the facilities that they used (Croft, 1997, 16). By 1998/9 students signed a register detailing name, date of visit, unique student identifier, program of study and whether this is the first or a subsequent visit. Once a week secretarial staff updated an Excel spread-sheet containing data fields such as name, ID, programme code and dates of visits. Croft (2000, 440) later reported that a swipe card system had been considered but was rejected on expense grounds. It is however now in use.

Ní Fhloinn (2009, 95) describes the system at Dublin City University (DCU). A card reader was trialled to monitor attendance but found not to be viable as students did not always remember to bring their ID card. In contrast DCU found the form-filling approach has unforeseen advantages, in that it provides the newly-arrived student with something to do when they first arrive in the centre, allowing the tutor to engage briefly with the student, while continuing to work with those already present. At the start of the first visit, students complete a registration form containing the student's name, student number, mathematics module and course and how they found out about the service. At each visit, the tutor records the tutor name, the date, and time of

arrival and departure of the student. Data are input by the director of the MSC into a database.

Woodhouse (2004, 3) reports that an Excel database was initially set up at Nottingham Trent University to record for each visitor their name and student ID number, course and year, date and time of visit, area of mathematics enquiry. It was difficult to implement a computer-based system so the mathematics support tutor asked for name and course, and detailed records were completed by them at the end of the session.

At the University of Limerick, Gill & O'Donoghue (2007, 3-4) report that all students that attend the support centre sign a register with the date, their name and student identification number, degree programme and the mathematics module that they are seeking advice for. This information is later entered onto an Excel spread sheet to enable analysis.

Lawson *et al* (2003) state that *"counting return visits, rather than just the number of visits, adds a little sophistication to this measure as students who return are demonstrating that they gained enough from their first visit to regard a second visit as worth making."* (Lawson, Croft & Halpin, 2003, 18).

In MacGillivray's study (2009, 463-464), QUTMAC (Australia) endeavours to collect quantitative data and maintain a database of usage statistics. Drop-in visits are recorded through students signing in and out by course and time anonymously. The duty tutor records show course and topic of enquiry.

EspressoMaths at the University of the West of England (UWE) operates a one-to-one mathematics support drop-by service. Henderson & Swift (2011,13) describe that data are collected through tutors completing a daily log via a website recording the way in which the drop-by station is being utilised.

At Robert Gordon University, Patel (1998) wrote that the MLSC collected data on the usage of different facilities available in the centre such as tutor contact hours, computer usage, video usage and study area usage. A comment was made that the records on study area usage were not as accurate as they would have wished, as it was difficult to capture this information. Others also report some data are difficult to collect. Croft (1997,15) mentions that there is no way of knowing which groups of students have availed themselves of the freely available literature resources.

Whitehead (1992,150) reported on the setting up of the BP Mathematics Centre at Coventry University in 1990. Students utilised a Visitors Book recording their course and purpose of their visit. This information was considered insufficient to monitor specific courses by individual students in order to predict the nature of enquiries for the preparation of learning materials. Consequently a more detailed student record was set up with name, course, year, diagnostic test result, first and subsequent visit dates, purpose of visit, tutor initials.

In summary both manual and computerised records are kept. Data may initially be collected manually and then entered into a database for later analysis. Depending on the details held (and this varies from institution to institution), it may be possible to determine

- which individual students are using the mathematics support service, and which departments/schools they are registered with
- which modules and areas of mathematics they are requiring help with
- how often they attend, for how long and when
- what are the busiest times
- which tutors are supporting which students, modules, departments and topics
- what queries are being addressed
- what other equipment or resources are being used or are needed

As Lowndes (2003, 21) says, it is important to keep a log of student participation. Individual names are not required, but the numbers attending and from which programmes together with the specific topic/area of advice are needed as this information can usefully enable further help sessions to be organised, may assist in decisions as to appropriate staffing of the clinic and can provide important feedback to module leaders/teams with respect to appropriateness of module content or their expectations of prerequisite knowledge. Ní Fhloinn (2009, 95) points out the advantage of additional detail. If student details are retained, it will be possible to monitor student attendance patterns and will enable the performance of students who attend to be monitored.

Studies evidencing analysis from these data will be discussed in section 6.

5.2 Collecting data through questionnaires, focus groups and interviews

Whilst usage data may show who is using a mathematics support centre and what topics are being discussed, they will not give any indication of the quality or success of this support or the student experience or expectations. A number of institutions collect feedback continuously and others at regular intervals. Studies have been conducted that employ various instruments such as questionnaires, face-to-face-interviews, observations of students and focus groups. Opinion is sought from several sources including regular users of mathematics support centres, all students studying modules with mathematics content including non-users, mathematics support tutors and module lecturers. A guide, *gathering student feedback on mathematics and statistics support provision – a guide for those running mathematics support centres* (Green, 2012) has been produced by **sigma** offering advice on seeking student opinion on mathematics and statistics support provision. Green discusses all aspects of student feedback and sample

questionnaires are provided from ten universities. Studies that utilise these methods are referenced in this section.

The Lawson *et al* (2001) survey on the prevalence of mathematics support in the UK sought to determine how student feedback was obtained. A variety of methods were reported *(ibid, 22)* including informal conversations between students and support centre staff. Formal processes included questions on module feedback questionnaires, voluntary comment cards and discussions at staff student consultative committees.

