

Learning support in mathematics and statistics in Australian universities

A guide for the university sector



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This Guide is based on findings from a project funded by The Australian Learning and Teaching Council (ALTC). After discussion on the history, nature and roles of learning support in mathematics and statistics in Australia, it synthesizes the findings of the project to provide information for the university sector on the need for, and the provision of, such support. The project was funded by the ALTC's Leadership for Excellence in Learning and Teaching Program. The title of the project was *Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities*, and its aim was to develop national capacity and collaboration in cross-disciplinary mathematics and statistics learning support to enhance student learning and confidence.

Support for this project has been provided by the Australian Learning and Teaching Council, an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The views expressed in this report do not necessarily reflect the views of The Australian Learning and Teaching Council Ltd.

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Preface

There has always been, and always will be, need for reliable, supportive and expert learning support for students in numeracy, mathematics and statistics across a wide range of disciplines in universities. Like language, mathematical skills and thinking underpin much in other areas, and tertiary study asks for them to be accessed and used confidently and promptly in new and sometimes taxing contexts. The past two decades have added difficulties and pressures in mathematics and statistics for tertiary students. Learning support in mathematics and statistics is a critical component in the totality of enabling student learning and avoiding preventable student attrition. Universities need to include ongoing sustenance and strategic planning for such support within their overall learning and teaching plans. It is an area in which a small quantity of resources in the overall university scene can produce enormous dividends in student learning, confidence and fulfilment of potential. This Guide brings together history, background, research, discussion and discovery about learning support in mathematics and statistics in Australian universities in order to inform and assist the whole university sector in the understanding, principles, practicalities and provision of such support to enhance student learning and confidence.

Overview

This Guide amalgamates the investigation and analysis findings of an ALTC-funded Leadership Project entitled Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities. The report of the Project is available on the ALTC's website <http://www.altc.edu.au> and on the website of the Australian Network in Learning Support in Mathematics and Statistics (ANILSiMS) established as part of the Project <http://silmaril.math.sci.qut.edu.au/carrick> . The aim of this Project was to develop national capacity and collaboration in cross-disciplinary mathematics and statistics learning support, to enhance student learning and confidence. The approach and methodology of the Project consisted of phases of discovery, collection and collation of information, a national Symposium, dissemination to direct stakeholders, establishment of a website, auditing resources, and analysis and synthesis of findings to produce this Guide. The information that forms the basis of this Guide, and gathered during the course of the Project, was obtained by a combination of searches, surveys, phone discussions and direct input from delegates to the 2007 national Symposium.

After briefly reviewing the initial and recent establishment of mathematics and statistics learning support (MSLS) facilities in Australian universities, Section 1 uses the information gathered in the Project on the activities of these facilities to produce a workable definition of such learning support. This definition helps to distinguish the differences to bridging courses and to citizenship numeracy. All are part of the totality of mathematics and statistics teaching and learning which play critical and crucial roles directly and indirectly in student learning, development and achievement across so much of higher education. This totality needs to be strengthened in every aspect to enable students to fulfil their potential and reduce their vulnerability to avoidable attrition. The components and their mutual arrangements within this totality depend on the university, its courses and structures. The focus of learning support tends to be on building mathematical fitness, confidence and transferability, all with reference to

the specific courses being taken by the students. This Guide aims to assist in the understanding, acknowledgement, recognition and ongoing sustenance of learning support in mathematics and statistics within this totality.

Because learning support in mathematics and statistics interacts or interfaces with an enormous variety of courses, levels, students and concerns, papers on it appear in a range of conferences organised by an array of professional groups, and a brief overview of this in Section 1 assists in understanding the diversity of MSLS interests. Section 1 concludes with a summary of MSLS in the UK. The development and networking in the UK of MSLS facilities, the continued national support of these through the establishment of a Centre of Excellence in Teaching and Learning, the joint projects with other disciplines, and the importance in which these are regarded by UK universities, contribute to the body of evidence for the value of systemic and systematic provision for learning support in mathematics and statistics in comparable higher education systems.

Section 2 discusses what is special about mathematics and statistics that has led to such extensive development of MSLS systems, aiming to increase understanding why the need for such provision is ongoing and will continue, and why there has been such rapidly increasing need over the past two decades. Similarities and contrasts with language and sport are used to assist this understanding. Almost all sources of information from learning support facilities in Australia report increasing demand and increasing pressures on them, and concerns about lack of security in both funding and position within their institutions. The decrease in numbers and sizes of mathematics and statistics departments has exacerbated the problems.

Section 3 presents an aggregated picture of the provisions of MSLS facilities in Australian universities as of 2007. The information presented in Section 3 was obtained through web and phone searches, an extensive survey, phone interviews and input from delegates to the 2007 national Symposium on MSLS. Section 3 first presents the combination of information sourced from the 32 universities that were found to have at least some form of MSLS in 2007, and then discusses additional information obtained from a subset of these 32 and from the 16 facilities that completed in-depth surveys.

Section 4 discusses key points in terms of recommendations. These include

1. MSLS should be part of core university business

Every aspect of mathematics and statistics education in higher education needs to be strengthened, and learning support in mathematics and statistics is a critical component within this totality of learning and teaching in enabling student learning and avoiding preventable student attrition. Universities need to include ongoing sustenance and strategic planning for such support within their overall learning and teaching plans. It is an area in which a small quantity of resources in the overall university scene can produce enormous dividends in student learning, satisfaction and success. However to produce such dividends, learning support in mathematics and statistics must be recognised as part of core business and championed and supported from the top. This was overwhelmingly the message common to all input, discussion and research, including universities that do not currently have mechanisms for learning support in mathematics and statistics but say they should have.

2. General principles in structure and funding of MSLS assist in facilitating maximum and ongoing effectiveness and efficiency

Details of structure and funding arrangements are likely to continue to vary across universities but whether a facility providing MSLS is associated with a central facility or a mathematics department or both, it needs its own identity and sufficient autonomy in its resourcing and accountability to be seen in its own right by students and staff across the university. All aspects of the connections between the discipline-specific program providers and the learning support systems need to be strong, collaborative and complementary.

3. The provision of physical and electronic structure and facilities should facilitate and maximise accessibility and supportive environments for students as appropriate for the nature of the institution.

4. Nature of support and staffing

The ongoing academic staff component of the facility needs to have expertise and experience in the learning and teaching of mathematics and statistics across disciplines at the university level, with particular experience at the first year level and with the variety of backgrounds of students accepted into tertiary courses. Such qualities may not necessarily reside in individual staff members but need to be considered in the overall composition of staff. Full time or fractional teaching staff should be academic staff with terms, conditions and support that encourage development and retention.

5. Postgraduate support in statistics

This emerged during the Project as one of the most needed across disciplines and across universities. These are genuine learning support needs of students and differ to the needs of researchers for statistical consulting or collaboration.

5. MSLS facilities need sufficient resourcing in collaboration with discipline-specific providers to produce and analyse quantitative data on student backgrounds, needs, achievement and progression in relation to MSLS.

One aspect that stands out in the information gathered by the Project, is how few MSLS facilities in Australia currently have sufficient resources to analyse data that would be of significant value to universities in their strategic planning. Most evidence of the value of MSLS currently comes from quantitative data on usage, and from qualitative data including student evaluations and feedback.

1. History and nature of learning support in mathematics and statistics in Australian universities

1.1 Learning support in mathematics and statistics in Australian universities is not new.

In 1965 the Australian National University (ANU) established the Communication and Study Skills Unit (CSSU) in the University's Counselling Services, and in 1973 the first Counsellor in Mathematics was appointed to this unit. This counsellor reported through the Director of the CSSU and the Director of Counselling to the Dean of Students. The duties of the Counsellor in Mathematics were to provide assistance to any ANU students whose lack of confidence and/or skills in mathematics were causing them difficulties in their university course. The Counsellor was under instructions to refer students with specific queries about assessment tasks in mathematics and statistics back to their lecturers and tutors. Diagnostic tests to assist in evaluating students' areas of weakness were developed, as were resources and workshops on topics of common need.

In 1984, Mathematics Learning Centres were established at the University of Sydney (USyd) and Central Queensland University (CQU). The USyd Centre was initially funded by, and reported directly to, the Vice-Chancellor. The CQU Centre was established as part of the Division of Teaching and Learning Services.

In the past fifteen years, in almost every university in Australia, at least some form of learning support in mathematics and statistics has been set up, and in 2007 when this project was mostly conducted, 33 of Australia's 39 universities had at least some form of support. In some universities, the support is associated with a central service, in others it is provided by a mathematics/statistics department, and in others by a combination. In many universities it started in order to meet the growing support needs of students in specific courses such as engineering, nursing, business and economics. In some universities it is available to any student, and in others it is available to specific groups and/or courses. In all cases, demand for the support has rapidly grown over the past decade and continues to outstrip supply. Many support mechanisms depend on the commitment and drive of individuals dedicated to helping students seeking, sometimes desperately, help for their learning and academic survival. Since 1995, when McInnes and James (1995) identified lack of mathematical skills and confidence as a barrier for success for many students, the need for learning support in mathematics and statistics has been steadily increasing.

