Australian Learning and Teaching Council projects in the Mathematical Sciences: A retrospective

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Abstract

Since 2004, the Australian Learning and Teaching Council (ALTC) and its predecessor, the Carrick Institute for Learning and Teaching in Higher Education, have funded numerous teaching and educational research-based projects in the Mathematical Sciences. In light of the Commonwealth Government's decision to close the ALTC in 2011, it is appropriate to take account of the ALTCs input into the Mathematical Sciences in higher education. We overview ALTC projects in the Mathematical Sciences, as well as report on the contributions they made to the discipline.

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1 Introduction

Since 2004, the Australian Learning and Teaching Council (ALTC) and the predecessor Carrick Institute for Learning and Teaching in Higher Education provided over $1.3 million in competitive grant and fellowship funding to academics focussed on improving learning and teaching in the Mathematical Sciences. With the Commonwealth Government's closure of the ALTC in 2011 and subsequent establishment of the Office for Learning and Teaching (part of the Department of Education, Employment and Workplace Relations) as the ALTCs replacement, it is an appropriate time to outline the contributions made to the Mathematical Sciences as a result of these projects.

More than half of the ALTC funding to the Mathematical Sciences over the seven year period was channelled into projects in the *Leadership for Excellence* scheme. Project leaders MacGillivray [6], Porter [10], Wood[1] [12] and Sharma [11] all headed teams working in this space and generally, the contributions continue to be felt at least in individual locations across Australia, if they are not fully contributing to the discipline nationally or internationally. The remaining funding was evenly spread across the *Discipline Studies*, *Competitive Grants*, *Priority Projects* and *Discipline Network* grant schemes, with project leaders Broadbridge [2], Adams [1], Matthews [9] and Mallet [8] directing activities supported by the remaining funding. Throughout this article we refer to these projects using the name of the project leader.

While sharing a general focus of learning and teaching in the Mathematical Sciences, the specific themes of the projects discussed here have been quite diverse. Broadbridge [2] for example, was concerned with Mathematics for students of engineering and the sciences. Somewhat closely related was the work of MacGillivray [6] and more recently Matthews [9], with both projects relating to quantitative skills not necessarily specifically for mathematics students. However, MacGillivray's work was more concerned with the issue of learning support, whereas Matthews' study is related to curriculum models in the sciences. Adams [1] and Porter [10] both considered technology and resources for teaching and learning, with Adams concerned with the establishment of enriched testing technology whereas Porter's work focussed more on the development of leadership among academics using teaching resource creation and sharing as a vehicle for this development. Wood and team [12] initiated a discipline specific professional development program, particularly for less experienced academics in the Mathematical Sciences. The projects of Mallet [8] and of Sharma [11] also concentrate on bringing about change in learning and teaching through a focus on contact with academics and institutions, both with a view to building networks and supporting academics interested in education.

[1]For this project, the report [12] was authored by Project Manager Tori Vu; however, for consistency we refer to the project leader, Leigh Wood, throughout this article.

We consider these projects in Mathematical Sciences learning and teaching and discuss the outcomes and contributions made to the discipline to date.

2 Completed projects: 2006–2009

2.1 Broadbridge: Mathematics for 21st century engineering students

Broadbridge, in 2006, was awarded a $100 001 *Discipline Studies* grant entitled "Mathematics for 21st century engineering students" [2]. This project involved a scoping study that surveyed the existing literature, universities, academics and importantly, industry, to arrive at a 'state of play' regarding mathematics teaching and learning as a service to other disciplines such as engineering. This project provided evidence for, and put into context, many statements that are generally expressed without firm backing from studies or the literature.

Specifically, by examining linkages between mathematics and engineering educators, Broadbridge's study illuminated the important connections between academics in the two disciplines. Broadbridge described the roles played by academics in mathematics and engineering working together to address the increased diversity of engineering students in the 21st century, and formed a picture of what is a rapidly changing educational landscape.