Croft (2000) describes a system for user feedback at Loughborough University where students are invited to complete a 'Comment Card', which is deposited in a posting box in the MLSC. The card contains the following questions:

> *"Do you find that the Centre is a useful resource?*
>
> *Which facilities have you found most useful?*
>
> *How did you learn about the Centre?*
>
> *Would you recommend the Centre to a friend? If not, say why not?*
>
> *Do you think that the Centre has contributed to or will contribute to your success at university? If so how?*
>
> *Were there any aspects of the Centre you found unsatisfactory?*
>
> *Please feel free to suggest any improvements to the service or facilities available."* (Croft, 2000, 442)

No details were provided in this paper on the number of responses compared to the number of students supported but no adverse comments were received.

At De Montfort University, student feedback is collected via comments each session and anecdotal evidence is recorded.

> *"Every student who attends the drop-in is asked to 'sign the attendance book' and comment, briefly on the support received. …. "We receive anecdotal evidence of the success of our work from students who return to thank us…"* (Wright, 2003, 11)

Student questionnaires are the most common method of data collection for detailed evaluation of the support centre experience. They are usually distributed only to students using the service, which as Lawson *et al* (2003) write is problematic.

> *"Although this gives some useful feedback the sample (of the whole student body) is biased to those who already value the centre."* (Lawson *et al*, 2003, 17)

To address this bias and to determine reasons for non-attendance, some institutions target whole student cohorts. Dowling & Nolan (2006, 53) describe that the MLC at Dublin City University developed a detailed questionnaire, sent to all 'target students', which were all students from first year service modules, at the end of two academic years (04/05 and 05/06). Students had to indicate their agreement with a number of statements on a 5 point Likert-scale.

Woodhouse (2004) reported that at Nottingham Trent University, feedback sheets were sent to all students at the end of year via lecturers and to course tutors to ask about the service provided by the Maths Support Centre. Questions related to awareness of the MSC, the means of communication about the Centre, satisfaction with support and reasons for non-use.

For the evaluation of the *espressoMaths* drop-by station, Henderson & Swift (2011, 13) write that UWE sent an email questionnaire in 2010 to all 2008-2010 drop-by station users for whom they had email addresses. The response rate was low but feedback was considered to be useful enough to repeat the exercise the following year.

In addition to surveys, some studies have included student interviews to obtain in-depth data. Dowling & Nolan (2006, 53) report that the manager of the MLC at Dublin City University conducted structured interviews with a number of students who visited the MLC regularly in May 05 and May 06.

Parsons (2008, 31) described several methods of collecting student feedback that have been used at Harper Adams University College during a period of six academic years. This encompassed questionnaires to supported students, email questionnaires to the whole student body, a large survey into teaching and learning of mathematics which included questions on mathematics support, and student comments on mathematics support from central college monitoring. Response rates to the email questionnaire to the whole student body were low, however they were representative of the modules for which support was given.

Although detailed usage records are maintained at DCU, Ní Fhloinn' s study (2009, 95-96) reports that an anonymous questionnaire on attitudes to and opinions on the MLC is sent towards the end of the academic year to first year service mathematics students. This usually elicits around 450 responses, half of whom use the MLC. The questionnaire contains 20 questions, which are a mixture of Likert items and open-ended questions examining for example satisfactory aspects and reasons for non-attendance.

To determine if the MASH (mathematics and statistics drop-in) support at the University of Sheffield is effective and to understand both usage and non-usage, a survey was sent to all students in ten departments whose students had availed themselves of mathematics support. Patel & Rossiter (2009, 100-102) reported that of the 183 responses received, 144 students had not made use of MASH. The number of responses was considered significant enough to provide meaningful evaluation data. The survey contained a mixture of open questions and Likert items and examined usage of the centre, the student's perception of the impact of the support on their studies and confidence and the reasons for non-engagement from non-users of the service.

In the study at the University of Limerick, Carroll (2011, Chapter 3) designed a student questionnaire which contained different types of questions (Likert scale, closed and open) and generated both qualitative and quantitative

data to examine impact on students' mathematics education and students' attitudes to mathematics. It was administered to 124 students who were using the centre currently or had in the past.

A study (Nzekwe-Excel, 2010) was conducted at Aston University to review the role and impact of the mathematics learning development centre. Nzekwe-Excel reported that in the academic year 2008/09, 35% (3415) of the student body attended the Mathematics Support Centre (*ibid*, 6). A questionnaire was distributed to all registered students in 2008/09 (9663) via email and received a 4% (377) response rate. Four of the questions that were asked related to perceptions of the MSC and how it contributed to students' personal development.

To obtain insights into the differences between student and tutor perceptions of mathematical difficulties and mathematics learning support, a study (Perkin *et al*, 2007, 48-52) was conducted at Loughborough University. Data were collected from both students and tutors through an in-depth survey which was given to students who frequently used the MLSC (n=37) and academic and academic related staff (n=33) who work there. The surveys were designed to obtain differences in perceptions of mathematical difficulties, contained a large number of questions (53 and 63 respectively) covering personal details, general questions, reasons for having a MLSC, future expansion and development of the MLSC, suggestions, and examined why students accessed support through the MLSC.

