Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities

A report for the Australian Learning and Teaching Council in the Leadership for Excellence in Learning and Teaching Program

Queensland University of Technology

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Executive Summary

In 1973 a Counsellor in Mathematics was appointed at the Australian National University. This was the first example in Australia of recognition of the need for learning support in mathematics and statistics. 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 additional to the formally scheduled classes and activities of their enrolled course.

There has always been, and always will be, need for reliable and expert help for students in numeracy, mathematics and statistics across a wide range of disciplines in universities. There are few disciplines at the tertiary level that do not rely at some stage on at least some quantitative confidence, whether the dependence explicit or implicit. 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. It is this transferability of mathematics and statistics that is the source of both their power and their challenge. The totality of mathematics teaching in a university comes from mathematics and statistics departments, within courses in other disciplines, and learning support in mathematics and statistics. The components and their mutual arrangement within this totality depend on the university, its courses and structures.

However in all types of universities, the need for learning support in mathematics and statistics has been increasing rapidly, with students from all faculties, including postgraduates, seeking support for their learning and survival. Factors of this increasing student need include changes in school educational emphasis over the past two decades, diversity of entry pathways, increased pressures on universities, decreased prerequisites, decreased numbers of mathematics and statistics providers, and the increasingly quantitative and problem-solving needs of a modern technological society. McInnes and James (1995) identified lack of mathematical skills and confidence as a barrier for success for many students, and, if anything, the situation has worsened since then.

In the past fifteen years, in almost every university in Australia, at least some form of learning support in mathematics and statistics has been started. In 2007, 33 of Australia's 39 universities had at least some form of support. However because this is usually in response to specific needs and often dependent on highly-motivated individuals, there has been a lack of consistency, sustainability and knowledge of this learning support. Also, as described in this report, although individuals had made contact and interacted at some conferences, Australia had not previously had the benefits of the variety of higher education systems in the UK, starting with the Teaching and Learning Technology Projects in 1992, that have consistently emphasized a national within-disciplines, across-universities approach.

The challenge for this Project was to develop national capacity and networking in cross-disciplinary mathematics and statistics learning support to enhance student learning and confidence. Through a range of processes of discovery, communication, collation, collaboration, cooperation, conferencing, auditing, analysis and annotation, the Project has brought together knowledge, awareness, understanding and resources to build leadership capacity and national community of practice. Through its synthesis and analysis, the Project has also produced an account and guide for the university sector on the need for, and provision of, learning support in mathematics and statistics.

http://silmaril.math.sci.qut.edu.au/carrick

Part 1 The Project Plan

1.1 Rationale

Numeracy, mathematics and statistics - their tools, their thinking and their associated generic skills – are needed directly or indirectly in many disciplines, with the mix and extent of implicit and explicit need depending on the discipline. The reliance can range from basic numeracy and simple concepts in data to discipline-specific mathematical or statistical methods. Mathematical thinking can be thought of as part of the generic skills that are developed through learning, using and practising specific mathematical skills. It is at the tertiary level that the solidarity of foundational mathematical skills and confidence are tested, as students are required to use and build on them in a range of demanding new contexts.

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 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 only on specific mathematical tools in considering how mathematics is needed, and ignoring all the skills and thinking power that come from mathematical development. Like language, numeracy confidence and mathematical thinking need time to develop, need to become a part of the individual, and, if specific skills are needed in a fully usable, transferable way, then mathematics and language need to be studied past – often significantly past – the level of those specific skills.

Over the past decade or more, the diversity of numeracy, mathematical skills and knowledge across tertiary cohorts has been increasing rapidly. This increased diversity is due to many factors including alternative pathways to tertiary education, changing patterns in student tertiary choices, cultural and first language diversification, the need to attract more students into some areas and/or some universities, and the many changes across schooling, 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.

Combined with greater focus on reducing attrition and on students as clients, and with pedagogical and professional demands on courses, this increased diversity and general decrease in background mathematical skills have necessitated changes in learning and teaching strategies across all disciplines. The challenge is in all tertiary programs, including mathematics and statistics degree courses themselves, but can be at its most severe and detrimental to student progression in other disciplines and the so-called ‘service courses’. For many tertiary staff and students in disciplines outside mathematics and statistics, the increased diversity and deficiencies in basic mathematical skills and confidence can be startling, 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. The generic skills, quantitative confidence and problem-solving capabilities developed over time by the doing of mathematics and statistics are generally not well understood outside the disciplines of mathematics, statistics and cognitive psychology (Vergnaud, 2004), or outside the experience of mathematics and statistics graduates who discover they are the “problem-busters” across a wide range of workplaces (Harlow, 2000).

Because universities cannot sustain, and the community cannot withstand, withdrawal and failure rates associated with the so-called but widely misunderstood “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.

However, in many universities, individuals or groups within mathematics and statistics departments or some central student support body or both have developed some measures for support for student learning in mathematics and statistics to try to meet the challenges of increasing diversity of background and confidence. 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, 2006 and 2007, Robinson and Croft, 2003), collection and analysis of data (MacGillivray and Cuthbert, 2003, Cuthbert and MacGillivray, 2007) and support for postgraduates (MacGillivray, 2003). These aspects of university-wide support for student learning in mathematics and statistics are of increasing importance.

The growth of such support measures has also occurred in other countries, most notably in the UK. As in a number of universities in Australia, the support in UK universities started as extra help for students in specific courses, such as mathematics and engineering, or business, or nursing, with some extending this to other areas and others not. In the UK the existence of the Learning and Teaching Support Networks, which are now Subject Centres of the UK Higher Education Academy, provided a collaborative network for sharing information, strategies and resources for these forms of support for student learning. Outcomes of the collaboration and leadership in the UK in this area include an audit of UK support centres in 2002, identification of good practice in the UK (Lawson et al, 2003) and the establishment of a (joint) Centre of Excellence in Teaching and Learning (CETL) in the Provision of University-wide Mathematics and Statistics Support, at Loughborough and Coventry Universities.

In Australia, individuals and groups involved in some form of learning support made contact with each other through attendance at conferences associated with a variety of professional groups or associations both nationally and internationally. The Project researched the background and development of the linkages formed through these contacts and the contributions made to learning support, bridging mathematics and adults’ learning mathematics. These are reported in the Guide in Appendix E. However without a systematic and systemic approach, and without the benefit of the cross-institutional networks and subject centres of the UK, fragmentation of national knowledge, awareness and capacity was inevitable. The disciplinary and cross-disciplinary priority of the Leadership for Excellence in Learning and Teaching Program of the Carrick Institute for Learning and Teaching in Higher Education, provided an opportunity to investigate, analyse and bring together the varieties of programs and facilities for learning support in mathematics and statistics in Australia, with the aim of

developing national capacity and leadership in this increasingly important aspect of enhancing student learning across the higher education spectrum.

1.2 Objectives of the Project

1.2.1 Overall objectives

The heart of the aim of the Project was the development of leadership capacity and sustainable systems in the provision of student access to skills that will help them to build confidence and decrease impediments to success in their courses. This required a systematic approach inclusive of all disciplines to provide enabling skills and knowledge in latitudinal provisions that encompass both discipline-specific and cross-disciplinary needs. The Project aimed to establish communication, networks and collaboration across all Australian universities in developing and sustaining university-wide student support in mathematics and statistics. Despite their differences, all Australian universities share at least some concerns and interests in this endeavour.

In 2006 knowledge and networking depended on the work of individuals and their professional and community efforts. It appeared that strategies ranged from drop-in support for specified groups to broader-based more extensive support, but little was known by 2006 of the details and the extent of support across Australia. The development of national networks and communities of practice is essential in order to build the capacity for quality in student learning and support. As the need for disciplinary and cross-disciplinary support for student learning in mathematics and statistics has grown, so has the need for national networking, collaboration, leadership and sustainable systems in this area. The Project aimed to make a significant beginning in meeting this need, providing and developing leadership in a fundamental educational experience that responsively moves across differentiation in disciplines and professional preservice programs.

1.2.2 Summary outline of the Project's objectives

The Project's objectives to fulfil its aim were to:

- audit the current services, background and needs in mathematics and statistics support for all Australian universities
- initiate a national network and community of practice in this support, and foster leadership development
- liaise with concerned and interested professional organisations and organisations for whom the Project is relevant and/or of interest
- liaise with university academic leaders and leaders in generic approaches to the enhancement of learning and teaching
- identify current resources, databases and arrangements for sharing resources and collaboration on future developments
- benchmark Australian practices
- develop guidelines of best practice in this area
- develop sustainable systems and leadership building capacity for a national approach to university-wide support for disciplinary and cross-disciplinary student learning in mathematics and statistics
- strengthen and develop collaboration with the UK in this work
- strengthen and develop Australia's international profile in this area

1.2.3 The outcomes the Project was designed to achieve

The deliverables planned for the Project were:

- a comprehensive report and analysis of the current nature and extent in Australian universities of provision of learning support in mathematics and statistics
- report of the proceedings of a national symposium
- an inventory and classification of resources with comments
- strategic plans for a sustainable structure for a national collaborative network and community of practice in university-wide quantitative support with collaborative international linkages
- a website to support the above
- recommendations of strategies and examples of good practice in the provision of learning support in mathematics and statistics
- leadership and further collaboration and projects by members of the community of practice established by this Project.