The information gathered during the course of the ALTC project was obtained by a combination of searches, surveys, phone discussions and direct input from delegates to the 2007 Symposium. Evidence of the increasing need for learning support in mathematics and statistics since 1995 lies in the number of facilities that have commenced operation, and the increasing numbers and diversity of students choosing to use the facilities, noting that such use is optional and voluntary for students. Almost all sources of information from learning support facilities in Australia report increasing demand and increasing pressures on them. Another common characteristic reported from almost all sources of information is a lack of security in both funding and position within their university.

1.2 Definition

Learning support in mathematics and statistics in universities is defined here as any facility or program providing extra assistance in mathematics and statistics for students *during* their enrolled study in a university degree program, whether undergraduate or postgraduate, with such assistance being outside the formally scheduled classes and activities of their enrolled course. Such support may include any or all of:

- drop-in assistance
- sessions or classes on specific topics or supporting specific subjects or units
- appointments for 1-1 assistance
- support facilities in paper or electronic form
- diagnostic testing with associated support assistance on specific topics
- designated space for support
- enabling or remedial programs
- support for postgraduates
- programs with no associated credit towards the student's course
- professional development for support staff
- programs of relevant research or scholarship, often involving collection and analysis of data on students backgrounds and progression

Higher education learning support in mathematics and statistics can therefore be described as any extra, optional, non-compulsory program or facility that assists students in developing mathematical and/or statistical confidence and skills during their enrolled study in a degree course, but with no credit associated with the learning support program. Sometimes such learning support may be aligned with specific components of the degree course, but its assistance is optional and supplementary to the designated activities of the program attaining credit towards a degree.

1.3 Difference to bridging

The above definition distinguishes between learning support and bridging programs in mathematics, which here are defined as preparatory programs to enable a prospective student to obtain prerequisite or assumed knowledge in mathematics *before* commencing their degree course. There are now many different forms of bridging programs available at, or associated with, universities, often fee-paying in some form, as well as the availability of external study for senior school subjects, and preparatory programs for international students (ELICOS and Foundation courses). In some universities, the group providing learning support also provides bridging courses in some form.

Initially, bridging programs in mathematics commenced in response to policies increasing access to higher education, and the Australian Bridging Mathematics Network was established in 1991 to provide a support group for those teaching into bridging mathematics. At the second Bridging Maths Network conference in 1992, the then Minister for Education stated that “mathematics is probably the single most important area of study” (Free, 1992). During the 1990's the Australian Bridging Maths Network (BMN) held observer status to the Australian Mathematical Sciences Council and its annual conferences provided forums for the development and exchange of ideas, experiences and research into the challenges of equipping students

with the underpinning mathematical skills vital to success in their study in a variety of courses.

Much of the focus of the BMN was increasingly on preparatory and bridging programs for mature age students. For example, in 2005 the BMN joined with the Australian Council for Adult Literacy in the 12th International Conference of Adults Learning Mathematics (ALM). The paper of Taylor and Galligan (2005) presented at this conference, gives an overview of the contributions of the BMN to adult learning in mathematics. ALM is an international research forum bringing together researchers and practitioners in adult mathematics/numeracy teaching and learning in order to promote the learning of mathematics by adults. ALM has become a Company and has also obtained the status of a National and Overseas Worldwide Charity by English and Welsh Law, UK, since the beginning of the year 2000.

1.4 Difference to citizenship numeracy

There is also a distinction between the type of skills and confidence building that are assisted by mathematics and statistics learning support, and citizenship numeracy. In his welcome to the 2005 AALL (Association for Academic Language and Learning) Conference, Professor Malcolm Gillies, then DVC (Education) at ANU made an impassioned plea for greater attention to be given to numeracy at tertiary level. Gillies' point in 2005 (Gillies, 2007) was that both literacy and numeracy are essential capabilities for life, but, whereas shortfalls in literacy are more readily recognised at the tertiary level and are being addressed to some degree, he expressed great disquiet that there appears to be little knowledge or concern about detecting and preventing stagnation or even decline in numeracy within the mass body of tertiary students.

There has recently been considerable attention given to the general concept of academic literacies in graduate capabilities, with awareness growing that these should include citizenship numeracy. However the aim of fostering citizenship numeracy as a literacy within the curriculum is different to the aims in providing learning support in the mathematical and statistical skills needed by students for, and during, study for their degree. The former is a desirable general graduate capability for citizenship; the latter is enabling the student to obtain the degree and is contributing to the fight to prevent attrition. Increased confidence and skills in mathematics and statistics naturally consolidate citizenship numeracy, but the purpose of learning support in mathematics and statistics is to combat deficiencies in confidence and skills that may prevent students realising their potential within their chosen course of study.

1.5 Papers, conferences and links

Because learning support in mathematics and statistics interacts or interfaces with an enormous variety of courses, levels, students and concerns, papers on it appear in a range of conferences organised by an array of professional groups. The Bridging Maths Network and Adults Learning Maths conferences are mentioned above, and since the 2005 conference, there has been increasing interest in numeracy from the Association for Academic Language and Learning. Papers on learning support in mathematics and statistics could appear at the conferences of the Mathematics Education Research Group of Australasia (MERGA), Australasian Engineering Education (AaeE), International Congress on Mathematics Education (ICME), International Conference on Teaching Statistics (ICOTS), Australian

Mathematics Society (AustMS), and Australian Association of Mathematics Teachers (AAMT), to name some.

In the past decade, the conference in Australia's region with probably the most delegates with at least some interest in learning support in mathematics and statistics, has been Delta, the Southern Hemisphere Symposium on Teaching Undergraduate Mathematics and Statistics. Delta is a biennial conference specifically on the teaching and learning of mathematics at university level. It started in 1997 and statistics was included in the titles from 2003. Delta is a community rather than an organization, and there is no formal society. There is an international committee and the convener of each symposium forms a local organizing committee. The name, Delta, came from the concept of change in university mathematics. Each conference has a different theme and location. The themes to date have been:

- in 1997, in Australia, "What can we do to improve learning"
- in 1999, in Australia, "The challenge of diversity"
- in 2001, "Gearing for flexibility". This Delta was held in South Africa, and attracted participants from many African countries for whom recent history had magnified the problems of teaching and learning, often in a second language
- in 2003, in New Zealand, "From all angles"
- in 2005, in Australia, "Blending beyond the boundaries"
- in 2007, in South America, "Vision and change for a new century".

As part of the ALTC Leadership Project "Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities", a symposium specifically on learning support in mathematics and statistics was held in July 2007. Information about the symposium, including abstracts and presentations can be found at <http://silmaril.math.sci.qut.edu.au/carrick/symposium.html>. Many delegates expressed a desire to hold such symposia on a regular basis. However it was agreed at one of the forums of the symposium, that participating in, and organising satellites to, conferences such as Delta and others described above, would be of greatest benefit and effectiveness.

The above comments and the themes for the Delta conferences illustrate the breadth of coverage in the teaching and learning of mathematics and statistics in universities. Particularly at the introductory or first level university courses, mathematics and statistics staff typically teach across many disciplines, programs, and a wide range of student backgrounds, attitudes, motivations and self-efficacies. Many university mathematicians and statisticians are also involved in a variety of ways with school level mathematics, and/or mathematics and statistics in the community, workplace, industry, government, or in projects in other disciplines. Considerations of curricula, enabling programs and learning support overlap with each other and with the formal teaching of mathematics and statistics within undergraduate and postgraduate programs. Learning support and bridging/enabling programs need to be associated with, or at the very least advised by, the expertise and experience of teaching mathematics and statistics to a wide range of students and programs at university.

1.6 Learning support in maths and stats in the UK

The UK's Maths, Stats and OR (MSOR) Learning and Teaching Support Network (LTSN) was awarded in 1999, and commenced operations in 2000. Learning support in mathematics and statistics was a significant component of this LTSN's work from the beginning, including cooperative projects with other LTSN's. As well as benchmarking and networking mathematics learning support in the UK (Croft, 2000, Lawson, Halpin and Croft, 2001, 2003), well-funded projects have produced considerable resources, already accessed by a number of Australian centres. The LTSN MathsTEAM project, motivated by the report "Measuring the Mathematics Problem" (Savage and Hawkes, 2000), was a collaborative project between four LTSN's (MSOR, Engineering, Physical Sciences and Materials Education) providing a comprehensive collection of case studies on diagnostic testing for maths, maths support and maths for engineering and science. Another LTSN-funded project produced mathcentre, <http://www.mathcentre.ac.uk/>, with free resources for all to use, and another project, funded by the Fund for Development of Teaching and Learning, produced the DVD-Roms mathtutor, <http://www.mathtutor.ac.uk/>.

In 2005, a Centre for Excellence in Teaching and Learning (CETL) in Mathematics and Statistics Support, was awarded jointly to Loughborough and Coventry Universities, with headquarters in Loughborough University. Coventry University's Mathematics Support Centre had been supporting students since 1991, and Loughborough University's Mathematics Education Centre had been established in 1996 based on previous learning support run within the Mathematics Department.