Lawson *et al* (2001) point to the value of academic staff feedback. Staff respondents were asked to identify good factors of their mathematics support and barriers to its success. The main barrier was students' reluctance to take up support when needed.

> *"Solicited and unsolicited comments from academic staff particularly in non-mathematics departments can give an indication of the value of the support centre."* (Lawson, Croft & Halpin, 2001, 23)

Patel & Little (2006) made use of tutor-maintained teaching logs, which contained session topics and descriptions of successes, failures and remedies. These were used to develop teaching practice.

> *"Thus teaching practice is honed to a set of fit-for-purpose approaches, each specific to individual or small group student needs and/or particular maths modules."* (Patel & Little, 2006, 136)

In two papers on scholarship in mathematics support services, Samuels & Patel (2008, 54; 2010, 12-13) discuss evidence of the use of reflective teaching logs from mathematics support tutorials as an invaluable tool for developing teaching strategies.

Few studies have been conducted that examine the nature of mathematics support across a range of universities. However Mac an Bhaird *et al* (2011, 51.12) report the development of a questionnaire by the Irish Maths Support Network, which was piloted to students from six Irish Universities in 2009-10. The paper based questionnaire was sent to 22 higher education (third level) institutions during the second semester of 2010/11. Data from nine institutions which participated are being analysed and will be published in due course.

In summary, it is considered important by many mathematics support centres to obtain feedback from users and deliverers on the services that are provided. Usage data alone do not provide sufficient information to discern how students are making use of the centre or what impact it has made on their studies. Insights into the student experience of mathematics support centres is obtained in the following ways:

- informal discussion with users and tutors – anecdotal evidence
- comments collected when students access support
- questionnaires ranging from simple to in-depth, distributed to both users of centres or all students in a year group. These are administered at various times, often at the end of academic years – on paper or by email
- structured student interviews
- observations of students using the centre
- surveys and informal discussion with academic staff who may or may not work in the centre
- tutor logs

In addition, data are sought from non-users of centres to gain further insights into mathematics support centres, mathematical difficulties and reasons for non-use.

5.3 Challenges to collecting data to evaluate mathematics support centres

Described above are a number of studies that have collected both qualitative and quantitative data to evidence and evaluate mathematics support. Some studies report challenges that were encountered. This section draws attention to these difficulties.

It would appear that usage statistics may be under-reported. Croft (1997, 16) mentions that although students using the MLSC were encouraged to sign a log book, on a small number of occasions students preferred not to sign in. The issue would seem to be on-going as he later stated that:

> *"These numbers underestimate true usage because students do not always remember to sign in or to give their department/programme."* (Croft, 2000, 440)

Likewise MacGillivray (2009) reports that the nature of providing mathematics support is not always conducive to statistics gathering.

> *"Because all records (students signing in) are voluntary, they tend to underestimate usage. As support sessions are informal and friendly and sometimes lively, staff*

often forget to keep a roll." (MacGillivray 2009, 464)

Woodhouse (2004, 3) reports that at Nottingham Trent University, a computerised logging in system impeded the friendly informality needed to get students to use the centre so manual records were taken and entered later by support staff.

Parsons (2008) comments on difficulties when obtaining student feedback.

> *"A difficulty with this approach lay in not knowing the most suitable time to administer a questionnaire (e.g. not knowing when was the last occasion you saw a student)".* (Parsons, 2008, 31)

She also felt students may have been inhibited in their responses by the lack of anonymity and presence of the tutor.

Ni Fhloinn (2009, 97) reports on the need to correlate qualitative data from student surveys with usage data as responses to feedback do not always tally. The example given shows more students reporting attendance than support centre records of attendance.

Croft (1997) says that it is not always possible to quantify aspects of mathematics support such as the use of resources.

> *"There was no way of knowing how many students availed themselves of free mathematics support leaflets placed in the support centre, library or careers service or from which department they came."* (Croft, 1997, 16)

In addition it is difficult to ascertain how a student uses these resources outside of the mathematics support centre and for how long.

Data for comparative studies are often problematic. Croft (2009, 4) reports that there are often difficulties in obtaining data as departments are reluctant to provide such information or the university does not collect the data that are required. So for example it is often impossible to correlate data with prior qualifications.

In discussing longitudinal studies, Croft (*ibid*, 5) comments that there are difficulties in obtaining comparative data due to the nature of higher education with significant changes year on year. Examples given were changes in entry requirements, changes to lecturing staff, and the students themselves. Students have different degrees of motivation and different visiting rates, all of which make it difficult to set up control groups.

As Gill & O'Donoghue (2007) say *"it is impossible to state that the Mathematics Learning Centre is the sole intervention which improves mathematics grades in the university. However positive outcomes are indications of a job well done."* (Gill & O'Donoghue, 2007, 11).

They provide a list of achievements that may be viewed as success factors.

Ahmed & Love (2010) find it impossible to draw meaningful conclusions in spite of reporting an increase in pass rates over the last six years and an increase in mathematics support attendance as the range of factors that influence examination results both positively and negatively are too numerous.

Reporting on the Remedial Mathematics Facility (RMF) at Queensland Institute of Technology in Australia, Hubbard (1986) describes the Annual Report where analysis is given of the performance of groups of students who did or did not make use of the facility.