In addition to the above deliverables, anticipated long term outcomes of the Project include

- enhanced student learning and confidence in quantitative underpinnings across disciplines
- enhanced understanding of the quantitative needs of students in many disciplines
- better data and analysis of the mathematical backgrounds of students entering tertiary study and of the role(s) of this background and of university support in their progression
- increased awareness in the tertiary and government sectors of the nature of students' mathematical needs for tertiary study across disciplines and the role(s) of underpinning mathematical skills across disciplines
- collaboration and joint work with UK centres in university-wide mathematics and statistics support, including extensions to other countries
- increased international recognition of Australia's work in the areas of cross-disciplinary mathematical and statistical support.

Part 2 Approach and methodology

The approach and methodology consisted 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 the Guide of Appendix E.

2.1 Discovery

In order to inform the collection of information, the design of a survey, the planning of the Symposium and overall approaches of the Project, the Project leader visited seven universities providing learning support in mathematics and statistics in Australia and three in the UK.

These universities were selected for initial visits as preliminary work in the Project showed that the arrangements for learning support in mathematics and statistics at these universities differ significantly in almost all aspects of their operation and history. Also, two of these universities have some of the longest established, but greatly contrasting, facilities for mathematics learning support in Australia. Extensive discussions with staff at the Australian facilities were extremely valuable in further planning of approaches, illustrating the range and magnitude of differences between such facilities.

The UK facilities visited were the Skills Unit in London South Bank University's (LSBU) Centre for Learning Support and Development, and Loughborough University's Mathematics Learning Support Centre (MLSC), which was awarded a Centre for Excellence in Teaching and Learning (CETL) by the UK's Higher Education Academy in 2005. These are two very different types of facilities with very different histories and characteristics, but both are regarded as first class within the UK and internationally.

2.2 Collection and collation of information

Information was collected through a number of different, complementary methods – web, phone, survey, and feedback from dissemination.

The initial investigation was via web searching seeking the existence, nature and web presence of mathematics learning support in all Australian universities and campuses. This was carried out from the point of view of students, staff members and external enquirers. This was followed by a similar investigation conducted by phone from the point of view of an external caller to the university asking if the university had such a facility and, if so, could the caller please be put through to it. The combination of these investigations also provided a database of contacts for national information requests, provision, liaising and networking. The results of these investigations were put together in Wilson (2007) and disseminated by email and to the Symposium delegates.

Based on the discovery phase, a comprehensive survey was designed and sent to the contacts obtained through the web and phone searches. The recipients were asked to forward the survey to the appropriate staff member in their university if this was not them, and to feel welcome to phone the Project team with any queries or for discussion.

A summary of core information from the web, phone, initial survey returns and visits by the Project leader was prepared and provided to Symposium delegates and university contacts. During and after the Symposium, they were encouraged to correct any

information, provide extra information if they wished, and complete the survey if this had not been done. Further phone calls were then made to obtain at least the core key information for each facility. This information was collated and again disseminated to all delegates and contacts.

2.3 The national Symposium

A highlight of both the Project and the Project's methodology was the Symposium on Learning Support in Mathematics and Statistics, which was held at QUT on July 19th, 20th, 2007. Notice of the Symposium was sent out to the recipients of the survey, to members of the Australian Mathematics Society (AustMS), to members of the Statistical Society of Australia Inc (SSAI), to DVC's (academic) or their equivalent, to the Association of Academic Language and Learning, to Education Network Australia (edna) and to the Australasian Engineering Education network.

The aim of the Symposium was to provide an opportunity for presentations, networking and discussion amongst staff involved in learning support for mathematics and statistics, with the focus on sustaining and developing this across Australian universities. The presentations, forums and panels were carefully chosen to provide a mix of information and discussion points ranging across the wide variety of models, practicalities, strategies and concerns across Australia and the UK. The panels included students and staff from other areas. Delegates were invited to provide feedback either by direct email or through a form that could be submitted anonymously.

The Symposium played a key role in the methodology of the Project, not only providing invaluable information, but most importantly, in laying the foundations for development of leadership capacity and the establishment of communication, networks and collaboration across all Australian universities in developing and sustaining university-wide student support in mathematics and statistics.

2.4 Within-project dissemination to direct stakeholders

Throughout the Project, ongoing dissemination to the direct stakeholders involved in providing learning support in mathematics and statistics, continued to contribute to information gathering and the development of networks, collaboration and leadership capacity. As described in 3.2, the information gathering continued after the Symposium via dissemination, feedback and follow up phone and email contact.

The Symposium report was written in accordance with suggestions and requests received during a forum at the Symposium and disseminated to all delegates, contacts and DVC's (academic). As requested, the first part of the Report was written in such a way as to assist learning support providers within their own institutions; this part is attached as Appendix D. This contributed further to the building of leadership capacity, particularly amongst newer providers.

2.5 Establishment of a website

The establishment of a website was a critical factor in the methodology to achieve the objectives of

- strategic plans for a sustainable structure for a national collaborative network and community of practice in university-wide quantitative support with collaborative international linkages, and
- leadership and further collaboration and projects by members of the community of practice established by this Project.

By starting it as initially a website for the Symposium, the aim was to also assist in establishing it as a long term website for promoting networking, sharing information and resources, and developing collaborations. After the Symposium, the website was therefore given the name of Australian Network in Learning Support in Mathematics and Statistics (ANiLSiMS)

2.6 Auditing and cataloguing resources

The first step in sharing resources and developing further collaborative resources is to audit and catalogue those currently available. An additional complication with web-based resources is the tendency for cross-linking across sites to produce a complex inter-related messy labyrinth with considerable overlap and no hierarchy or system. Resources produced by a particular facility and placed on their website will be organised and classified according to their use which is often associated with their institution's courses and structure. But many websites also include links to specific resources on other websites, either selected to complement their own or as a general non-annotated resource. That is, individual websites are naturally organised to fit the needs of the institution or facility supporting the website, and this creates a vast system of cross-connections with overlaps and inconsistent classification schemas. This is a disincentive to staff looking for resources. In addition, the more resources that are available, the more daunting it is to search for, and assess the value of, those on particular topics.

Hence, in pursuing its objectives of facilitating networking, collaboration and the leadership capacity that is grounded in helping people develop links across universities and across professional lines, the Project's objective in auditing and cataloguing resources was to provide a systematic umbrella across websites that would facilitate both the overview of resources available on topics and the finding of suitable resources for specific needs.

2.7 Analysis and synthesis of findings to produce a guide

The final component in the approach of the Project was to analyse and synthesize the wealth of information collected through the discovery, web, phone, survey, Symposium and within-project dissemination phases, to produce a guide to the history, nature and provision of learning support in mathematics and statistics in Australia. It also includes recommendations arising from the findings of the Project. This Guide is included as Appendix E of this report and is available as a separate publication. It will be widely disseminated within and outside Australia, and is intended to inform and assist the providers of learning support, all levels of university management and leadership, professional associations and government.

Part 3 The progression of the Project

3.1 September, 2006 – March, 2007

After some initial contacts and discussions by phone, the Project leader undertook visits to staff and facilities providing learning support in mathematics and statistics in the University of New South Wales (UNSW), the University of Sydney (USyd), the University of Technology Sydney (UTS), Macquarie University (Macq), RMIT University, University of Melbourne and Swinburne University. The arrangements for learning support in mathematics and statistics at these universities differ significantly in almost all aspects of their operation and history. Also, two of these universities have some of the longest established, but greatly contrasting, facilities for mathematics learning support in Australia. Hence visits to them not only enabled indepth information to be obtained about these particular facilities, and valuable liaisons established, but also provided information for the design and development of an Australia-wide survey.

In January-February, 2007, the Project leader travelled to the UK, visiting staff and facilities in London Southbank University (LSBU), Glasgow University and Loughborough University, and participating in planning and joint projects. At Glasgow University, the Project leader participated in the updating and extension of web-based learning and teaching support programs in statistics.