Informed by an extensive literature review, a survey questionnaire, on-site visits and a one day workshop, the Broadbridge study presented evidence of a number of issues facing learning and teaching in the Mathematical Sciences in the 21st century. These issues included the increased variability in the mathematical competencies of commencing engineering students and university entrants in general, the decrease in mathematical content and courses in engineering degrees, the increased difficulty faced by employers in seeking to recruit mathematically confident graduates, and the reduction in academic staff numbers in mathematics departments coupled with increased class sizes.

This study has continued to provide evidence for use by academics seeking to bring about positive change in learning and teaching in the Mathematical Sciences.

Various recommendations were presented in Broadbridge's project report to the ALTC, seeking to address the issues of diversity, cross-disciplinary collaboration and pathways for mathematically able engineering students. In particular, Broadbridge recommended maintaining an assumed knowledge requirement of intermediate mathematics for commencing engineering students and the encouragement of students to study advanced mathematics in high school. The report supported the inclusion of greater levels of statistics and stochastic modelling in engineering degrees as well as employing a streaming process to enrich the mathematical experience of capable engineering students. There was also call for engineering curriculum committees to combine with, or include, Mathematical Sciences academics and for greater collaborative teaching by Mathematical Sciences and Engineering academics. The report also supports the establishment of student help centres and for existing centres to be utilised fully.

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

MacGillivray's $133 578 *Leadership for Excellence* project undertook the challenge of developing national leadership capacity and networking via a community of practice in the area of learning support for cross-disciplinary mathematics and statistics with a view to enhancing student learning and confidence.

The project involved a review of the current state of play with regard to the need for learning support and the services already provided in learning support for mathematics and statistics. MacGillivray's work initiated a

national community of practice along with international links, benchmarked Australian practices in learning support for mathematics and statistics, and identified the resource base currently available for learning support in the country.

Arising out of the Leadership for Excellence project was a guidebook that synthesised the project findings and recommendations with regard to learning support [7]. The data collected and input obtained through workshops and discussion groups were combined to develop guidelines for best practice in the provision of learning support in mathematics and statistics, reported in MacGillivray's guide to the university sector. The national community of practice no longer exists as a formal entity; however, informal links remain and reinvigorating this network is a topic of current interest in the community.

2.3 Adams: A new enabling technology for learning and teaching quantitative skills

The \$134 749 *Competitive Grant* scheme project of Adams [1], entitled "A new enabling technology for learning and teaching quantitative skills" was aimed at developing tools and approaches to enhance quantitative and mathematics skills of students transitioning between upper secondary school and the lower levels of tertiary education.

The project identified that understanding and applying mathematics skills are essential in many fields such as the sciences, statistics, economics, engineering and information technology, and used this broad significance as a pointer to the importance of developing mathematics skills in transitioning students. In order to develop the appropriate technological tools and approaches to improving students' quantitative skills, the intention of this project was to improve on existing electronic mathematics teaching tools such as online testing systems that simply randomised numbers used in stock questions. Instead the project saw the development of a system to generate a suite of random questions along with fully worked, typeset solutions. A key improvement of the system

was the ability to implement questions with more than simple numerical solutions and subsequently to generate the full solutions to the problems in a style similar to students' own handwritten working.

A further outcome of the project was the development of over 100 question and worked solution templates that have since been made available on the ALTC website. These template problems covered topics such as advanced secondary and lower level tertiary mathematics, with some problems contextualised using content from science, engineering and business.

2.4 Porter: Building leadership capacity for development and sharing of mathematics learning resources across disciplines and universities

Porter's $220 000 *Leadership for Excellence* project was aimed at building leadership capacity in Mathematical Sciences academics across Australia via the development, collection and sharing of resources to support learning. The project involved building leadership skills in academics across both disciplines and universities simultaneously, while the academics were producing the mathematics learning support materials. Through extensive and widespread collaboration, the initial group of prospective leaders co-opted a wider group of participants to be involved in the resource development and sharing activities.