> *"This kind of analysis is difficult because of the number of unknown factors in determining examination performance."* (Hubbard, 1986, 250)

Hubbard also mentions that as a centre develops, the nature of evaluation changes making early evaluations less valid.

In relation to pass rates, Lawson (2001) writes of the difficulties in comparing evaluations.

> *"However the effect of a support centre on failure rates is very difficult to measure. In the first few years of provision it may be possible to compare pass rates with those when no centre existed; but when a centre has been established for several years it is very difficult to prove that pass rates would be lower if it did not exist."* (Lawson, 2001, 23)

A final issue relates to time in respect of data collection and analysis.

> *"With finite resources, there is always a balance to be met between the amount of effort expended on first-line support and effort expended on data collection and analysis."* (Pell and Croft, 2008, 169)

It will be seen however in section 6 that in spite of these difficulties, the mathematics support community has been able to assess the impact and effectiveness of their mathematics support through rigorous evaluation.

5.4 Evidence from internal and external reports

Several studies refer to the use of external evaluations and reports as a source of data to demonstrate impact of mathematics support centres. An example given by Croft (2000, 442) is the External Subject Review (formerly Teaching Quality Assessment and now Institutional Audit carried out by the QAA) where reviewers have specific obligations to look at the quality of student support. He states that this evidence should be collected and summarised periodically. Croft (2009, 7) gives student comments on mathematics support in the National Student Survey as another example of a source of data which could be trawled for comments to evidence the impact of mathematics support.

Parsons (2005, 4) at Harper Adams University College reports the use of engineering mathematics external examiner reports for this purpose.

Another example is given by Gill and O'Donoghue (2007, 7) who cite evidence of the recognition of the role of the Centre in the Quality Review as encouraging future funding of the Centre by the Institution.

Lawson *et al* (2001) mention that a number of institutions in their study referred to these comments. *"A number of institutions mentioned comments in reports from organisations such as QAA and Professional Body Accreditation Panels as indications of their success."* (Lawson, Halpin & Croft, 2001, 22)

Internal reports may also provide useful sources of data. Croft (2000, 443) gives the example of minutes from student representative boards, which may record comments from students on the experience of the Mathematics Learning Support Centre.

Although evaluation of this nature is not conducted by mathematics support centre staff, research to provide evidence of the impact of a MSC often refers to external reports particularly as statements are independent of the providers of the MSC service. Comments on MSCs in reports are used to demonstrate the impact of mathematics support centres on students and institutions.

Section 6:
Analysis

The previous section showed ways in which data are collected for the evaluation of mathematics support. Many studies show examples where data have been analysed to evidence the use and impact of mathematics support.

6.1 Evidence of analysis to show mathematics support centre usage

Section 5.1 described mechanisms for collecting quantitative data to demonstrate the usage of a mathematics support centre. This section shows how usage data have been used to demonstrate the importance and impact of mathematics support.

MacGillivray & Croft (2011) claim that as mathematics learning support is optional, usage data provide evidence that students and staff value the provision. *"The fact that they come or seek advice is a measure of the extent of their needs and their perception that the learning support can help them."* MacGillivray & Croft (2011, 197).

The full extent of student need may be understated though as it is known that many students who would benefit from support do not access it. MacGillivray & Croft maintain also that continued use of mathematics learning support programs is a measure of student engagement.

Many studies show that data are used to evidence the numbers of students that attend in a given period, for example per academic year. This measure is extended to show the number of student visits by period. Comparisons are made to show trends year on year. An example of this is given by Croft (2000).

> *"A measure of success is the number of students who make repeated visits over time – such students must be finding the support helpful."* (Croft, 2000, 440-441)

Booth (2003) uses attendance data to show success of the mathematics support centre. *"The success of the Centre can be measured by the amount it is used, which is significant. As time has progressed the Centre has grown from a small room used occasionally by a handful of students to the significant facility it is now with over 18000 student study visits and a further 12000 shop-visits each year."* (Booth, 2003, 17)

Woodhouse (2004, 3) also looked at the distribution of visits made by students by week (1, 2-4, 5-9, 10-14, 15+) and the number of all visits by week compared to the number of first visits by week. This demonstrated that visits were assessment driven. Comparisons were made by year and by department.

Dowling & Nolan (2006, 52) made use of comparative student visit data to determine the impact of mathematics support on target students (students recommended to attend mathematics support) and at-risk students (students identified as having mathematical difficulties).

In Patel's study (1998, 1), usage data are analysed to show usage patterns along with details of which student groups used the mathematics support centre and in which ways. The usage in hours of the MSC is analysed to obtain a usage for each resource – tutor, computer, video and study area.

Croft (2000, 440-441) reports data that were analysed to show total number of student visits, total number of students supported, number of students supported by programme, and the number of students supported by faculty. The latter could have funding implications as it would be possible to allocate costs in proportion to usage.

Staddon & Newman (2003) report that the collection of this type of data may help justify future funding. *"The Centre has attracted more users every year, and careful record keeping has strengthened requests for extra resourcing."* (Staddon & Newman, 2003, 22)

Using usage data to compare the success of different centres is clearly not possible as the nature of each centre is very different. As Lawson *et al* (2001) say, *"The number of students seen is clearly affected by the number of hours a centre is staffed per week."* (Lawson *et al*, 2001, 21). It is obvious that a centre that is staffed five days a week will have very different usage data to one open only for a few sessions prior to an examination period.