The LSBU Skills Unit provides a wide range of services across all faculties in a university with significant cultural, racial and socio-economic diversity. Discussions were held with Susan Starkings, Head of the Skills Unit, who established a central facility in learning support in mathematics and statistics when LSBU's mathematics and statistics department was closed in the mid-nineties. This department had provided learning support to specific student groups including engineering, science and nursing, and had collected data which Susan analysed to demonstrate the enhanced learning and decreased attrition amongst those students who used the learning support. The original learning support expanded to become the Skills Unit which receives visits and much interest from other universities in the UK and abroad, investigating the establishment, expansion or adaptation of learning support. The Unit's program is extensive and includes specific topic sessions, drop-in workshops, one-one appointments, statistical assistance for postgraduates, support and testing for trainee teachers. 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 mathematics pre-entry for social work. Mathematics support includes and makes use of the mathcentre and mathtutor resources developed and available from the Loughborough Mathematics Learning Support Centre, as described below. Support for nursing students is a major component. Sessional staff are carefully selected, trained, mentored and monitored, and collection and analysis of data on the effectiveness of programs remain a core activity. Some difficulties due to being just one part of what has become a large central facility are beginning to emerge.

The major component of the UK visit was to Sigma in the Loughborough University's Mathematics Learning Support Centre (MLSC). Sigma is the UK's Centre for Excellence in Teaching and Learning (CETL) in Mathematics and Statistics Support, awarded jointly to Loughborough and Coventry Universities, (headquartered in Loughborough University) whose mathematics learning support centres took the lead within the Maths, Stats and OR (MSOR) LTSN in benchmarking and networking mathematics learning support in the UK (Croft, 2000, Lawson, Halpin and Croft, 2001, 2003). Well-funded projects have produced considerable resources in the UK, 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 mathematics, mathematics support and mathematics 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/. Sigma is enhancing existing provision and addressing mathematics and statistics support needs proactively, including strengthening the capacity to support students 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 mathematics support centres, and underpinning all activities with a substantial programme of pedagogic research. The CETL is eager to liaise with Australian developments, and during this visit the Project leader was appointed as a Visiting Fellow to the CETL to develop plans for joint research projects and Australia-UK links. During the visit to the CETL, the Project leader gave two presentations, *University-wide maths and stats support on a wing and a song,* and *Diagnostic testing*, with the latter being the plenary at a Loughborough-Coventry conference.

Between November and February, the investigation via the web into the existence, nature and web presence of mathematics learning support in all Australian universities and campuses, was carried out from the point of view of students, staff members and external enquirers. This was followed by a similar investigation conducted by phone, again from the point of view of external enquirers who could be staff or students. A database of contacts for national information requests, provision, liaising and networking was also established. Reports based on these investigations were prepared to provide informative overviews of the national situation with respect to web and phone information on mathematics learning support in Australian universities.

Based on the combination of information obtained through the visits and research within Australia and the UK, a comprehensive survey was developed and emailed in March to relevant staff in 38 Australian universities. The survey was also informed by similar surveys that have been conducted in the UK. The survey consisted of 34 questions on the nature, extent, usage, funding, reporting line, clientele, staffing, data, location and resources of any learning support in mathematics and statistics for undergraduates and/or postgraduates in the university.

The staff to whom the survey was sent were located through the prior web and phone investigation described above. The recipients were asked to forward the survey to the appropriate staff member in their university if this was not them, and to feel welcome to phone the Project team with any queries or for discussion. The survey is in Appendix A.

Of the 38 surveys sent, 13 responses were received before the Symposium and 3 after. A summary of the main information from the surveys received before the Symposium, from the web and phone investigations, and visits by the Project leader, was prepared and disseminated for discussion and feedback at the Symposium.

Another source of information during this phase of the Project was Professor Malcolm Gillies. In his welcome to the 2005 AALL (Association for Academic Language and Learning) Conference, Professor 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.

Following this plea, together with the realisation that the demand for learning support in mathematics was rapidly increasing, the AALL became interested in numeracy. During the phases of collection and collation of information via various methods and sources, it was discovered that AALL was conducting a survey of its members on numeracy needs and demands. Thenceforward the Project therefore included AALL along with all the other relevant professional associations in its contacts and dissemination stakeholders.

Professor Gillies' comments are geared towards numeracy for citizenship similar to literacy for citizenship. Although the fostering of citizenship numeracy is clearly part of the totality of mathematics and statistics education over all of society, it is different to providing learning support in the mathematical and statistical skills needed by students for, and during, study for their degree. The former is a general graduate capability for citizenship; the latter is enabling the student to obtain his or her chosen degree and is contributing to the fight to prevent attrition in university courses. This is discussed further in the Guide of Appendix E.

3.2 April-September 2007

3.2.1 The national Symposium

Amidst increasing awareness of the fundamental roles of mathematics and statistics in a modern society, a Symposium on Learning Support for Mathematics and Statistics was held at the Queensland University of Technology (QUT) on 19th-20th July, 2007. The Symposium provided an opportunity for presentations and discussion amongst staff involved in learning support for mathematics and statistics, with the focus on building and sustaining networking and developments across Australian universities.

The Symposium aimed to incorporate a range of matters of interest to all those involved in such learning support, including:

- an overview of the current services, backgrounds and needs in Australian universities
- plenary papers from national and international leaders in this area describing something of the diversity of challenges and achievements to date
- presentations from individuals and groups directly involved in the provision of such support
- discussion of current and future needs, plans and strategies
- development of collaborative networks for sharing resources, information and support
- strengthening awareness of the value and importance of mathematics and statistics learning support across the tertiary sector
- development of strategies for promotion and increased support for mathematics and statistics learning

Symposium delegates and speakers from all types of universities – from the most to the least traditional, from both city and regional universities – came together to share experiences, challenges, hopes and fears for the future. Delegates represented the diversity of forms of learning support in mathematics and statistics that have developed separately in universities across Australia. Presenters, panellists and delegates reported on, and discussed, developments and progress in Australia, with input also

from the UK, where, in the past decade, there has been national fostering and financial encouragement of networking *within* disciplines *across* the university sector.

The Symposium was not attached to any particular association, nor did it offer an opportunity for refereed papers. The Project funding enabled the registration to be kept low while still providing conference services and plenary speakers of international standing, and the School of Mathematical Sciences also provided considerable funding support. Notice of the Symposium was sent to mathematics support centres identified through a web/phone search, to members of the Australian Mathematics Society (AustMS), to members of the Statistical Society of Australia Inc (SSAI), to DVC's (academic) or their equivalent, to the Association of Academic Language and Learning (AALL), to Education Network Australia (edna) and to the Australasian Engineering Education network.

Fifty-six delegates from 26 Australian, 1 New Zealand and 2 UK universities attended the Symposium. The list of universities represented at the Symposium is provided in Appendix B. It was very beneficial to have representatives of all types of Australian universities with their diversity of students, courses and campuses. The Symposium program is provided in Appendix C. The presentations and panels were carefully chosen to provide a mix of information and discussion points ranging across the variety of models and practical issues across Australia, with input from the UK. Delegates were eager to hear about activities and challenges in different universities and to share experiences. The panels of students and staff from other areas were also well-received.

Presentations, panels and discussion ranged widely, but the **commonality of issues across *all* types of universities** was significant. These include:

- insufficient overt recognition of the critical roles of mathematical and statistical skills in underpinning student success in many courses, including postgraduate
- the need for universities to acknowledge and act on their responsibility to care for students permitted to enter with diverse mathematics backgrounds and skills
- the need for learning support in mathematics and statistics to provide a range of services tailored for needs of relevant courses, circumstances and cohorts
- the difficulties of meeting increasing student needs in mathematics and statistics with uncertain funding, stretched personnel and scarce space
- the importance of sourcing experience and expertise in teaching mathematics and statistics at tertiary level, and knowledge of backgrounds and specific needs
- the value for students of diagnostic assessment and the importance of adequate resourcing for data collection and analysis, and research.

The Symposium brought together individuals and groups from mathematics, statistics and central learning support services, and from all types of universities, in a unique opportunity to share their commitment in providing support essential for students' immediate academic survival and long term development. Symposium delegates supported the following **plans**:

- establishment and maintenance of a website for providing information, networking, discussion forums, resource sharing, visibility and representation for learning support in mathematics and statistics in undergraduate and postgraduate courses in universities across Australia
- circulation of reports and statements of issues and needs to university authorities, professional bodies and government
- liaison with professional societies and conference organisations for purposes of participation in, and organising satellites to, conferences and meetings

- encouraging data collection, analysis and research
- increasing international links and collaboration

3.2.2 Points and issues raised in Symposium presentations, panels and discussion

The abstracts and a number of presentations are available at http://silmaril.math.sci.qut.edu.au/carrick/symposium.html#presentation.

The UK plenary speakers, Richard Gadsden of Loughborough University and Susan Starkings of London Southbank University, described the histories, clienteles, activities, successes and challenges of the two different but well-established centres, Sigma and LSBU's Skills Unit. These are described in 3.1 above.