This CETL is called Sigma, <http://www.sigma-cetl.ac.uk/>. It was awarded capital funding of £2 million, with recurrent funding of £0.5 million annually for 5 years. In addition, Loughborough University has designed, provided and furnished a permanent home for the Centre. Sigma is enhancing existing provision and addressing mathematics and statistics support needs proactively, including strengthening the capacity to support students in more disciplines, in statistics, at the postgraduate level, and with disabilities and from non-traditional backgrounds. Sigma also seeks to influence positively other parts of the higher education sector, providing cross-disciplinary and sector-wide dissemination, assistance for establishing and sustaining maths support centres, and underpinning all activities with a substantial programme of pedagogic research. Staffing is by qualified mathematics and statistics personnel, and strong links are maintained with mathematics and statistics departments and professional organisations, directly and through the MSOR Subject Centre (previously LTSN) of the Higher Education Academy. A presentation about Sigma, given at the 2007 Symposium, can be found at http://silmaril.math.sci.qut.edu.au/carrick/presentations/Gadsden_07.ppt.

In 2006 the first MSOR-CETL conference was held on the combined interests of teaching and learning and learning support in undergraduate mathematics and statistics. This conference was again held in 2007 and 2008 and is planned to continue as an annual conference with papers from both UK and international speakers and refereed proceedings. This built on the 2005 Helping Everyone Learn Mathematics (HELM) conference that was organised by the MSOR Subject Centre, including groups involved in learning support. These conferences built on foundations laid by a range of MSOR workshops.

As in Australia, learning support in mathematics and statistics in the UK can be based in a mathematics and/or statistics department or in/as a central group or a combination. However because of the MSOR Subject Centre and the CETL structures, there is strong networking and strong association with mathematics and statistics departments, and hence good access to resources and the full range of expertise and experience in the teaching of mathematics and statistics across disciplines in universities.

Also as in Australia, the decrease in the number and size of mathematics and statistics departments has increased the need for good learning support in mathematics and statistics. An example of this in the UK is at London Southbank University. There Susan Starkings set up central mathematics and statistics support on the closure of the mathematics department in the late 1990's. This initiative grew and is now a major part of the Skills for Learning (of which Susan is Head) in the University's Centre for Learning Support and Development. Particular successes include the fast track summer program, the moving-on course, the specific support for nursing, for the postgraduate certificate of education (PGCE) and maths pre-entry for social work. Apart from these specific areas, maths support includes specific topic sessions, drop-in workshops, one-one appointments and makes use of the mathcentre and mathtutor resources. The Maths Support Programme maintains close links with developments in the undergraduate teaching of mathematics/statistics through the MSOR and CETL network. A presentation about this Centre, given at the 2007 Symposium, can be found at <http://silmaril.math.sci.qut.edu.au/carrick/presentations/Starkings%2007.ppt> Discussion at the symposium after this paper focussed on the Centre's access to, and use of, data to track and report on student progression, and on training and supervision of staff.

The development and networking in the UK of facilities providing learning support in mathematics and statistics, the continued national support of these through the establishment of a CETL, the joint projects with other disciplines and LTSN's and the importance in which these are regarded by UK universities, contribute to the body of evidence for the value of systemic and systematic provision for learning support in mathematics and statistics in comparable higher education systems.

2. Need for learning support in mathematics and statistics

2.1 What is special about mathematics and statistics that has led to the emergence, development and ongoing provision of learning support systems? Referring again to the definition as given in (1.2), such systems are responding to needs of students beyond those that are met by the normal support provided within the learning and teaching of any unit/subject/course/module. Not all students want to use such systems, and not all students need to use such systems. From all sources of information for this project from Australia and the UK, it is clear that a vital contribution of facilities providing learning support in mathematics and statistics, is the message to students that it is both important and acceptable to identify mathematical weaknesses, and to seek and accept help. As a nursing student commented in an evaluation of the system of diagnostic assessment and associated special support sessions at QUT,

I have avoided this stuff for the last 20 years, but it really is easy and fun

Sources of information for this project also report that use of the support systems is not restricted to those with the weakest skills. The word "want" is important. This is

indicative of the importance of sufficient systematic support to facilitate the development of confidence in mathematical and statistical skills to the level perceived by individual students to be necessary for their success in their tertiary studies.

There is a temptation for some to regard the need for mathematics and statistics learning support (MSLS) systems as a response to temporary conditions. Many of those involved in tertiary education have a tendency to blame school education, while many of those involved in school education blame universities. There are certainly changes over the past decade that have increased the need for MSLS, and some of these are outlined in (2,3) below. But many of these are unlikely to be temporary changes, and reports from all information sources indicate that problems that *can* be tackled by universities (such as prerequisites and curricula) are exacerbating rather than causing the demand for MSLS. And there are some characteristics common to all educational levels that have brought the need for MSLS to the foreground. These include

- the decline of the attitude of “sink or swim”. This is of course a highly desirable change but the challenges in school mathematics education of caring for all students’ futures across all abilities are great, particularly in middle school, while at tertiary level the focus on avoiding and reducing attrition is in significant contrast to previous eras
- attitudes of “just in time” or minimum instant-use knowledge that over-emphasize mathematics and statistics as collections of knowledge and rules more than as skills bases and ways of thinking
- lack of understanding and/or acknowledgement of the roles of both the specific and generic skills of mathematics and statistics in underpinning the development of skills and thinking in many disciplines

There has probably always been a need for MSLS as a component of the totality of tertiary learning and teaching in mathematics and statistics, with the many changes over the past three decades in the higher education sector, in attitudes in education, and in increasingly quantitative needs of a modern society, bringing this need forward, with increasing acceleration over the past decade. Section 2.2 discusses further the special nature of mathematics and statistics in student learning, and Section 2.3 focusses on recent influences and effects.

One aspect that stands out in the information gathered by this project, is how few MSLS facilities in Australia currently have sufficient resources to analyse data that would be of significant value to universities in their strategic planning. Such data analysis is also important in providing quantitative evidence of the contributions of MSLS to improving student achievement and reducing attrition, as in MacGillivray and Cuthbert (2003) and Cuthbert and MacGillivray (2007). As discussed in Sections 3 and 4 below, evidence of the value of MSLS currently comes mostly from quantitative data on usage, and from qualitative data including student evaluations and feedback. As most delegates to the 2007 Symposium commented, the type of data collection and analysis of MacGillivray and Cuthbert (2003) and Cuthbert and MacGillivray (2007) requires resources beyond those currently available in facilities already stretched to the limit in trying to meet student needs.

2.2 Ongoing need

The reasons for ongoing need for MSLS lie in the nature of mathematics and statistics, in the manner in which they underpin other disciplines, in the ways they are called on at tertiary level, and in the widespread lack of recognition or acknowledgement of the many dimensions and roles of mathematical and statistical thinking in the higher order processes demanded at tertiary levels. Considerations of similarities and contrasts with language and physical prowess can also help in understanding why and how mathematical and statistical skills and confidence are of such significance.

Maths is a natural human activity, as fundamental and important as language. Like language, mathematical skills and thinking underpin much in other areas, and tertiary study asks for them to be accessed and used confidently and promptly in new and sometimes taxing contexts. Like language, mathematical confidence and thinking need time to develop; they need to become a part of the person; and, if specific skills are needed in a fully usable, transferable way, then both mathematics and language need to be studied significantly beyond the level of those specific skills.

However there are differences to language that tend to make tertiary students particularly vulnerable to lack of confidence in mathematics and statistics. The development of mathematical skills and confidence is cumulative. To apply mathematics in an only slightly different context or to proceed in the next step in mathematical thinking requires very great familiarity with, and mastery of, the component background knowledge and skills. Thus different levels of achievement in the same prior learning can result in great variation in coping abilities in new contexts or the next step. In addition, what may appear as only a slight weakness is isolation or at a lower level, can be significantly inhibiting with a new or larger context. The extent of inhibition depends on the individual. Hence even students with officially the same educational background may vary widely in confidence.

The importance of mathematics and statistics across disciplines lies not just in specific skills. Confidence with, and understanding of, solutions to simple problems enables use and extension of these within more complex discipline-specific scenarios. Transferability of mathematical skills involves going from a familiar context to a general or unfamiliar context. It is this transferability of mathematics and statistics that is a core aspect of both their power and their challenge. The concentrated logic of mathematical thinking enables the essential nature and structure of real context-based problems to be identified and described in such a way as to facilitate selection of strategies and tools. The coherent thinking of mathematics and the training in asking questions enables objective analysis of situations and solutions. It is not surprising that mathematical learning is empowering but can also feel demanding – for everyone, no matter how “good” they are at mathematics!

There are also similarities between mathematics and sport. Physical activity is natural to humans and physical health is important for both success in, and quality of, life. The “having” of physical skills is not a dichotomy across individuals. Natural capabilities in physical and sporting skills are a multi-dimensional and multi-faceted complex continuum across individuals, but everyone can develop their inherent skills, often extensively. And it is increasingly recognised that general fitness is necessary to develop sport-specific skills – just as general mathematical fitness is needed to

develop discipline-specific quantitative skills. Unfortunately the level of acceptance and accolades given by society to the rigorous development of sporting skills through regular training, is not extended to the development of mathematical skills.