In addition to monitoring student attendance patterns and the performance of students who attend, the analysis of usage data may assist the day-to-day operation of a centre. Ní Fhloinn (2009) gives examples. Through usage data,

> *"it is possible to assess the busiest times of the week, how long students stay on average and the topics most frequently covered. This contributes to more efficient planning of resources."* (Ní Fhloinn, 2009, 95)

Marr (2010) describes the way in which this type of analysis contributed to mathematics teaching and learning at St Andrews.

> *"At the end of each academic year, the Head of the Mathematics Support Centre prepares a summary report outlining attendance patterns for that year (ensuring that information given cannot be used to identify individual students). In addition, reports are prepared on a School-by-School basis, summarising numbers visiting the Centre by year group or by module, and identifying topics for which they have been seeking assistance. These reports are given to the Vice-Principal (Learning and Teaching) as well as to the relevant Directors of Teaching and Heads of School. Obviously, this information is potentially sensitive, and it is up to the recipients to respond if they require clarification or wish to mine further. An example of the highly effective use of one such report has resulted in collaboration with*

the Physics Department, leading to improved student learning and more effective use of staff time." (Marr, 2010, 26)

In addition to analyses that show the usage of mathematics support, many studies attempt to address the nature and impact of the support. These will be discussed in the next section.

6.2 Evidence of analysis to evaluate mathematics support centre impact on student performance and retention

As indicated previously, evaluations of usage data show trends and indicate measures of demand for mathematics support. They do not however give any insights into the impact of the mathematics support centre on the student learning experience. In this section studies are shown that use quantitative data to analyse the activities of the mathematics support centre.

In order to encourage the uptake of mathematics support amongst students who are considered to need it, diagnostic testing often takes place at the start of an academic year for first year students. The diagnostic test is used as a screening instrument to identify students who may be at risk of having difficulties with the mathematics content of their courses and, in some cases to trigger a visit to the mathematics support centre. Analysis of performance data with reference to the diagnostic test results together with mathematics support centre attendance may show the impact of mathematics support on progression and retention.

Patel (1998) reports that at Robert Gordon University, all first year students (engineering, applied science and business) undertook a diagnostic test at the beginning of the academic year to enable course leaders and mathematics tutors to identify students at risk and encourage them to seek mathematics support.

In addition to monitoring support centre usage and student feedback, Dowling & Nolan (2006) report that Dublin City University (DCU) examined the pass rates of students who were considered at-risk of failing their first year in mathematics. In 2004, a 15 question multiple choice diagnostic test was developed and administered to target students. It identified 'at risk' students who were advised to visit the MLC. Comparison over two years of pass rates showed the MLC contributed directly to retention of students.

> *"It can therefore be argued that the MLC contributed directly to the retention of these students, with the consequent benefits (financial and other) accruing to DCU. We firmly believe that these figures as well as the feedback from users of the MLC indicate that it plays a significant role in terms of retention among first year students in DCU, as well as helping many other students become more confident and perform more ably in mathematics and the mathematical aspects of their other curriculum subjects."* (Dowling & Nolan, 2006, 53-54)

Patel & Little (2006) provide evidence that diagnostic assessments with mathematics study support can significantly increase module pass rates. At Robert Gordon University online diagnostic testing of all first year students that require some form of prior mathematics learning takes place. Students are made aware of mathematics support (one-to-one and group) in the Student Support Facility (SSF). Weak students receive an informal pre-support interview. The Patel & Little study shows a statistical review of pass and fail rates for students who received or did not receive study support. It finds that mathematics study support increases the mathematics related module pass rates to an above average level for students who lack confidence in their mathematics ability.

Cuthbert & MacGillivray (2007) report an Australian investigation at Queensland University of Technology (QUT) of completion and retention rates on first year engineering students. They examined the effect of optional extra mathematics support (which included drop-in support) from the QUT Maths Access Centre. The study found that students who access support *"are nearly twice as likely to complete the course as the whole cohort and half as likely to discontinue engineering."* (Cuthbert & MacGillivray, 2007, 8). They did not assess the impact of the drop-in support separately from the other support available.

Lee *et al* (2008) describe linear regression models including data collection to predict first year performance on an engineering course. Data were collected from 133 mechanical engineering students at a UK university and included diagnostic test results, gender, details of prior qualifications and results and MLSC use. Some data were available from university records whilst other elements had to be collected via tests and questionnaires. Significant factors in the regression models were students' mathematics diagnostic test results, whether they had visited the MLSC during their first year of study and the number of statistics modules they had studied during A-level mathematics. Apart from finding that a mathematics diagnostic test is a useful predictor of future performance, the models showed that *"students' marks could be improved by seeking help in the university's mathematics learning support centre."* (Lee *et al*, 2008, 44).

In a comparison of failure grades over four academic years for three mathematics modules, Gill & O'Donoghue (2007) show a dramatic reduction in failure rates once the mathematics learning centre (MLC) opened. A diagnostic test is administered to identify students 'at-risk' of failing and to prioritise the support services towards these students. A comparison of end of term grades for 'at-risk' students was made for those who attended support and those who did not and it was clear that those who had attended performed better than those who did not. Gill & O'Donoghue considered this to be a positive indication for mathematics support.