The discussion after Richard Gadsden's paper on Sigma commented on the extent of government recognition and funding in the UK and the staffing of the drop-in centre by qualified mathematics personnel, but mostly focussed on the provision of statistics support for postgraduate students. The last is an area of rapidly-increasing and extensive demand in the UK and Australia, creating great challenges for already stretched staff in both statistics learning support and statistics academic groups. Discussion after Susan Starkings's 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 Australian plenary speakers focussed on strategies and principles for meeting transition learning needs, and on the importance and benefits to the university sector of mathematical and statistical skills and confidence, with discussion focussing on the many problems caused by lack of understanding of the roles and value of mathematics as a long term life skill. Difficulties with interpreting DEEWR data on student numbers also featured prominently in discussion.

The report of the investigation via websites and phone into current Australian mathematics and statistics support prompted agreement from delegates on the importance of both a 'public face' and a 'students' and staff face' for mathematics support and of good website/internet presence.

The presentations from different Australian universities reflected the variety of practical situations, but there were a number of interesting overlaps of factors and their effects that fed much discussion throughout both the formal and informal components of the Symposium. For universities which offer distance education, whether involved in bridging or enabling courses or not, the technology of distance communication is a key factor in learning in mathematics because of the importance of connecting with individuals. Technology that enables fast individual communications with students and can facilitate timely direct feedback on their questions and work, contributes significantly to helping students' development of skills and confidence - the critical elements of good learning in mathematics. Mathematics learning support in multi-campus universities has particular challenges of balancing effectiveness, efficiency and connecting with students in need who do not necessarily seek help unless it is overtly and readily available.

A number of papers, particularly a presentation on mathematics support for first year chemistry students led to discussions on one of the most critical and least acknowledged conundrums in mathematics learning – balancing the forces of context motivation on one hand and development of skills and confidence on the other. This problem emerges most obviously and significantly at the tertiary level, because it is

here that it is assumed that students can readily transfer and apply their foundational mathematical skills and thinking to a range of new contexts. This requires the strength of background that comes from time and practice - the concept of "just in time" has very limited value in mathematics learning. Many professionals in other disciplines have long forgotten how they acquired the mathematical thinking and skills that have become part of them. This is completely understandable but can be highly inhibitive in understanding current students' difficulties. The problem is further complicated by students coming to tertiary study believing they have been given sufficient foundational skills. Their reactions when they discover they haven't range from distress to disbelief to denial. Learning support in mathematics and statistics has, and will always have, a key role in helping students in this situation, but the growth of the problem has vastly outstripped the resources assigned to tackling it. The problem is also being greatly exacerbated in recent trends in program and curriculum design by denial.

There is no single solution or "silver bullet". Some presentations referred to preparatory not-for-credit courses in various formats which are of considerable help to students who choose to do them. But for all delegates, the discussion following the presentation from the director of the University of Sydney's Mathematics Learning Centre captured a common grievance. Universities need to take greater responsibility in acknowledging and tackling the "mathematics problem", through a balance of the use of pre-requisites, firmer resourcing of learning in mathematics and statistics across disciplines and learning support, and course structures that permit students with less adequate backgrounds to "catch up". One discussant said:

> *universities need to be clear and blunt with students instead of just assuming they are capable of succeeding ...[without sufficient mathematical background]… and taking their study dollars*.

The University of Sydney's Mathematics Learning Centre (MLC) was set up in 1984, under the Vice-chancellor, to help students judged to be at risk due to inadequate backgrounds. The MLC's programs provide bridging and support assistance across all faculties, working closely with staff, particularly with staff in business and economics, agriculture, psychology, mathematics and science. However students must be judged as eligible for assistance to participate in the MLC's programs. The eligibility criteria, which include mathematics studied at school below the assumed knowledge for the student's course can be found in http://www.usyd.edu.au/stuserv/maths_learning_centre/publications.shtml.

There are two points of major interest in this: the first is that students without the requisite mathematics background for their course are permitted entry but are expected to go to the MLC for upgrading their mathematical foundations rather than do a unit/module for credit; and the second is that assistance is available only under eligibility criteria. In 1984, placing restrictions on the availability of assistance was consistent with the ANU's 1970's parameters for the Counsellor in Mathematical Methods who was requested not to help with "homework" or assignments, but in this decade is more likely to reflect the increased extent and spread of the need for extra help with numeracy, mathematics and statistics.

In all universities with nursing courses, the mathematics learning support is heavily in demand to help nursing students. Although other health courses also call on mathematics learning support, particularly at postgraduate level, nursing is a special case of interest because its mathematical needs in drug dosage calculations are very specific but the students' confidence and accuracy must be substantial by graduation. In such situations, the expertise of mathematics learning centres can have significant beneficial effects and readily measurable impact. Close cooperation with nursing staff and highly targeted diagnostic testing with special topic sessions seem to be the favoured approach. A number of staff in mathematics learning centres are involved in

developing or trialling pedagogic approaches to optimise student learning in drug dosage calculations.

Speakers in the two discussion panels, on models and funding models for learning support in mathematics and statistics, had been chosen to represent contrasts. In the first panel, one university with no mathematics department, no mathematics prerequisites and undergraduate courses only, is focussing on mathematics and statistics readiness with a series of various workshops, with lecturers' cooperation because they have realised the wider mathematics problem. The second university represented in this panel has a mathematics department that teaches 90% of the university's mathematics and statistics. They have a mathematics and statistics learning centre staffed by lecturers and casual tutors and a well-established statistics consulting centre available to postgraduates. But both universities report common student problems in algebra, calculus and problem-solving techniques. Discussion again touched on the growing needs of postgraduate students for statistics support for them as *students* and hence different to collaborative statistics help for researchers. Considerable discussion then centred on the difficulties of meeting rapidly increasing student demand for help with over-stretched staff and space resources, and the need for staff development, employment stability and career development.

The second panel on funding models included discussion on the federal funding through enabling subjects (Australian Govt Form C30011) with no credit attached, central funding through access and equity funds, and mixed model funding from central and faculty/departmental sources. There was agreement that central funding and central accountability are important, and that continuity and stability of funding is greatly needed to enable pro-active and ongoing development of expertise, resources and staff development. It was also commented that sharing of information, resources, funding opportunities and evidence of success will assist in gaining better recognition and champions.

The participants on the panel "From the students' viewpoints" varied in background, courses and mathematics confidence, but had similar reasons for fully endorsing mathematics learning support, including the environment of no pressure, shared problems, no question too small or too trivial, special purpose support tutorials, availability of resources and assistance "while you work", feeling secure with the support and developing rapport with staff, tutors and fellow students. The value of a sense of community and collegiality with fellow students and staff was apparent in the students' comments.

The discussion panel of staff from disciplines emphasized the range of challenges that arise from diversities of students and courses even in the same faculty. Teaching staff in other disciplines are in agreement that changes in the past 10-15 years have made some of these challenges extremely difficult to meet, particularly in a climate of variability in student numbers and pressures of demand for graduates. The importance of collaboration and linking between all staff and facilities involved in teaching and supporting learning in mathematics and statistics came through in comments and discussion.

In the final session of the Symposium, delegates discussed ideas and plans for networking, sharing information and resources, and furthering the standing and work of mathematics learning centres. It was resolved that a website with forum facilities would be the most useful form of communication and networking. Opportunities for linking with conferences and professional associations were discussed and possible publication channels identified. Delegates emphasized the need for presence,

dedicated space and functional stability, and the importance of data collection, analysis and research.

3.2.3 Evaluation and dissemination from the Symposium

Feedback information obtained at the Symposium, supplemented by phone and email discussions and a few more survey returns, resulted in an updated and more extensive summary of the Australian state of affairs in learning support in mathematics and statistics. This was again disseminated to all contacts and Symposium delegates for checking.

Delegates' feedback during the Symposium acclaimed it a success and of great value. Post-symposium, delegates were invited to provide written feedback either by direct email or through a form that could be submitted anonymously. The overall response rate was approximately 40%. The responses, both email and via the form with comments, were summarised, sent to all delegates with the Symposium report, and also placed on the ANiLSiMS website.

A substantial Symposium report was written, added to the website, and emailed to all Symposium delegates, contacts and academic DVC's (Deputy Vice Chancellors). As requested by the Symposium delegates, it included a 2-page overview (included in this report as Appendix D) suitable for use in representing the importance of learning support in mathematics and statistics.

3.3 September, 2007 – May, 2008

3.3.1 Visiting fellow, CETL, Loughborough; CETL-MSOR 2007 Conference

During September, the Project leader was an official visitor as a Visiting Fellow to the UK's CETL in university-wide support in mathematics and statistics, at Loughborough University. The planning of collaboration and joint research projects included diagnostic testing, the collection and analysis of data, the nature of learning support, and the challenges of meeting increasing demand for statistics support.