The demands made of students' mathematical confidence and skills in university study in many disciplines are their use (i) in different contexts, (ii) within multi-step situations, (iii) with different notation and (iv) in problem-solving which requires conscious identification of what is the same and what is different to previously-seen, even very familiar, problems. All of these are aspects of transferability, and many tertiary teachers in other disciplines do not fully comprehend the time and support needed for students to achieve this transfer into the discipline scenarios with which the teachers are so familiar. Also student difficulties in transferability often manifest themselves as mistakes with basic skills, leading tertiary teachers to too much repetition rather than consolidation of students' prior experiences. A significant step in solving the so-called "mathematics problem" would be to provide training for tertiary teachers in the art of teaching transferability of mathematical skills. Simply put, this involves understanding and consolidating students' background knowledge and skills within (i) – (iv) above.

The totality of mathematics support in the above broad sense in a university comes from mathematics and statistics departments, relevant staff in other disciplines, and learning support in mathematics and statistics in the way in which this term is now generally used and described in section 1. The components and their mutual arrangements within this totality depend on the university, its courses and structures. The focus of learning support tends to be on building mathematical fitness, confidence and transferability, all with reference to the specific courses being taken by the students.

2.3 The increased and increasing need for learning support in mathematics and statistics

In all types of universities in Australia, UK, NZ and similar countries, the need for extra learning support in mathematics and statistics has been increasing rapidly over the past decade, with students from all faculties, in courses ranging from nursing to engineering to postgraduate research, seeking, sometimes desperately, support for their learning and survival. A core reason is the much greater diversity of numeracy, mathematical skills and knowledge backgrounds across tertiary cohorts. This increased diversity is due to many factors including

- alternative pathways to tertiary education and changing patterns in student tertiary choices
- cultural and first language diversification
- increased numbers of mature age and retraining students
- pressures on universities to attract and retain more students in some areas and/or some universities
- decreased numbers of mathematics and statistics providers
- the increasingly quantitative and problem-solving needs of a modern technological society, and
- changes in school educational approaches over the past 15 years, including the many changes in the way mathematics is regarded particularly in grades 1-10 with the increased emphasis on more general activities and decreased emphasis on mathematical techniques and skills.

In 1995, when McInnes and James identified weaknesses in mathematical skills and confidence as a barrier for success for many students, the effects of misunderstandings and myths about the importance of mathematics across disciplines and the mathematical needs of students were starting to show. One such myth is that increasing computer power and technology decreases the need for mathematics, whereas in fact, they increase the need for mathematical skills and thinking because they open the way for tackling more and more complex and data-laden problems in all disciplines. Other mistakes are the focus on instant gratification, the only-if-it's needed attitude to mathematics, and the just-in-time myths. Such narrow and short-sighted views of mathematics as just a set of rules and tools ignores what is required for students to be able to develop mathematical thinking and to use even basic tools with confidence in new contexts, within multi-layered scenarios, in problem-solving within other disciplines, and in real time under pressure.

In the late 1980's, a commendable move to improve the educational inclusivity and appeal of maths for all students across school levels had some unfortunate by-products. The myths and mistakes outlined above are some of these. Others are over-emphasis on the peripherals of activities, benchmarking to the lowest standards, and the fostering by many of a maths denial that was not sufficiently curtailed. The combination of all of these factors has resulted in significantly increased diversity and an overall average general decline in background mathematical skills. Ironically, over the same period, society has become more technologically dependent and data-laden, with associated increasing need for mathematical and statistical skills and thinking. It is very common now that threshold tests for graduate employment include non-negligible numeracy and quantitative problem-solving components.

Combined with greater focus in universities on reducing attrition and on students as clients, and with pedagogical and professional demands on courses, this increased diversity and average general decline in mathematical skills have necessitated changes in learning and teaching strategies across all disciplines. In many ways the challenge in mathematics and statistics degree courses is less than in other disciplines and the so-called 'service courses' because mathematics and statistics staff have greater awareness and understanding of the extent, the nature and the tackling of the problems. For many tertiary staff and students in disciplines outside mathematics and statistics, this increased diversity and the presence of weaknesses in basic mathematical skills and confidence can be frightening, bringing with it the realisation of dependence on numeracy and foundation mathematical skills previously implicit or taken for granted, and of the seemingly enormous challenges of dealing with it within the pressures of their courses. Because universities cannot sustain, and the community cannot withstand, withdrawal and failure rates associated with the perceived "mathematics problem", the reaction in many disciplines has been to try to reduce, disguise or dissipate dependence on quantitative skills and confidence, whether explicit or implicit. Unfortunately this can often exacerbate the problem for students and staff, and does not tend to help students with either their immediate or their future mathematical and/or statistical confidence.

Hence the past decade has seen the great and growing need in almost all Australian universities of at least some form of learning support in mathematics and statistics. The type and extent of measures that have arisen in universities to provide disciplinary and cross-disciplinary support for student learning in mathematics and

statistics have depended on the university structure and culture, and on the work of individuals and groups within universities. Other significant factors contributing in a positive way to these developments include care for student learning, progression and at-risk students, and the growth of research and scholarship within the mathematics and statistics professions on student development of mathematical and statistical thinking and confidence (see for example, Croft, 2002, Garfield, 2002, MacGillivray, 2002, Pfannkuch et al, 2003, Bass, 2004). More advanced recent developments in such support include diagnostic testing (Wilson and MacGillivray, 2007, Robinson and Croft, 2003), collection and analysis of data (Cuthbert and MacGillivray, 2007, MacGillivray and Cuthbert, 2003) and support for postgraduates (MacGillivray, 2003). These aspects of university-wide support for student learning in mathematics and statistics are of increasing importance.

However, although at least some measures for the provision of learning support in mathematics and statistics have emerged in almost all Australian universities, there is generally too much uncertainty and structural vulnerability in the provision. The decrease in numbers and sizes of mathematics and statistics departments has exacerbated the problems. Universities need to guard against the dogma of denial of the importance of mathematics, and ensure that the totality of help for their students in numeracy, mathematics and statistics is espoused and sustained. The components of this help within a university should be coherent, linked and valued. Learning support in mathematics and statistics has become an increasingly important component in this totality, building individual confidence and repairing weaknesses. Many students have lauded such support in helping them succeed, and quality data and sound analysis have demonstrated students' desire for such support and its benefits for student progression. It has become critical that learning support in mathematics and statistics be funded and staffed in an ongoing, stable and sustained way.

Section 3 Report of research into the current Australian situation in university learning support in mathematics and statistics

The research reported below was carried out during 2007 by means of web searches, phone enquiries, and an extensive survey with followup during and after the 2007 Symposium on Learning Support in Mathematics and Statistics. The survey design was informed by the UK experience (Lawson et al, 2003) and initial visits to the UK and some Australian centres providing learning support in mathematics and statistics.

3.1 The shopfronts

As well as providing information on the appropriate recipients of the survey, web searches and phone enquiries were also carried out from the point of view of students, staff or the general community seeking information about learning support in mathematics and statistics, denoted below by MSLS. What is reported below was found *only* via web and phone searches prior to the survey and followup questions, and simply focuses on existence information.

3.1.1 Web information

The web searches began with the home pages of Australia's thirty-nine universities, treating the Australian Defence Force Academy as a separate institution for purposes of web-searching. Three methods were used for searching within each university. These were:

- using the search facility to look for “mathematics/statistics learning support/centre”
- browsing through Student Services
- hunting for and then through the Mathematics Department, if the university had one.

Through at least one of these search methods, 26 universities were found to have MSLS. None of the above search methods found the MSLS facilities that existed and had web presences at 5 other universities; these facilities and their web presences were discovered by other means. For another 4 universities, reference only to a bridging or enabling course was found; one of these universities was subsequently found to have recently commenced MSLS. Thus of the 32 universities with some form of MSLS, 6 could not be discovered through any of the above web search methods, although allowance must be made for the newness of one of these 6 facilities. There was no pattern in the universities with no readily-discovered web presence for their MSLS. They included large and small universities, old and new, city and regional, with three of the facilities being university-based and three being based in the Mathematics department.

The questions of whether any of the above search methods is more effective than others, and whether this depends on the location of the MSLS facility were next examined. Of the 26 universities with MSLS facilities discovered by at least one of the search methods, one has two unrelated MSLS facilities (neither of which was easy to find), so in Table 1 below there are 27 MSLS facilities. Using only the information/impression given by websites, each of these 27 facilities was broadly classified (according to the impression given by the website) as university-wide or centrally based support (Univ-based), or within/based in a Mathematics Department/School (Maths-based). As is seen in Section 3 below, the impressions created by the websites were not necessarily correct, and the classification is also not a strict dichotomy, as universities with mathematics staff tend to have MSLS involving some mixture of, or linking, university-wide and mathematics bases. However, the classification based on website impressions is appropriate for considering whether the effectiveness of the type of search method is affected by location of the MSLS. Table 1 below shows the number of MSLS facilities found by each of the 3 search methods described above.