Robinson & Croft (2003) describe an intervention which had the aim of improving retention rates among engineering students. All students took a diagnostic test during the first

week of their first year and were informed of support that that was available through the MLSC. Students below a threshold were considered 'at-risk' and were offered extra help. One group was offered group tuition and encouraged to visit the MLSC and a second offered support on an individual basis through the MLSC. Some students did not accept offers of help. Analysis found that students accepting support performed much better than those who did not. Of the 29 students who accepted help across the two groups, 27 passed and of the 25 who did not accept help, only 11 passed.

Pell & Croft (2008, 172) describe a study which sought to examine the impact of the mathematics learning support centre (MLSC) at Loughborough University over a five year period on the grades of first year engineering students. Analysis was made of attendance (no of visits to the MLSC) by module and by grade for each year. It was found that the MLSC was regularly attended by a significant number of engineering students (approximately 1 in 5). Pell & Croft found there was a measurable impact of mathematics support activity. Making the assumption that MSLC attendance can only improve performance, they concluded that the small but noteworthy number who attended regularly but received a minimal pass grade would otherwise have failed. The MLSC therefore contributed directly to the retention of these students. In addition to this, the proportion of fail grade students seeking support was less than pass grade students seeking support indicating the need to develop strategies to target these vulnerable students. Pell & Croft found also that the facility is used more by more able students seeking excellence than the less able avoiding failure.

In a statistical study to examine the influence of the Mathematics Support Centre on grades of first year students at the National University of Ireland, Maynooth, Mac an Bhaird & O'Shea (2009) considered past examination and diagnostic test results when comparing grades of students who did/did not attend the MSC. They found significant evidence to suggest the MSC is making a difference to first year students who attend the MSC and has particular influence on the most at-risk students.

Bamforth *et al* (2007) describe a study where a pre-sessional mathematics course was offered to engineering students prior to the start of their first year undergraduate course. It had dual aims – to reinforce mathematical competency and encourage the on-going use of mathematics support. Data are given for two academic year groups and the study seeks to identify through the examination of diagnostic test scores, final module marks and attendance at mathematics support the impact of the support. Frequent attendance by those students who were less well-prepared mathematically on entry was found to have a positive impact. The study goes on to examine whether this positive impact is seen at the end of the second year of study and identifies a drop in performance.

Croft *et al* (2009) discuss an initiative at Loughborough University to address the mathematical unpreparedness of undergraduates. This includes the provision of the mathematics support centre and considers evaluation including the tracking of pass/failure rates. The paper also considers vulnerable students such as those with additional needs.

6.3 Student satisfaction, wellbeing and mathematical confidence

In addition to the impact of mathematics support on pass and retention rates, some studies report changes in student attitudes and mathematical confidence and comment on the student learning experience.

The studies report that caution must be taken in the interpretation of qualitative data however. In 2002 Lawson *et al* (2002, 24) describe a study that interviewed 58 students accessing mathematics support at seven institutions and sought to determine students' views on attitudes of support centre staff to problems students were encountering with mathematics. They enquired on the location and opening times of the centre and included an open question on good and bad points of the centre. Lawson *et al* report that evidence from such studies may not be representative of the whole student body. The example given is the views on the location being suitable or not do not take into account the opinions of non-attenders.

MacGillivray & Croft (2011) discuss the analysis of data on resource usage. A visit to a website does not show resource usage but does *"represent interest or visibility."* (MacGillivray & Croft, 2011, 199)

Woodhouse (2004) reports analysis after one year of setting up a MSC at Nottingham Trent University. Analysis is shown from a feedback questionnaire that was sent to all students on their awareness of the MSC, their opinions on the means of communication about the MSC, reasons for non-use and other comments. 159 students responded and nearly all written comments were positive.

Other studies also report that students rarely offer negative comments about the support they receive.

> *"Generally, the comments made are very positive because it is usually the case that staff working in the centres are trying hard to help, and students acknowledge this. So while pleasing, the results are not surprising, and thus don't really reveal very much."* (Pell & Croft, 2008, 168)

In a separate paper Croft (2009) states:

> *"It is rare to find negative feedback from students regarding the provision of mathematics support (except perhaps to say that it should be even more available!)* (Croft, 2009, 7)

Whilst Pell & Croft (2008) say that usage data may show that a well-used centre is satisfying student demand, they would value more evidence of impact.

> *"What would be much more powerful would be quantitative data on how those who use the centre*

perform in their mathematics examinations, and whether failing students are those who do not make use of the centre." (Pell & Croft, 2008, 168)

Patel & Rossiter (2011) report on an initiative that demonstrates the impact of the mathematics support centre in this area. The strategy sought to increase student engagement in mathematics learning. It was administered through the mathematics and statistic help centre (MASH) and involved identifying individuals who needed extra support. Based on screening test results, an individualised learning programme with resources was generated. This early introduction to MASH showed an increase in the number of visits, positive student feedback and improved results. It was felt that the initiative increased students' awareness and willingness to use centralised support.

Patel & Samuels (2009) reported on research in progress that was seeking to analyse the relationship between students' approaches to studying and the effectiveness of mathematics support. A questionnaire was developed to determine preferred learning styles. No results were given in this paper but may be seen in Patel (2012).