The Project leader was also a keynote speaker at the annual UK conference on tertiary teaching and university-wide learning support in mathematics and statistics. The conference was held on 10th, 11th September, at the University of Birmingham. The aim of this conference is to promote, explore and disseminate emerging good practice and research findings in mathematics and statistics support, teaching, learning and assessment. The conference is relevant to all those teaching mathematics, statistics or numeracy, whether this is to specialist mathematics students or students studying components of mathematics within their degree programs (such as bioscience, chemistry, computer science, economics, engineering, nursing, physics, psychology, social work, etc.). The conference explores not only the issues at the transition to university, but any issues throughout the entire student learning experience from foundation year through to post-graduate level. This is achieved by a combination of key-note speeches, plenary sessions, hands-on demonstrations, workshops, poster sessions and discipline-specific discussion sessions.

The themes of the 2007 conference included

- Innovative uses of technology and m-learning
- Supporting the specialist student in Mathematics and Statistics
- Mathematics and Statistics support for the non-specialist
- Supporting students with disabilities

- Developing learning resources
- Using e-learning and e-assessment
- Pedagogic research

3.3.2 Audit, classification, catalogue and annotation of web-based resources

As described in 2.6, major deliverables of the Project were the audit of resources currently available on the web, the creation of a classification scheme, and the development of an over-arching catalogued and annotated bank of web-based resources. The establishment of this consolidated and consistently organised over-arching resource will not only be of assistance to staff and students, but also encourage further development of collaborative resources, thus building leadership capacity.

This mammoth task was tackled by first listing all resources available on all learning support websites in Australia and then devising a hierarchical classification. All the resources were then placed in this schema together with their link, their place of development and comments on each. Armed with this same hierarchical schema, the main resource banks in the UK were also investigated and classified similarly. The resulting catalogued and annotated bank of resources are available on the ANiLSiMS website http://silmaril.math.sci.qut.edu.au/carrick .

The Australian resources on the website are classified by level, topic, and subtopic. For each resource the website gives: the institution where it was developed; its home site or section; the URL; the format and size of the resource; together with description and comments. Approximately 200 resources are included in this bank.

The UK resources are classified according to the same schema. For each UK-based resource the website gives: the name of the site; the URL; the type of resource; the size of the resource; a description; and whether it is available on video, ipod and/or available for purchase on DVD. Over 300 resources are included in this bank.

3.3.3 A Guide to Learning Support in Mathematics and Statistics in Australia

All the information, data and input obtained through the entire Project were brought together and analysed, and a guide written. This includes history, analysis of the nature of and need for learning support, synthesis of the findings of the Project, and recommendations for the provision of support. This Guide forms Appendix E of this report, and is also published separately for wide dissemination throughout the university sector in Australia and overseas.

3.3.4 Contacts for maintenance of network information

All current contacts were emailed requesting confirmation of their details, and a representative of each learning support facility as the contact for maintaining correct information on the ANiLSiMS website, and for arranging electronic and access grid room meetings. As confirmation of the need for greater recognition and sustainable development of learning support in mathematics and statistics across the Australian university sector, it was disturbing to note the number of changes to personnel and structures in just seven to eight months.

Part 4 Project effects

4.1 Use and advance of existing knowledge with reference to program priority and literature

Priority two of the Leadership for Excellence in Learning and Teaching Program, is disciplinary and cross-disciplinary leadership to enhance learning and teaching through leadership capacity-building in discipline structures, communities of practice and cross-disciplinary networks.

This priority is identical to the aim of the Project in the area of learning support in mathematics and statistics. This area was badly in need of work to investigate and analyse the national scene, to bring together information, people and resources, and to draw attention to its increasingly significant roles for the university sector. The reasons for the need were also the challenges. The area is a component of the totality of learning and teaching in mathematics and statistics, the importance of which there has been far too much denial and neglect over the past one to two decades. Because both specific and generic mathematical skills and confidence underpin student learning across so many disciplines, and because of the nature of mathematical confidence, not only will learning support always be needed, but denial and neglect of these contributors to student learning have been rapidly increasing the need for mathematics and statistics learning support. The totality of learning and teaching in mathematics and statistics is made up of many components, and the combination of the struggle to provide learning support in mathematics and statistics, and the variety of ways in which it has come into being in different universities, contributed to the need for this Project.

Essential achievements of this Project in tackling these challenges and meeting this priority include

- the advancement of the existing knowledge and understanding of learning support in mathematics and statistics, including its history, nature and roles in higher education
- the investigation, analysis and reporting of the current state of affairs across Australia
- the bringing together of people and resources in a sound foundational footing for further developments in a community of practice and leadership capacity-building
- the establishment of national and international networks and links that not only cross disciplines but also cross a large number of professional groups and associations whose interests include at least some aspects of the totality of learning and teaching in mathematics and statistics
- the alerting of university managements and leadership to both the need and the potential for mathematics and statistics learning support to contribute significantly to universities' interests across disciplines at both undergraduate and postgraduate levels.

Because learning support in mathematics and statistics crosses many boundaries, whether artificial or real, the literature on it tends to be scattered across a variety of types of publications and conferences. Although this Project did not set out to do a literature review, the investigations into the history, nature and achievements to date of learning support in mathematics and statistics have included information from, and references to, literature that is of value to practitioners and leaders.

4.2 Factors critical to, or impeding of, the success of the approach

Factors critical to the success of the approach of the Project included

- the success of the QUTMAC
- collection and analysis of data related to the QUTMAC's operation
- the experience of the Project leader from secondments and collaborative projects with the MSOR Network of the UK's Higher Education Academy
- the extensive teaching, student mentoring and course coordination experience of the Project leader across most disciplines and all levels
- the extensive experience of the Project leader in working with teachers, syllabi developers and students in school mathematics and statistics
- the national and international standing of the Project leader in learning and teaching in mathematics and statistics
- the leadership experience of the Project leader in university and professional contexts at the national and international levels, and across a range of professional interests
- the recent experience of the QUTMAC in the development and running of symposia in statistical thinking for postgraduates across disciplines
- the availability of personnel with the relevant expertise and experience for the other members of the Project team
- the strong support of QUT, particularly the School of Mathematical Sciences on all aspects, Professor David Gardiner's support of the QUTMAC, and Deborah Southwell for the initial application
- the strong support of staff of the Australian Learning and Teaching Council.

Factors that impeded the approach of the Project were mainly

- the variety of professional groups with either some interest in the area or some tendency to claim interest and "ownership" of certain aspects
- the effects of more than a decade of denial and neglect of the roles of mathematics and statistics in underpinning student learning within and across disciplines
- the effects of too much emphasis in Australia on competition rather than cooperation between universities
- the absence of the culture that had been fostered in the UK over almost two decades of the emphasis in higher education learning and teaching being on developments within disciplines across universities.

4.3 Extent to which the approach/outcomes are amenable to implementation in a variety of institutions or locations

The emphasis in the Project throughout investigation, analysis, reporting, networking and combining resources has consistently reflected practicalities and strategies that have proved to be effective and efficient in Australia and the UK. To this end no single model is recommended. Rather, the variety of models that have grown up in meeting needs in the variety of types of universities, locations, student cohorts and courses have been represented as accurately and fully as possible to best inform all institutions. The network and linking across professional associations is of relevance to all providers of learning support in mathematics and statistics and all institutions. The bank of catalogued resources reflects current usage across the sector, facilitates the spread of shared usage and encourages further development of benefit to all institutions. The Guide of Appendix E of this report is of use and relevance to all universities in Australia and of interest to universities internationally. The recommendations of the Guide permit their implementation in any institution, emphasizing how a small quantity of resources can effect significant and important

returns in student learning and reduced attrition in any institution. In particular, the allocation of sufficient resources to meet the recommendations on collection and analysis of data, and the assistance for student learning of diagnostic testing, can be implemented in all institutions for significant within-institution benefit.

As described in 3.2, the Symposium Report included a 2-page overview (Appendix D) intended to assist providers in furthering the cause of learning support in mathematics and statistics. Within only a few months of the Symposium, feedback was received from two delegates that the Report had been of significant help to them within their institution.

4.4 Description of ways Project outcomes shared across the higher education sector

The phone and survey collections of information were shared through dissemination at the Symposium and by email to all contributors and contacts. The 2007 Symposium not only brought stakeholders together but also ensured sharing of the outcomes from the Symposium of information, networking and collaboration plans through dissemination by the Symposium delegates on return to their own institutions. The Symposium report was designed to be suitable for wide dissemination through email and the website.

The principal aims of the website are to promote sharing – of information, of networking, or resources and of future capacity-building and development of leadership in the area of learning support in mathematics and statistics.