Location according to website	Web search method			Total no. of facilities
	Search facility	Via Student Services	Via Maths Dept (2 have no Maths School/Dept)	
Univ-based	8	16	6 (out of 15)	17
Maths-based	8	4	10	10

Table 1. MSLS facilities found by different web search methods

Although Table 1 indicates the expected tendency for the successful search methods to be associated more with the location according to the website than in general or with another “base”, there is not a strong pattern. What does stand out are the failures of a general search method. The search methods via student services and via mathematics departments both involve hunting and persistence. .

The above research demonstrates that each university should ensure that its MSLS facility, no matter what or where it is, can be found, and easily found, by the students and staff to whom it is relevant. In general, searching university webpages can be very frustrating. Good practice could include:

- having an obvious name
- having a webpage for the facility
- linking to the webpage through student services and relevant departments and faculties
- ensuring the webpage is a source of information rather than a means of promotion.

3.1.2 Phone information

The phone searches began with each university's general enquiries number, with the caller asking if the university had any support facility for students enrolled in their university who needed extra help with the mathematics or statistics required for their studies. It was not necessarily expected that a general enquiries person would be able to immediately direct the call, but it was expected to eventually obtain the desired information. Because of ADFA's unique position as part of a university and as a special institution combining university and non-university training within highly structured schedules, it was not included past the stage of initial web searches. Hence the phone searches were conducted with 38 universities.

Of the 38 university general enquiries services contacted by phone, 4 confidently transferred to their MSLS facility (2 university-based and 2 maths-based), 9 transferred to a mathematics department, 23 transferred to student services, 1 transferred to an unidentified (and never subsequently identified) location, and 1 was not transferred.

Tables 2 and 3 below show how the phone search results related to the web search results. Table 2 classifies these results in terms of the number of transfers involved to obtain the information or in ending the search, and Table 3 in terms of the type of result obtained by the web search.

Number of phone transfers involved	Relationship of phone search results to web search findings				
	Consistent with web search finding	Partially consistent with web search finding	Inconsistent with web search finding	No information or deadend	Information not found through web search
0	4	0	1	0	0
1	14	0	2	5	4
2	5	0	0	2	0
Total	23	1	3	7	4

Table 2 Relationship of phone search to web search findings by number of phone call transfers involved

Web search findings	Relationship of phone search results to web search findings				
	Consistent with web search finding	Partially consistent with web search finding	Inconsistent with web search finding	No information or deadend	Information not found through web search
Apparently univ-based MSLS	9	0	2	5	0
Apparently maths-based MSLS	7	0	1	1	0
Two separate MSLS facilities	0	1	0	0	0
No MSLS facilities	5	0	0	0	4
Enabling/bridging only	2	0	0	1	0
Total	23	1	3	7	4

Table 3 Relationship of phone search findings to web search findings by nature of web search findings

This reinforced the overall findings of the web searches, that there needs to be better awareness and profiling of MSLS within universities to help students and staff locate the facilities that are provided, and that there appears to be little relationship between current awareness with either type of university or type of provision. Not surprisingly, the longest-established and largest centres tended to have the highest profile but two of the most established centres were not found by phone, and were found by web searches only through fairly extensive searching of student services.

Good practice for phone information could include:

- having an obvious name
- having a clearly identified phone contact
- ensuring the facility name and phone contact are included in the university's phone directory
- ensuring the facility name and phone contact are included in information supplied to student services and faculty offices

3.2 Information from the survey, reports at symposium and followup consultation

3.2.1 Sources of information

Once appropriate contacts were identified, an extensive survey was emailed to thirty-two universities. Sixteen completed surveys were returned, and fifteen of these universities were represented at the 2007 symposium. Another eleven Australian universities were represented at the symposium and information was obtained from a combination of their websites, their symposium presentations and/or phone consultation. The symposium report is available at

<http://silmaril.math.sci.qut.edu.au/carrick/symposium.html>

Five Australian universities with at least some form of MSLS did not complete the survey nor were represented at the symposium. Three of these universities have drop-in centres run and staffed by the Mathematics School/Department and in each case, the phone call to the university general enquiries number resulted in immediate connection to the facility. Much of the survey was not relevant to them, and information was provided through the phone call and their website. Another university provides support in statistics for postgraduate students but no undergraduate MSLS. The remaining university has a centrally-based teaching and learning centre with a fulltime MSLS staff member. The website could be found only through student services, and, although the contact person is identified on the website, the phone call to general enquiries did not result in a successful connection to the facility. As there was no response to the survey nor to phone messages nor to emails, only web information could be used for this case.

3.2.2 Location, funding and clientele level

From the surveys and consultations, where the MSLS facilities are based and how they are funded were able to be determined. For a variety of reasons, seven universities have two MSLS facilities. For example, one university has a different facility on each of two campuses. This is different to facilities with nodes on a number of campuses; these are treated as a single facility, even if there may be some campus-specific differences in services. Three universities have separate facilities for undergraduate and postgraduate MSLS, but in two of these, both facilities are located in maths/statistics. Another two universities have two facilities that have developed in response to a range of student needs, and that liaise with each other. Only one university has two MSLS facilities that appeared to be unaware of each other before this project.

Table 4 below gives the classification of the thirty-two universities with MSLS by where the facilities are based and how funded. The equity/enabling funding is either through equity and access funding or through special federal government enabling funding.

	Centrally-funded	Funded by Maths Dept/School	Combination funding	Equity/enabling funding	Total
Centrally-based	11	1	0	1	13
Maths-based	2	7	3	2	14
Both	Central	5	0	0	5
	Maths	1	4	0	

Table 4. Location and funding of MSLS facilities

The definition of MSLS must again be emphasized. No matter where the MSLS facilities below are located, they meet the definition of MSLS given in Section 1. The range of students and types of assistance do not depend on the location of the MSLS facility.

Of the thirteen centrally-based and centrally-funded (including from equity/enabling funding) MSLS facilities, three universities do not have a Maths Department/School. For the others, apart from the one that is funded by the Maths Department/School and

the one for which only the information from the website was available, all reported interaction with the Maths Department/School ranging from informal to very close.

Table 5 below shows the number of campuses serviced by the MSLS facility. Three facilities that provide distance MSLS are included in the 3 or more campuses.

		1 campus	2 campuses	3 or more campuses	Total
Centrally-based		8	1	4	13
Maths-based		13	1	0	14
Both	Central	3	1	1	5
	Maths	5	0	0	

Table 5. Location and number of campuses serviced by MSLS facilities

Table 6 below classifies the clientele of the MSLS facilities into undergraduate, undergraduate and postgraduate assistance at the undergraduate level, undergraduate and postgraduate at any level (that is, assistance with coursework and research), postgraduate research only. The postgraduate assistance is almost totally in statistics, whether with introductory undergraduate level statistics or with the statistics relevant to postgraduate research. It should be emphasized that Table 6 includes only assistance provided by the MSLS facility as reported in the survey or by website or direct consultation. It does not include any assistance given by mathematics and statistics staff outside the remit of the MSLS facility. This applies particularly to the postgraduate level as mathematics and statistics staff, especially the latter, are frequently approached for assistance by postgraduate and advanced level undergraduate students.

One of the most urgent and unmet needs in many universities is for assistance in statistics to postgraduate and honours students.

		Undergraduate	Undergraduate and postgraduate at ug level	Undergraduate and all postgraduate levels	Postgraduate research only	Total
Centrally-based		9	4	0	0	13
Maths-based		8	1	3	2	14
Both	Central	5	0	0	0	5
	Maths	4	0	0	1	

Table 6. Location and level of clientele of MSLS facilities

3.2.3 Types, subject areas and amount of assistance

Figure 1 below shows the most common types of assistance provided at undergraduate level by MSLS facilities. Others include advising, mentoring, diagnostic testing, and some MSLS facilities are involved in tutor training. Provision of resources is not included here as almost all MSLS facilities provide assistance in locating resources. Some have developed their own online and paper resources as well as providing links to other online resources. A section of the website developed under

the auspices of this project <http://silmaril.math.sci.qut.edu.au/carrick/> provides an audited catalogue of these and other key MSLS resources with links.