In a study conducted by Parsons *et al* (2011), seven final year engineering students were interviewed to examine their experiences and confidence in learning mathematics. Questions were asked concerning their use of mathematics support and whether it should be available. Evidence for the benefits of mathematics support was shown.

Croft *et al* (2008) report an intervention for extending the model of mathematics support from remedial to one of enhancement. An action research study was undertaken which resulted in extending the mathematics support centre provision for second and third year mathematics students. Evaluation showed peer support played a significant role in student motivation and confidence.

Nzekwe-Excel (2010) describes a study at Aston University conducted via a questionnaire to determine the impact of the mathematics support centre. He concludes that *"it does not just help to develop students' mathematical skills but also re-models and contributes to addressing their negative experiences and perceptions about mathematics."* (Nzekwe-Excel, 2010, 9)

Evaluation in Carroll's study (2011) at the University of Limerick established that

"the mathematics learning centre improved students' confidence in their mathematical ability; improved their attitudes towards mathematics; helped to improve their study habits and played an influential role in preventing several students from withdrawing from college completely." (Carroll, 2011, 66)

Gillard *et al* (2012) report a study at Cardiff University which statistically analysed the relationship of self-reported student confidence and ability of students who attended the MSC. They show that students perceive the MSC to have significantly improved their confidence and benefited their ability. The study found gender differences and recommended further research into student expectations of tutors and what makes an effective support tutor. Woodhouse (2004) comments on the nature of the students who availed themselves of mathematics support.

"The students who made best use of maths support were those who were confident in themselves (although not necessarily with maths), well-motivated and well organised. They were often mature students who quickly recognised their need for support and took early advantage of the help offered. Other students who became regular attendees discovered Maths Support later in the year as they became more focussed and more able to identify their own needs. These students also made good progress. A few conscientious students who were already fairly confident with maths used the support to raise their marks even higher." (Woodhouse, 2004, 4)

In Pell & Croft's study (2008) comparing mathematics support centre attendance with first year engineering students' module grades, they also found that in addition to improving performance and retention, the centre was also used by more able students seeking excellence thus moving *'the mathematics support model from one of remedial support to one of enhancement."* (Pell & Croft, 2008, 172)

Mac an Bhaird, Morgan *et al* (2009) found similar results in their study – there were a group of strong students who *"seemed not to be worried about failing, but were using the centre to improve their chances of achieving first-class marks."* (Mac an Bhaird, Morgan *et al*, 2009, 121)

Solomon *et al* (2010) report on data gathered from a qualitative study relating to second and third year mathematics students at two UK universities with developed mathematics support centres. They report that initiatives aimed at addressing mathematical difficulties have evolved into collaborative working spaces which draw on student interaction and peer support.

6.4 Non-users of mathematics support centres

As can be seen from these studies, attendance at a mathematics support centre would seem to contribute to improved performance, retention and mathematical confidence. Highlighted in this section are studies which specifically seek to address why students who could benefit do not attend.

"There was also a minority of disaffected or uncommitted students who rarely attended lectures or seminars and did not respond at all to personal contact; these students were very difficult to reach or help. The students who remain of concern are those who presumably knew that they were struggling and who were aware that help was available but who still chose not to come to the Centre and subsequently failed their maths module." (Woodhouse, 2004, 4)

In a study in 2001, Lawson *et al* (2002, 24-26) attempted to address this group of students by seeking views through interviews with students who did not use the MLSC (22

students from 2 different institutions). They were asked about their mathematics preparedness for their course, the attitude of teaching staff to problems with mathematics, the location of the support centre and the opening times of the support centre.

An in-depth study (Symonds, Lawson & Robinson, 2008) was conducted at Loughborough University to identify why some students do not engage with mathematics support. The first phase considered students (n=179) who had failed a module in their first year (05/06 or 06/07) and had never or rarely used the MLSC. Contact was made by e-mail on three occasions and feedback was sought from seven students using individual interviews or focus groups. Additionally on the spot interviews (n=85) were held across campus on three occasions and in two different locations. Students were encouraged to give open-ended responses which were recorded in writing. The second phase was conducted in a similar way but the students targeted were regular users (n=88) of the MLSC (06/07) who had failed a first year module. Seventeen students were interviewed and were presented with reasons given by non-users for their lack of engagement with the support and were asked if any of these had been a barrier to determine how they had been overcome. Additional detail is given in (Symonds, 2009).

A study was carried out at the National University of Ireland Maynooth by Grehan *et al* (2010a) to determine why students do not engage with mathematics support. It compared students who failed their first year with those of similar academic backgrounds who passed the first year and attended the mathematics support centre at least five times. Twelve students filled in a short questionnaire and seven were interviewed with open-ended questions. Analysis showed mathematical background was not the only factor in predicting future success in mathematics. Some students were unaware they had a problem or were unwilling to admit it until it was too late. They neither engage with their programmes of study, nor with mathematics support and demonstrate different coping strategies to students who were motivated to engage to some extent.

In reporting further analysis, Grehan *et al* (2010b) identified a fear category which inhibited engagement with mathematics support – fear of failure, fear of the unknown, fear of being singled out and fear of showing a lack of knowledge or ability. This fear inhibited students in relation to peers or tutors and affected engagement and coping strategies.