Dissemination of the Guide of Appendix E is via the website and by direct mail to learning support providers, mathematics and statistics departments, deans and DVC's (academic) in all Australian universities.

The website has already been publicised by some interest groups. Its URL and the Guide of Appendix E will be disseminated to all professional associations/groups with at least some involvement in mathematics or statistics education.

The websites of the UK MSOR and CETL networks will include a link to the ANiLSiMS website.

The Project leader has been invited to write a paper to appear in a special issue of the Internal Journal of Mathematics Education in Science and Technology (IJMest). The paper's title is *Roles and challenges for mathematics and statistics support for student learning and progress*

4.5 Links with other projects

One of the most pleasing outcomes of the Project is the successful application LE8-783 "Building leadership capacity for development and sharing of mathematics learning resources across disciplines and universities." This Australian Learning and Teaching Council project is also in the disciplinary and cross-disciplinary priority area of the Leadership for Excellence in Learning and Teaching Program. The grant partners are University of Wollongong and Central Queensland University, with significant involvement of a key staff member at University of Southern Queensland. The project team met at the 2007 Symposium which was both the foundation and impetus to their development of the ideas and successful application.

A number of participants in the project funded by the Discipline Based Initiatives Scheme, and entitled Mathematics for 21st Century Engineering Students (http://www.amsi.org.au/publications.php), have accessed the website of the Project and some have expressed interest in pursuing the concept of sharing resources specifically for engineering mathematics.

Dr Leigh Wood of Macquarie University was an advisor, plenary speaker and evaluator of the Project, and has recently been successful in obtaining an Australian Learning and Teaching Council priority grant to look at generic skills. Although this is not directly linked to the Project, issues of support for numeracy, mathematics and statistics are significant in the development of generic skills.

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Appendix A Survey form

Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities

We are undertaking the above project, financially supported by The Carrick Institute for Learning and Teaching in Higher Education, aimed at researching and developing national capacity and collaboration in cross-disciplinary learning support for mathematics and statistics. This stage of the project involves a survey of Australian universities to establish the nature and extent of current support. We would be grateful if you could assist us by completing the attached survey and returning it by email (h.macgillivray@qut.edu.au or tm.wilson@qut.edu.au)or by post by 30th April.

If you think you are not the appropriate person to reply to this questionnaire, we would be very grateful if you could pass it on or contact us. Please feel free to include comments on additional pages if you wish.

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The term Mathematics Support Facility should be taken to mean any facility available to students that supports their learning in mathematics and or statistics and exists outside of the regular classes provided as part of an enrolled program (lectures, practicals, tutorials, etc). The term does not imply the existence of dedicated location or staff though these may exist.

Please provide as much information as you are able. We are grateful for your help

1. Name of institution _____
2. Name of support facility _____
3. Person in charge of running the facility (e.g. director, leader)
   - name _____
   - phone _____
   - email _____
4. To whom does the facility report (e.g. Dean, PVC, DVC, VC)
   - name _____
   - position _____
   - email _____
5. What are the primary aims of the facility?_____
   _____
   _____
   _____
6. Which students are allowed to access the facility? (e.g. all, maths students only, first years only) _____
   _____
7. What disciplines do the student users tend to come from? (Please give estimates of approximate proportions e.g. Engineers 40%, Maths 30%, Business/Economics 20%, Other 10%) _____

_____

_____

8. In which general areas of mathematics or statistics do (undergraduate) students most often seek help? _____

_____

_____

9. Please estimate the approximate number of units (subjects/modules) from which students come to seek support _____

10. What type of support do you offer to undergraduates?

    a. 1-to-1 drop-in Y N
    b. 1-to-1 by appointment Y N
    c. Unit/subject specific tutorials or support sessions Y N
    d. Other (please specify) _____

11. Please give estimates of figures for an average week:

    a. 1-to-1 drop-in availability in hrs/week _____
       Approx number of units/week _____
       Approx number of students/week _____
    b. 1-to-1 by appointment approx hrs/week _____
       Approx number of units/week _____
       Approx number of students/week _____
    c. unit specific tutorials/support sessions approx hrs/week _____
       approx number of units/week _____
       approx number of students/week _____

12. Are the figures given in 11

    a. taken from records kept or
    b. best guesses

13. What resources are provided by the facility?

    a. on-line resources Y N
    b. paper resources Y N
    c. other _____

14. Does the facility support postgraduate students? Y N

15. If the response to 14 is yes, is this support in mathematics or statistics or both, and what type of support is offered to postgraduates _____

_____

_____

_____

_____

16. Does the facility carry out any diagnostic testing? Y N

17. If yes to 16, do students get their results in these tests? Y N

18. If yes to 16, are the results used in data analysis or for research? Y N

19. How many people staff the facility?
    a. No. of FT staff _____
    b. No. of PT staff and their fractions _____
    c. No. of academic (not dedicated) staff
       volunteers _____ approx hours/week (total) _____
       assigned _____ approx hours/week (total) _____
    d. No. of postgraduate students _____
       volunteers _____ approx hours/week (total) _____
       paid _____ approx hours/week (total) _____
    e. No of undergraduate students
       volunteers _____ approx hours/week (total) _____
       paid _____ approx hours/week (total) _____

20. Is any training provided to those who staff the facility? Y N
    Please add comments if you wish _____

_____

_____

21. How is the facility funded? _____

_____

22. Is the facility a permanent or short-term arrangement? _____

23. Where is the facility located?
    a. dedicated room (s) Y N
    b. always the same room Y N
    c. Maths department Y N
    d. Library Y N
    e. university support services Y N
    f. other _____

24. What, if any, connection does the facility have to the mathematics/statistics Department/School?

_____

_____

25. How long has the facility been in existence? _____

26. Does the facility have its own website? Y N

27. How do most students find out about the facility? _____

_____

28. Do you think the facility is sufficiently known within your university?

_____

_____

29. On a scale of 1 (lowest) to 10 (highest), rate the degree of recognition of the *value* of the facility within your university _____

Please add comments if you wish _____

_____

_____

30. How does the facility measure its success? _____

_____

31. What do you perceive to be the main advantages of your facility at the current time? _____

_____

_____

_____

32. What are the current problems facing your facility? _____

_____

_____

_____

33. What would you see as the most pressing needs to meet if you had more funding? _____

_____

_____

_____

34. Given the resources and support likely to be available, what would you envisage for your facility in 5 years time? _____

_____

_____

_____

Appendix B
Universities represented at the Symposium, July 19th-20th, 2007

Central Queensland University
Charles Darwin University
Charles Sturt University
Flinders University
James Cook University
LaTrobe University
Lincoln University, NZ
London Southbank University, UK
Loughborough University, UK
Macquarie University
Monash University
Queensland University of Technology
RMIT
Southern Cross University
Swinburne University
University of Adelaide
University of Canberra
University of Melbourne
University of New England
University of New South Wales
University of Newcastle
University of Queensland
University of Southern Queensland
University of Sydney
University of Technology, Sydney
University of Western Australia
University of Western Sydney
University of Wollongong
Victoria University

Appendix C Symposium Program

Time	Day 1, B117 Thursday 19th July
8:30am	Registration
9:00am	Welcome
9:10am	Richard Gadsden Mathematics Education Centre Loughborough University, UK *Sigma: the UK's Centre for Excellence in Teaching and Learning in Mathematics and Statistics support*
10:10am	Therese Wilson Queensland University of Technology (Carrick Project) *A snapshot of Australian current mathematics and statistics support*
10:30am - 11:00am	**Morning Tea (outside B117)**
11:00am	Leigh Wood Director, Learning and Teaching Studies in Higher Education Division of Economic and Financial Studies, Macquarie University *Multiple transitions: supporting academic achievement*
12:00pm	Janet Taylor and Linda Galligan Learning and Teaching Support Unit Centre, University of Southern Queensland *Affecting systematic change in academic numeracy: steps on the journey*
12:20pm	Jackie Nicholas The Mathematics Learning Centre, University of Sydney *The Mathematics Learning Centre at the University of Sydney: issues, success and failures*
12:40pm	Antony Dekkers Mathematics Learning Centre, Central Queensland University *Critiquing the Principles of Adult Learning which form the basis for Practice at the Mathematics Learning Centre at CQU*
1:00pm - 2:00pm	**Lunch** *Dusk (adjacent to the Gardens Point Guild Bar on the top floor of Y block)*
2:00pm	Discussion Forum Panel: Karen Baker, University of Melbourne Jules Holt, Southern Cross University *Models and ranges of learning support in mathematics and statistics*
2:40pm	Discussion Forum Panel: Mary Coupland, University of Technology Sydney Paul Andrew, University of Adelaide *How should learning support in mathematics and statistics be funded?*
3:20pm - 3:50pm	**Afternoon Tea (outside B117)**
3:50pm	Helen MacGillivray School of Mathematical Sciences & Maths Access Centre Queensland University of Technology *How learning support in maths and stats can enhance the university sector*
4:50pm	Discussion of key points and day one close
7:00pm	Symposium Dinner, 7pm