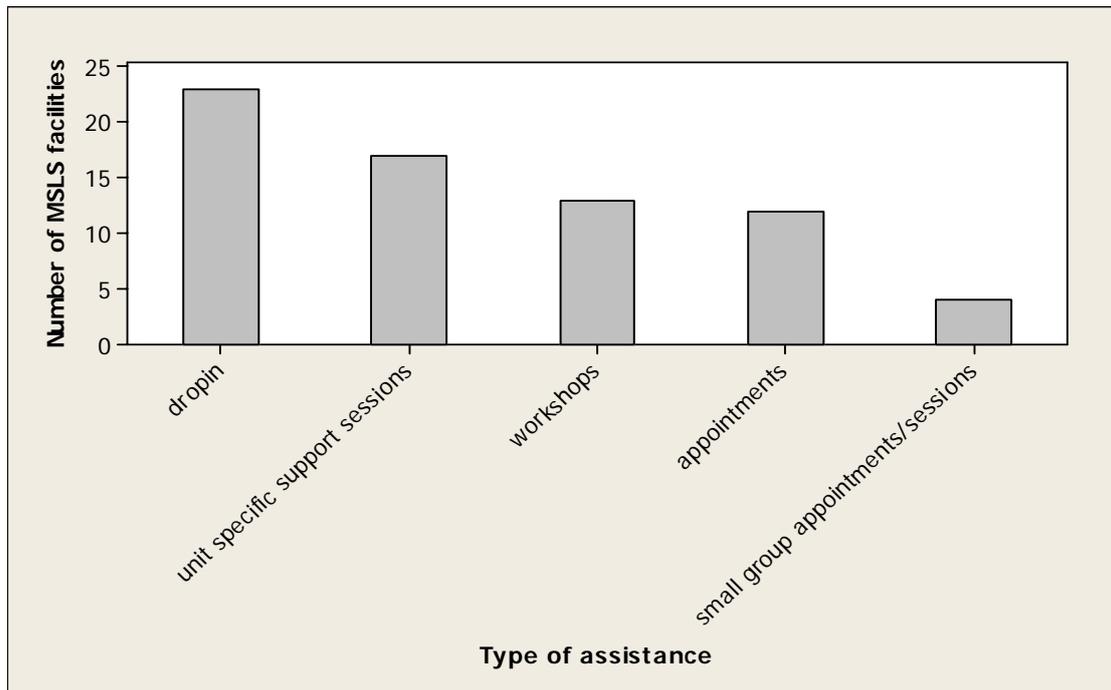


Fig 1. Most common types of assistance provided by MSLS facilities

Figure 2 below shows the frequency of disciplines/subjects/courses reported by MSLS facilities as the most common areas from which undergraduate users of MSLS services come.

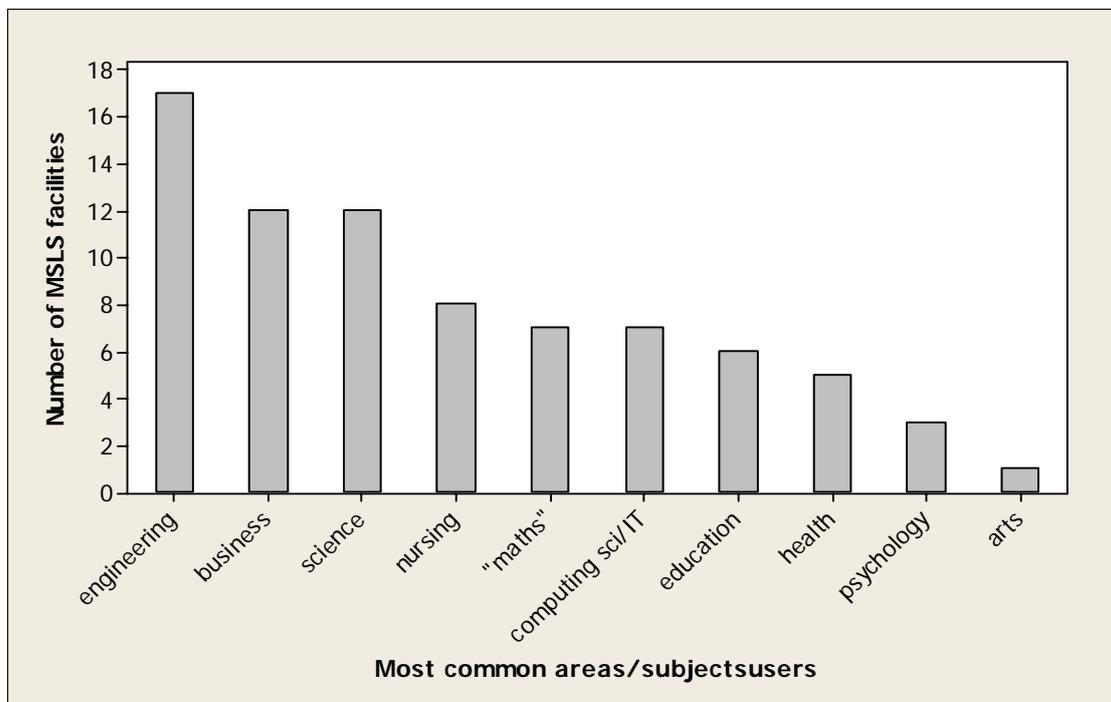


Fig 2. Frequency of most common areas/subjects of users of MSLS services

When maths is named, it is not always clear whether a distinction is being made between students doing a mathematics degree and students taking maths units within another course, and frequently it is not possible to distinguish. Hence specific mentions of maths by respondents are denoted by “maths” in Figure 2.

The most common areas above are no surprise to those involved with MSLS. Many MSLS facilities are providing lifelines for students in areas with the greatest problems and inner conflicts in perceptions of the roles of mathematics both directly and indirectly in their disciplines. Engineering, business and science are all highly dependent both directly and indirectly on maths skills and confidence, and these areas have been notable in their reduction of entry requirements and, more importantly, reduction of time in their courses given to developing their students’ maths skills and confidence. As in the UK, many MSLS facilities have developed and/or grown because of the needs of engineering students with weaker maths backgrounds than in previous generations and in course programs with less time given to developing maths. Also as in the UK, nursing is an area with highly diverse quantitative backgrounds amongst their students but with strict requirements for good skills and familiarity in a very specific area of maths, namely dosage calculations.

With twenty-three MSLS facilities naming drop-in in their list of services, it is the most frequently-offered form of assistance. For these facilities, Figure 3 below provides some indication of the number of hours per week this form of assistance is available.

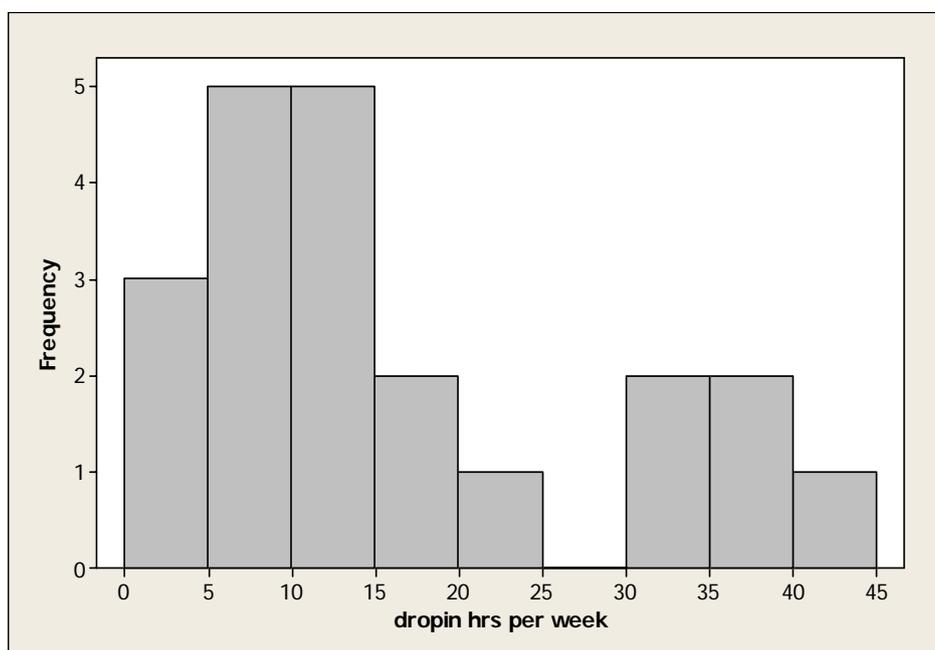


Fig 3. Histogram of number of drop-in hours per week for MSLS facilities offering this service

The number of hours of drop-in per week has more association with the size of the university and the age of the MSLS facility than the type of university. The five universities with facilities offering more than thirty hours per week of drop-in assistance consist of three of Australia’s oldest universities, another capital city

university and one regional university. The facilities consist of three centrally-based and two maths-based facilities established for lengths of time ranging from twelve to twenty-three years.

Figure 4 below shows the total number of hours per week for drop-in, unit specific support sessions and appointments for 26 of the MSLS facilities.