Reporting on the Study Advice Service (SAS) at the University of Hull, Ireland (2006, 2) comments on methods that have been found to work to reach the students who should be seeking help and are not. These include making students aware of who the support staff are by attending lectures in semester one, making support as easy to access as possible including an email service, and departmental workshops.

In their study which endeavoured to measure the effectiveness of the mathematics support centre (MSC), Mac an Bhaird *et al* (2009, 121) analysed feedback from users and compared the grades and MSC attendance of first year students. They found in spite of evidence that attendance at the MSC had a positive impact on performance, the majority of students identified as at-risk from the diagnostic test and prior results did not attend the MSC and targeting these students was a priority. In addition they commented that although attending the centre boosted confidence and encouraged a good work ethic, it was however important and necessary for students to work independently as well.

6.5 Analysis of mathematics support centres in relation to staff

A small number of studies have incorporated the views of staff. This section details studies that are concerned with feedback to and from staff.

In describing the operation of the MSC at the University of Massachusetts in Amherst, Beveridge (1993, 4) describes that feedback from the centre on difficulties students are encountering was given to mathematics tutors. Tutors were encouraged to work their office hours in the centre and so obtained an informal overview of difficulties their own students were encountering. Monthly seminars involving the mathematics department and the Head of Maths Centre were held but it was felt that much more could have been done to inform mathematics lecturers about common student problems.

Patel (1998) comments that feedback from the MLSC at Robert Gordon University on skills commonly causing problems is given to teaching staff so that issues may be addressed early in the semester.

In their study on the mathematics learning support centre at Loughborough University, Perkin *et al* (2007) included a census of academic and academic related staff, most of whom worked in the centre. Findings related to staff perceptions of students' mathematical abilities and difficulties, reasons why students access the MLSC and suggestions for improvements. There was a difference in perceptions between staff and students as to students' preparedness for their courses.

Section 7:

Further Research

This literature review has identified a significant number of evaluation studies that have taken place to evidence the use and impact of mathematics support. As Gillard *et al* (2011) say,

> *"a wealth of information relating to mathematical support services is recorded but formal measurement of their effectiveness continues to be difficult."*
> (Gillard *et al*, 2011, 49)

Some areas, where further research would be desirable, have become evident, namely:

- reasons why students do not avail themselves of the support available and mechanisms that could be employed to increase engagement.
- identification of the barriers to recognising that support is needed and accessing it before it is too late.
- for students who regularly visit the mathematics support centre, what contribution is this making to their learning of mathematics? Would their studies be as successful if support were not available? Is support desirable and/or needed throughout their programme of study?
- to investigate what constitutes effective delivery of mathematics support and the influence of gender differences as identified in Gillard *et al* (2012).
- follow-up studies to determine whether the positive effects of mathematics support continue beyond the first year as suggested by Challis *et al* (2004, 64). These should examine progression and retention rates throughout all programmes of study and potentially examine the effect of increased mathematical confidence and success on non-mathematics modules.
- although evidence has been found through internet searches of mathematics support activity in countries other than the United Kingdom, Ireland and Australia, little evidence has been found of evaluation of these centres. Direct contact has been made with some centres and it would appear that evaluation is limited and restricted to usage data or a justification in internal reports of the necessity for the mathematics support centre.
- a recommendation from Gillard *et al*'s study (2011, 50) was to encourage the dissemination of good practice of the evaluation of mathematics support. They sought the adoption of standardised measures for comparison across institutions. As the nature of mathematics support varies widely across institutions, this has proved difficult as local contexts are so different, but further research may be fruitful.

Section 8:
Conclusion

Ní Fhloinn says that

> *"accurate evaluation of the operation of such centres is an important, but complex task given that centres should ideally be integrated into the overall learning experience of the student, complementing structures such as lectures and tutorials."* (Ní Fhloinn 2009, 95)

She continues that it can be very difficult to establish that the Mathematics Support Centre has been the key reason behind the retention of any particular student and that the aim of evaluation should be to ensure that the centre is operating as efficiently as possible, and having a positive effect on student learning, in particular for those students who are struggling with mathematics.

This report has reviewed the literature to date and found evidence of a number of studies that have attempted to evaluate the operation and effectiveness of mathematics support. These vary in scope from quantitative analyses of mathematics support centre usage to in-depth studies on the impact on progression and retention rates, mathematical confidence and students' learning of mathematics.

Whilst the skills gap between school and higher education mathematics continues to prevail, the consequent mathematical and statistical unpreparedness of students for university study in all courses remains. Mathematics support centres will continue to be provided to support students in their efforts to succeed. In order to maximise the limited funding that is available for these purposes and to target support towards those students who need it most, rigorous evaluation will need to take place. It is hoped that this study will have provided a baseline and contributed to knowledge in this field.

Section 9:

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The National HE STEM Programme

Working across the higher education sector with a particular focus upon the disciplines of Chemistry, Engineering, Mathematics and Physics, the National HE STEM Programme supports higher education institutions in encouraging the exploration of new approaches to recruiting students and delivering programmes of study. It enables the transfer of best practice across the higher education STEM sector, facilitates its wider adoption and encourages innovation. Through collaboration and shared working, the Programme focuses upon sustainable activities to achieve long-term impact within the higher education sector. As part of this philosophy The National HE STEM Programme actively disseminates project outcomes and evidence based good practice to HEIs beyond those involved in the project.

The **sigma** Network

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