Time	Day 2, B117 Friday 20th July
8:45am	Arrival tea and coffee
9:00am	Susan Starkings Head, Skills Unit, Centre for Learning Support and Development London South Bank University *Mathematics Support for Students on Vocational Courses*
10:00am	Panel "From the students' viewpoints" Chair: Cameron Hall, QUT Simon Micallef (Eng), Sue Pennells (Pharmacy), Joshua Brookes (Maths/Eng)
10:30am - 11:00am	**Morning Tea (outside B117)**
11:00am	Michael Bulmer Mathematics Department, University of Queensland *PASS programs*
11:20am	Allan Ernest, Helen Barton and Jennifer Scott Learning Skills, Student Services, Charles Sturt University *Learning Skills Services in Mathematics at Charles Sturt University: a multi-campus, distance education environment*
11:40am	Lyn Armstrong Learning Centre, University of Western Sydney *Issues for mathematics and statistics within a central learning support unit*
12:00pm	Ronald Monson Victoria University *Creating Computational Interfaces*
12:20pm	Carolyn Kennett Learning Centre for Numeracy Skills, Macquarie University *Mathematics support for first year chemistry students*
12:40pm	Ann Porter School of Mathematics and Applied Statistics, University of Wollongong *Summertime Math*
1:00pm	**Lunch** *Dusk (adjacent to the Gardens Point Guild Bar on the top floor of Y block)*
2:00pm	Panel of staff from other disciplines Ruth Christie (IT), Peter O'Shea (Eng), Andrew Paltridge (Business)
2:30pm	Discussion *Where to from here - strategies, networks, resources*
3:30pm	**Afternoon Tea (outside B117)**
4:00pm	Key points from discussions
4:30pm	Conference Close

Appendix D

Overview from Report from the 2007 Symposium on Learning Support in Mathematics and Statistics in Higher Education

Full report available on http://silmaril.math.sci.qut.edu.au/carrick

Overview

Amidst increasing awareness of the fundamental roles of mathematics and statistics in a modern society, a Symposium on Learning Support for Mathematics and Statistics was held at the Queensland University of Technology (QUT) on 19th-20th July, 2007. The Symposium provided an opportunity for presentations and discussion amongst staff involved in learning support for mathematics and statistics, with the focus on building and sustaining networking and developments across Australian universities. Funding for the Symposium was provided from a Disciplinary and Cross-disciplinary Leadership Project, *Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities*, of the Carrick Institute for Learning and Teaching in Higher Education, together with support from QUT's School of Mathematical Sciences.

Fifty-six delegates from 26 Australian, 1 New Zealand and 2 UK universities attended the Symposium. The list of universities represented at the Symposium is provided in Attachment A (of the Symposium Report). It was very beneficial to have representatives of all types of Australian universities with their diversity of students, courses and campuses. The program is provided in Attachment B (of the Symposium Report). The presentations and panels were carefully chosen to provide a mix of information and discussion points ranging across the variety of models and practical issues across Australia, with input from the UK. Learning support in mathematics and statistics in the UK has progressed considerably, with funding and acknowledgement by government and universities, a process assisted by the work of the Learning and Teaching Support Networks (LTSN), now of the UK's Higher Education Academy. Delegates were eager to hear about activities and challenges in different universities and to share experiences. The panels of students and staff from other areas were also well-received. Delegates' feedback during the Symposium acclaimed it a success and of great value. Post-symposium, delegates were invited to provide further feedback either by direct email or through a form that could be submitted anonymously. A summary of these with delegates' comments is provided in the full Report.

Presentations, panels and discussion ranged widely, but the **commonality of issues across *all* types of universities** was significant. These include:

- insufficient overt recognition of the critical roles of mathematical and statistical skills in underpinning student success in many courses, including postgraduate
- the need for universities to acknowledge and act on their responsibility to care for students permitted to enter with diverse mathematics backgrounds and skills
- the need for learning support in mathematics and statistics to provide a range of services tailored for needs of relevant courses, circumstances and cohorts
- the difficulties of meeting increasing student needs in mathematics and statistics with uncertain funding, stretched personnel and scarce space
- the importance of sourcing experience and expertise in teaching mathematics and statistics at tertiary level, and knowledge of backgrounds and specific needs
- the value for students of diagnostic assessment and the importance of adequate resourcing for data collection and analysis, and research.

The Symposium brought together individuals and groups from mathematics, statistics and central learning support services, and from all types of universities, in a unique opportunity to share their commitment in providing support essential for students' immediate academic survival and long term development. Symposium delegates supported the following **plans**:

- establishment and maintenance of a website for providing information, networking, discussion forums, resource sharing, visibility and representation for learning

support in mathematics and statistics in undergraduate and postgraduate courses in universities across Australia
- circulation of reports and statements of issues and needs to university authorities, professional bodies and government
- liaison with professional societies and conference organisations for purposes of participation in, and organising satellites to, conferences and meetings
- encouraging data collection, analysis and research
- increasing international links and collaboration

There has always been, and always will be, need for reliable, supportive and expert help 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. It is this transferability of mathematics and statistics that is the source of both their power and their challenge. Mathematical learning is also highly cumulative and focussed, tending to make it feel demanding – for everyone, no matter how "good" they are at mathematics! The totality of mathematics support in this 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 below. The components and their mutual arrangement within this totality depends on the university, its courses and structures.

However the past two decades have added extraordinary difficulties and pressures in mathematics and statistics for tertiary students. In the late 1980's, a commendable move to improve the educational inclusivity and appeal of maths had an unfortunate by-product of starting a denial of maths that was not sufficiently curtailed. 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. 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. As early as 1995, McInnes and James identified lack of mathematical skills and confidence as a barrier for success for many students.

Business and industry need to be more public in their valuing of the skills that come from mathematics and statistics. Professional societies need to be more pro-active in helping society to understand how mathematics and statistics underpin other disciplines and problem-solving. 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.

Appendix E

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.

2008

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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 indepth 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 furbished 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.

	Web search method			Total no. of facilities
Location according to website	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.

	Relationship of phone search results to web search findings				
Number of phone transfers involved	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

	Relationship of phone search results to web search findings				
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	0	5
	Maths	1	4	0	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.

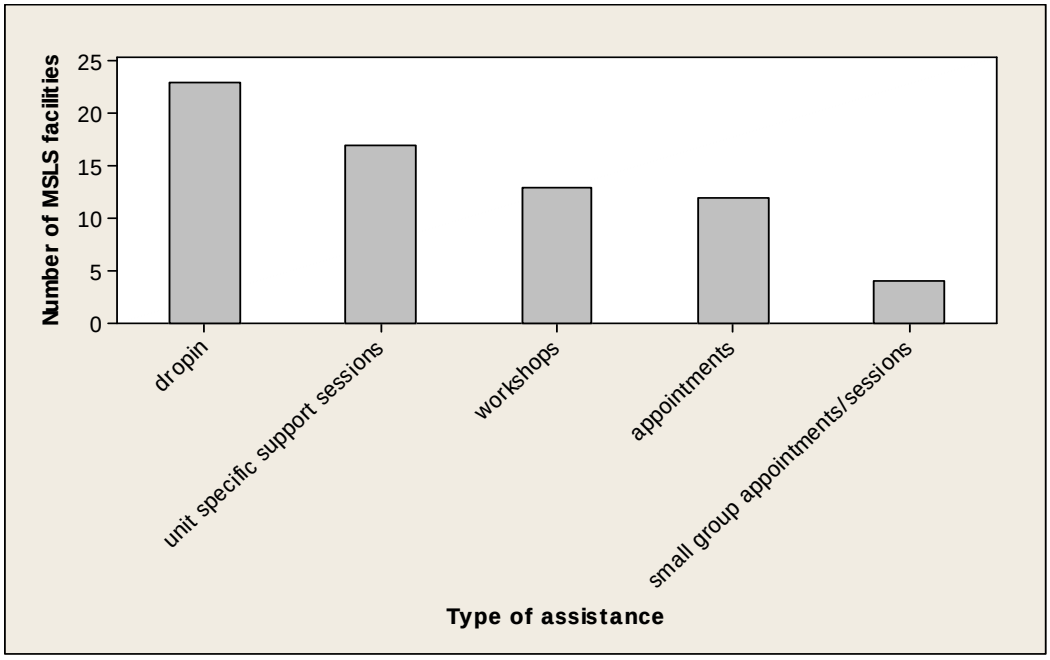

Fig 1. Most common types of assistance provided by MSLS facilities

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.