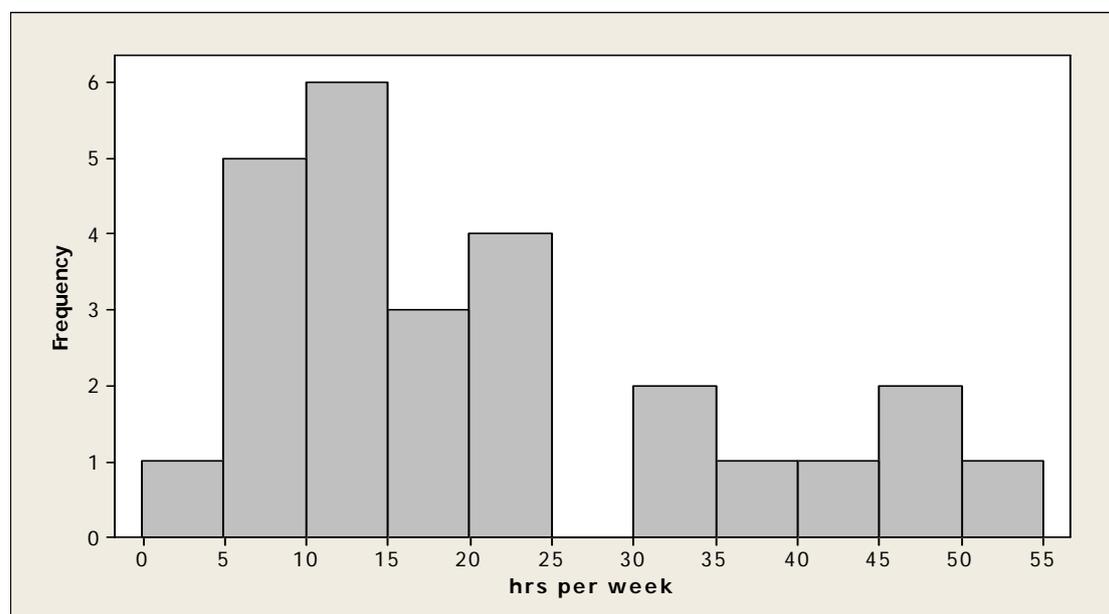


Fig 4. Histogram of hrs per week drop-in, unit specific sessions, appointments

3.3 Further information from facilities completing the written survey

Responses to the written survey were received from sixteen universities. The data from these are included in 3.2 above. This section provides some of the qualitative and extra information from the sixteen written surveys.

The sixteen facilities who completed the survey were reasonably representative of all the facilities reported above. One central learning support facility does not currently provide mathematics and statistics support but has identified this as a gap and is making moves to address this. Thus although this facility completed the survey, their responses do not refer to mathematics and statistics learning support and hence only 15 facilities are reported here. Another central learning support facility started offering mathematics support in 2007 in response to student and staff concerns.

The aims of the facilities are consistent with the reasons given in 2.3 above, and the spread of types of assistance, areas/subjects of users, and hours per week across these surveys is reasonably consistent with the overall spread reported above. The number of units/subjects serviced by the facilities varies from 2 to 50, with an average of approximately 15. The number of students using the facility per week varies, but averages or estimates range from 7 for a university with an advisor available for 6 hours a week for one-one appointments, to 380 for a facility that provides 36 hours of drop-in duty per week and 12 hours of unit-specific sessions. Nine of the facilities, ranging from the smallest to the largest, reported that these numbers come from records kept of usage and attendance.

Both online and paper resources are used; no facility reported using one in preference to the other. Only five of the facilities reported use of diagnostic testing. If diagnostic testing is used, students are given their results as the emphasis is on assisting students to understand their strengths and weaknesses. Only two of these facilities, both in Queensland, make use of collective results of diagnostic testing in their data analysis or research.

More than half the facilities do not have a fulltime person employed in mathematics and statistics learning support, including the most long-established facility. Whether fulltime staff are employed or not, all but two depend on part time, sessional and/or unpaid staffing. Thirteen describe their facility as permanent or longterm, with two subject to renewal, and all report at least a room as dedicated space. Figure 5 below gives the age of these fifteen facilities. As can be seen, these include the three oldest facilities of this type in Australia.

Only nine have their own website, and all use multiple and repeated ways of alerting students and staff to their services. In response to the question “Is the facility sufficiently known within the university?” only three responded with an unqualified yes. Five responded “moderately” or yes by certain groups of students, and two that initial recognition is high. Other comments were “reluctant to over-promote due to workload”, “can never be well enough known”. When asked to rate recognition of value on a 1-10 scale, the ratings ranged from 2 to 10, with a number of respondents commenting that recognition is higher in some areas of their university than others. Because learning support is voluntary, usage of facility is mentioned as the most common and in many ways best measure of success. Student surveys, evaluations, and direct feedback from staff and students are all mentioned. For postgraduate assistance in statistics, “Graduate Research School surveys highlight it in top 2 or 3 important services for postgrads”. Two specifically mention evaluation of effects on student performance.

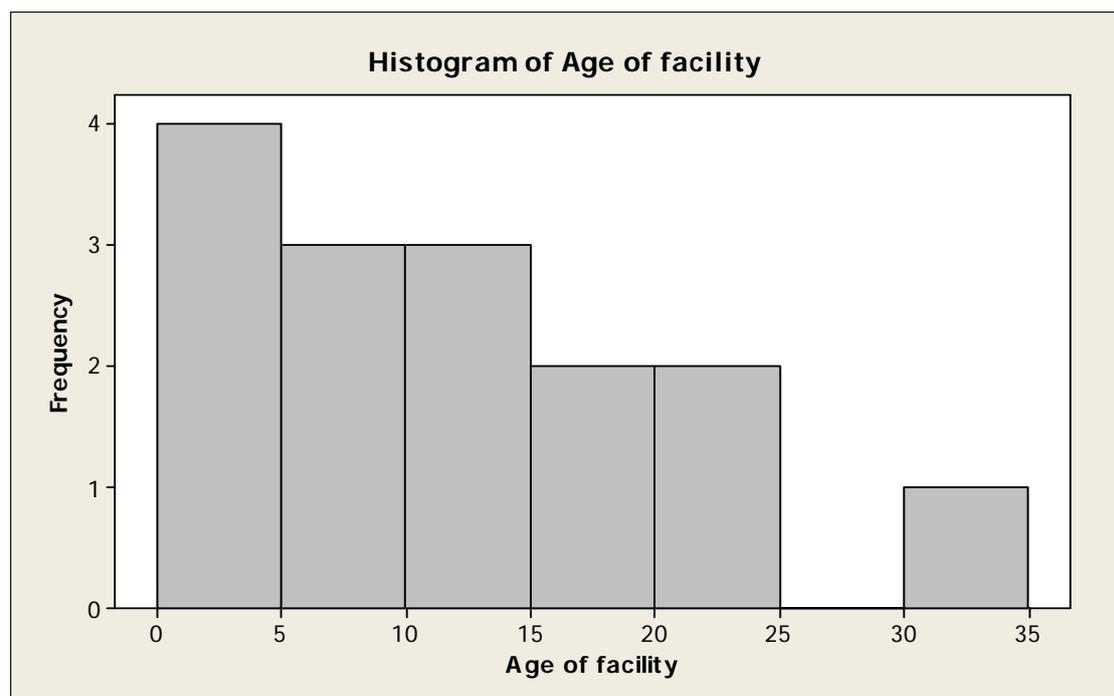


Fig 5 Histogram of age of facility

Comments on current main advantages include: “many students wouldn’t survive without it”, “drop-in room provides centre for activities”, “dedicated rooms accessible”, “responsive to the needs of the Schools and of students”, “there is a place to refer students who really need help because of...substantial problems with their assumed knowledge.”

Current problems are overwhelmingly staff, budgetary and space deficiencies in trying to meet increasing student needs and numbers, and a decrease in maths backgrounds. The threat of restructures, the unpredictability and sudden influxes of student demand, balancing workload, finding staff and lack of recognition all are mentioned. In providing statistics support for postgraduates, mention is made of problems caused by undergraduate statistics not being taught by statisticians, students leaving statistics to the last minute, and honours students and staff expecting to use a service funded only for postgraduates.

4. Recommendations in the provision of learning support in mathematics and statistics

The research reported in section 3 supports and illustrates the comments and discussion of section 2. The need for learning support in mathematics and statistics is not new as it is due to the nature of skills and confidence directly or indirectly essential in a wide range of university courses, but the need has been rapidly escalating to the point of necessity to acknowledge and fund it as a core university activity in fighting attrition and enabling students to develop and achieve to their potential.

This section combines the input from visits to facilities in Australia and the UK, papers and discussion at relevant conferences, personal and phone interviews, web and phone searches, surveys and the 2007 Symposium discussions, papers and forums, to present an overview of key points informed by input from, and observation of, facilities involved in learning support in mathematics and statistics in Australian and UK universities at the time of the project. The synthesis of the findings of the project enable recommendations to be made for the provision of, and good practice in, effective and efficient university-wide learning support in mathematics and statistics.

4.1 It is time for learning support in mathematics and statistics to be part of core university business

Australia’s learning support in mathematics and statistics has tended to arise in response to need and been driven and championed by individuals with vision and commitment. This is partly why much of their achievement has tended to be taken for granted; other reasons include trivialisation or ignorance of the importance of mathematics and statistics confidence for student learning across faculties and disciplines. The latter is symptomatic of a general denial of mathematics for more than a decade, the consequences of which must now be acknowledged and faced by all types of universities. Every aspect of mathematics and statistics education in higher education needs to be strengthened, and learning support in mathematics and statistics is a critical component within this totality of learning and teaching in enabling student learning and avoiding preventable student attrition. Universities need

to include ongoing sustenance and strategic planning for such support within their overall learning and teaching plans. It is an area in which a small quantity of resources in the overall university scene can produce enormous dividends in student learning, satisfaction and success.