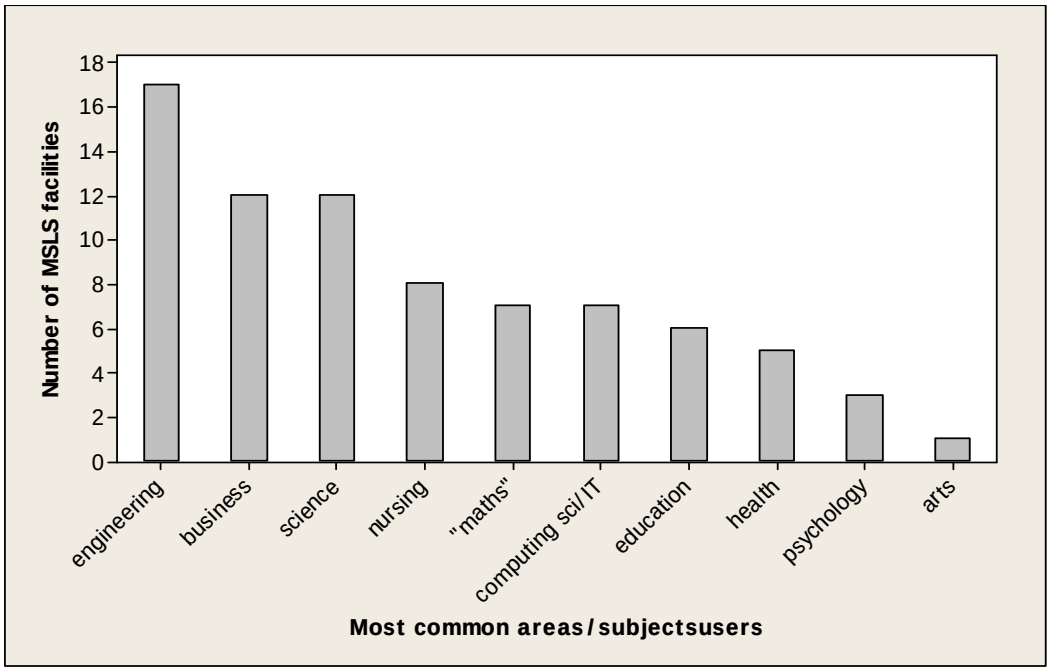

Fig 2. Frequency of most common areas/subjects of users of MSLS services

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.

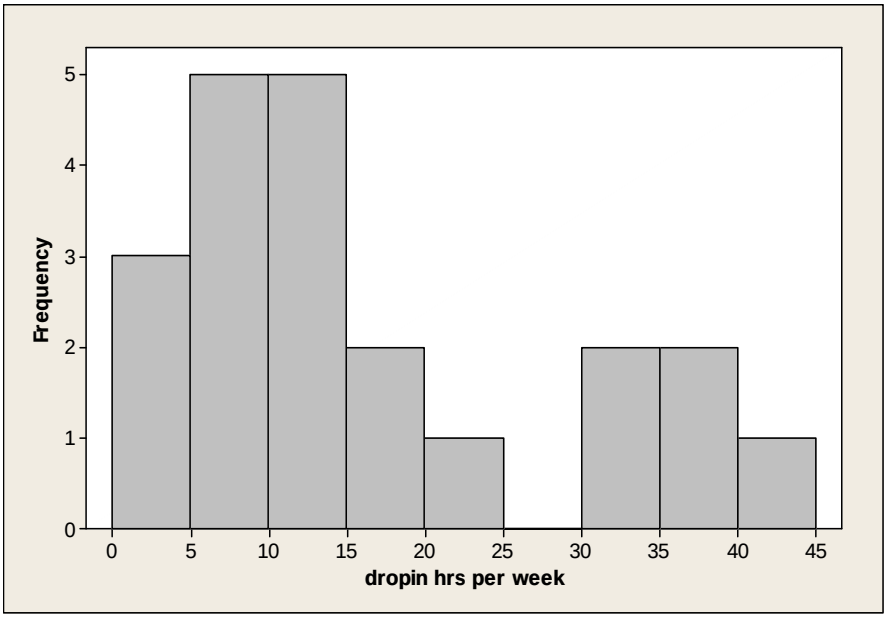

Fig 3. Histogram of number of drop-in hours per week for MSLS facilities offering this service

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.

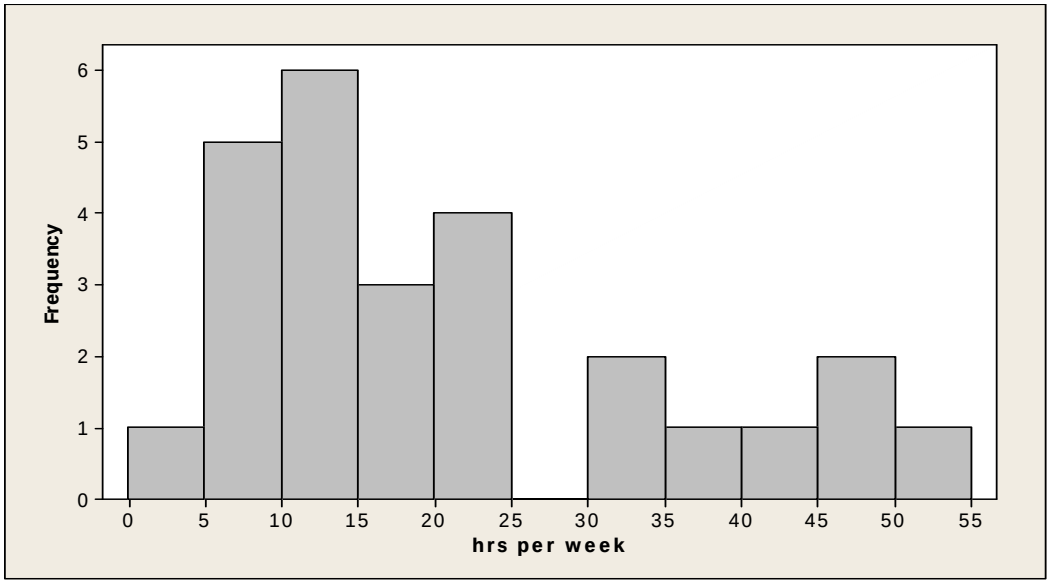

Fig 4. Histogram of hrs per week drop-in, unit specific sessions, appointments

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.

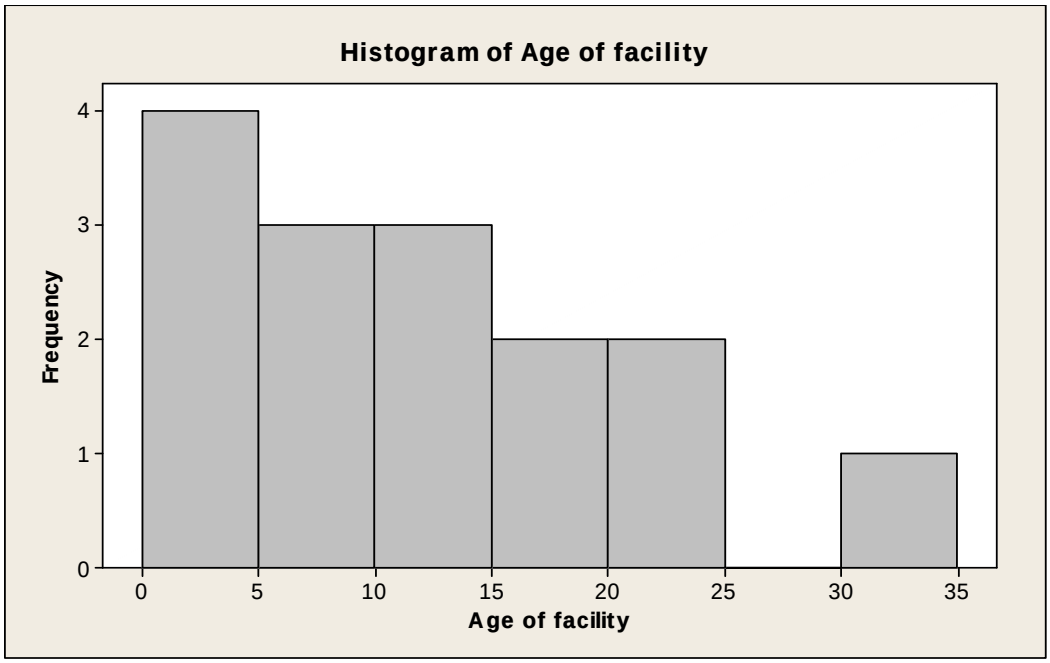

Fig 5 Histogram of age of facility

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 over-arching 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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