However to produce such dividends, learning support in mathematics and statistics must be recognised as part of core business and championed and supported from the top. This was overwhelmingly the message common to all input, discussion and research, including universities that do not currently have mechanisms for learning support in mathematics and statistics but say they should have. 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 ongoing 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.

Just within the period of this project, facilities have suffered setbacks in restructures, loss of resources or loss of staff, simply because the nature of their roles and contributions have not yet been fully recognised and allowed for in a sustainable way. During the same period, in other universities which were without, or had previously possessed and then closed, such a facility, the need has become so great it could no longer be ignored and steps are being taken to meet it. It is time for such rollercoasters to be replaced by secure and strategic planning.

4.2 Structure and funding of learning support in mathematics and statistics

Details of structure and funding arrangements are likely to continue to vary across universities but a number of general principles assist in facilitating maximum and ongoing effectiveness and efficiency. Whether a facility providing learning support in mathematics and statistics is associated with a central facility or a mathematics department or both, it needs its own identity and sufficient autonomy in its resourcing and accountability to be seen in its own right by students and staff across the university. The ideal arrangement is to be an entity in itself, reporting to the overarching academic body of the university, but with at least associations or links with mathematics and statistics and with any central learning support agency. All aspects of the connections between the discipline-specific program providers and the learning support systems need to be strong, collaborative and complementary.

If the facility is not closely associated with a mathematics/statistics department, there must be at least some mechanisms for strong inter-relationships with the learning and teaching of mathematics and statistics in higher education,

- to facilitate the interchange of experience, expertise and information
- to expedite training, recruitment and retention of appropriate staff, including sessional staff, to mutual benefit
- to facilitate appropriate diagnostic testing, data collection and analysis
- to develop and disseminate research and scholarship with maximum impact and relevance
- and for the sustenance and satisfaction of continuing staff.

The conferences and journals in learning and teaching in mathematics and statistics in higher education have included, and continue to include, scholarly papers on learning support in mathematics and statistics. There is growing recognition that mathematics and statistics education in the university sector requires its own research and pedagogic focus.

If the facility is not closely associated with a central learning support facility, there should be mechanisms for sufficient links for information sharing, for mutual benefit and awareness within the university-wide context, for informing university management, and for facilitating information flow and assistance to faculties. In addition, within the research of this project, it has been very clear that the general scholarship of learning and teaching in higher education needs far more input from, and knowledge and understanding of, the roles, contributions, practicalities and pedagogies of learning support in mathematics and statistics in universities.

If a university chooses to include the provision of courses or programs that substitute for prerequisites or assumed knowledge within the same facility as the provision of learning support in mathematics and statistics, it is essential to resource both and to differentiate between the two for students, staff and management. There is, however, increasing recognition that acceptance into courses of students without prerequisite or assumed knowledge places the responsibility for redressing this absence on course structures which allow students the necessary time to acquire the skills and knowledge of their fellows. This increasing recognition reflects the growing realisation of the damage to the interests of universities, students and hence the community, of denial of the fundamental and underpinning role of mathematics in learning across higher education.

Delegates to the 2007 Symposium and all those involved in learning support in mathematics and statistics in universities in Australia and the UK, and in some universities contacted during the project in New Zealand and other countries, unanimously emphasized the importance of networking between providers of this support. Part of the mission of the UK's CETL fulfils this role within the UK and also links with providers and networks elsewhere. This project and its website <http://silmaril.math.sci.qut.edu.au/carrick> provide the lead to build and maintain such a network in Australia. Within months of the 2007 Symposium, the effects of the project and budding networking were apparent in supporting new and younger workers in the area, and developing synergies between more established workers to facilitate further projects. However the past has shown that because staff often move between learning support in mathematics and statistics and other fields, such networking must be supported, encouraged and possibly even facilitated by institutions. Memoranda of agreement amongst individuals have not, and will not, work. This matter should be discussed by university academic managements.

4.3 Physical and electronic structure and facilities

As with institutional and funding structures, details of physical and electronic resourcing may vary across universities, but again findings from the research of this project provide common principles to assist in planning and implementation.

As discussed in 3.1.1 above, websites are essential for information within and across universities. Some recommendations for good practice are given in 3.1.1 above.

As demonstrated in 3.1.2, it is also essential for the facility to be well known within its institution, with clear contact information available for any phone enquiry.

As seen in 3.2.3, the most common form of service provided is a drop-in room. This ideally should be a space where students can work, can access at least paper-based resources and can access assistance from a duty tutor during specified hours. Its value is lessened if it is only available when a tutor is on duty or if there is no staffing assistance at all. Its atmosphere should be conducive to work with collaborative work encouraged provided others are not disturbed. Provision of another nearby area for collaborative work may assist in maintaining the appropriate environment of quieter work with assistance in the drop-in room. Availability of wireless and computers increases the value to students of such areas and will also ensure that security and/or monitoring are provided, which increases in itself the learning value of the space.

Because the students who most need learning support in mathematics and statistics often require the most encouragement to access the support, this core space should be welcoming and in a location easily seen and accessed by students. The challenges of multi-campus universities need to be considered without precluding the voluntary and therefore somewhat unpredictable nature of the usage of the assistance. The technology of live remote access, such as chat rooms and tablet technology, may be of assistance, particularly where campuses are distant from each other.

Whether resources are paper-based or electronic, easy-to-find and well-indexed bite-size resources are of most value for students seeking to consolidate background skills and knowledge, to strengthen weaknesses that are often highly individual and may be quite local, and to access specific-purpose assistance.

4.4 Nature of support and staffing

The staffing of drop-in facilities as described above may consist of a mixture of highly experienced and less-experienced staff, and of sessional, fulltime and volunteer staff. Duty tutors should not be subject-specific but the publicising of general levels and/or areas for which assistance is available and/or for different duty tutors is helpful for students and can avoid difficult situations such as demands from advanced students in other areas for highly-specific assistance. Even a small amount of drop-in duty time is an ideal way for staff to learn of the range and extent of types of difficulties and questions from students across different courses. Mentored drop-in duty can also be an invaluable component in a program facilitating learning to teach mathematics and statistics.

Specific topic support sessions are often popular with students and can be excellent ways of assisting students in areas of common need. The choice of such areas and how to tackle them in a group situation should be informed by student work and staff advice. Common needs in a discipline may be highly specific as in medical dose calculations in nursing, or extensive as in engineering, or variable as in business, science and social sciences, or more generic as in health, information technology, law and humanities. Such information may come from experience, from collaborative or liaison work with staff in other areas, or from diagnostic testing. Diagnostic testing is

very valuable in informing students of key background knowledge and skills needed in a subject or course, and guiding them to appropriate specific-topic sessions.

Because of peak periods and irregularities in demand, and course or subject-specific needs, sessional staff are important in staffing. Recruitment, training, monitoring and mentoring of sessional staff are not trivial exercises, and can be demanding of leaders in time and emotional energy. Sharing of this with relevant academic groups can assist in sharing the load, staff and mutual information and understanding.

The ongoing academic staff component of the facility needs to have expertise and experience in the learning and teaching of mathematics and statistics across disciplines at the university level, with particular experience at the first year level and with the variety of backgrounds of students accepted into tertiary courses. Such qualities may not necessarily reside in individual staff members but need to be considered in the overall composition of staff. Full time or fractional teaching staff should be academic staff with terms, conditions and support that encourage development and retention.

4.5 Postgraduate support in statistics

This area emerged during the project as one of the most needed across disciplines and across universities. These are genuine learning support needs of students and differ to the needs of researchers for statistical consulting or collaboration. Like undergraduate students, postgraduate students need confidence and skills that underpin their work as well as sufficient understanding of specific statistical tools to feel secure in defending their use in their research. Most postgraduate students need to consolidate, revisit or extend their prior exposure to statistics in order to understand it from a more mature point of view. As for undergraduates, it is time for universities to acknowledge and include in core business the needs of postgraduate students across disciplines for learning support in statistics. As above, the structure and funding mechanisms for providing such support may vary across universities. But it is learning support in conjunction with research student support. What is essential is that it is recognised and provided in a way that distinguishes it from statistical consulting and collaboration for research, even if such services may be linked by location, funding, chain of management or staffing.

4.6 Data collection and analysis

It is in universities' interests to ensure that a facility providing learning support in mathematics and statistics has sufficient resources to include collection and analysis of data as these provide invaluable information for course structuring, for staff in many disciplines and for university monitoring and management of student progression and attrition. Data can include usage of support services, diagnostic testing, effects on student performance, effects of backgrounds, and longitudinal analysis. The last three require collaboration between the MSLS facility and the discipline-specific providers, and sound statistical analyses.

5. Conclusion

This report brings together history, background, research, discussion and discovery about learning support in mathematics and statistics in Australian universities in order to inform the whole university sector of the need for such support to be part of core business in supporting students across faculties and disciplines. Recommendations are made to assist universities in strategic planning and management of such support, to outline aspects of good practice in the provision of such support, and to illustrate how good practice can effectively and efficiently contribute to improving students' potential for learning and achievement.

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