The project culminated in a national symposium where participants presented seminars on topics including the development of resources for mathematics and statistics, and also leadership in the area such as dissemination and peer review of resources. Recently, a growing collection of learning support videos has been released via the "Content without borders" open access repository service [4] providing a freely available resource collection for Mathematical Sciences academics and learning support staff.

2.5 Wood: A national discipline-specific professional development program for lecturers and tutors in the Mathematical Sciences

In recent times it has become quite common for universities to offer generic professional development activities, and in some cases *require* involvement in these by academic staff. However, such activities are often not tailored to specific disciplines. Wood's \$215 000 *Leadership for Excellence* project identified Australia's urgent need for formal, discipline specific, professional development for Mathematical Sciences academics and aimed to develop and embed such a program across Australia by linking with the Australian Mathematical Society.

This Leadership for Excellence grant has seen the successful development of discipline-specific professional development activities for Mathematical Sciences academics in a number of forms. A professional development workshop arising out of this project is now run back-to-back with the Australian Mathematical Society's national conference each year. There is also a twelve module unit (equivalent to a unit in a four unit Graduate Certificate program) in Mathematical Sciences academic professional development available online at the Society's website.[2]

3 Ongoing Projects: 2010–Present

3.1 Matthews: Quantitative skills in science: curriculum models for the future

Recently, in a report to the Group of Eight Universities [3], Professor Gavin Brown stated that

[2] http://www.austms.org.au/Professional+Development+Unit

> The state of the Mathematical Sciences and related quantitative disciplines in Australia has deteriorated to a dangerous level, and continues to deteriorate.

Prompted by this and similar statements, a $220 000 Priority Projects grant was awarded to a team led by Matthews [9]. This currently ongoing project seeks to address the urgent problem of deteriorating quantitative skills, particularly in the sciences. This is seen as an issue that requires curricular change, and the contributions of the project are to undertake international benchmarking of quantitative skills in science, to identify proven curriculum change strategies both in Australia and abroad, and to develop a framework to nurture science students' development of quantitative skills in science.

3.2 Learning and Teaching Academic Standards—The LTAS Project

In 2009, the Australian Government awarded the ALTC $2 million to to bring together communities of academics from various disciplines with a view to defining academic standards for their individual fields of study. As a result, the Learning and Teaching Academic Standards (LTAS) project was established to facilitate and coordinate this activity of defining standards, as well as the implementation of the academic standards by discipline communities. The standards are of great importance to the disciplines as the higher education sector enters a new regulatory environment under the Tertiary Education Quality and Standards Agency. This agency is charged with the regulation and quality assurance of tertiary education against agreed standards—standards which the academic community has both an interest and a responsibility in defining.

For the LTAS project, Mathematical Sciences was included in the broader field of Science. The approach for defining the learning and teaching academic standards for Science was agreed at a Learning and Teaching Forum organised by the Australian Council of Deans of Science, held in July 2010. The approach

involved the development of overarching Threshold Learning Outcomes (TLOs) for a Bachelor of Science degree along with examples of how the generic TLOs could be made specific for individual discipline areas such as chemistry and mathematics. This work for mathematics is one focus of the Network led by us.

The LTAS project for Science was lead by Jones and Yates [5] and commenced with the drafting of initial ideas for TLOs by the leaders in conjunction with a small group of academic experts. Consultation with reference and advisory groups and a number of workshops led to the release of a consultation article for public comment in December 2010. A total of 32 Australian universities commented or contributed by early 2011, with the final Standards Statement endorsed by the project reference group and the Australian Council of Deans of Science in June 2011.

The statements focus on five areas: understanding science, scientific knowledge, inquiry and problem solving, communication, and personal and professional responsibility. A full elaboration of the statements can be found in the report to the ALTC [5].

3.3 Sharma: Fostering institutional and cultural change through the Australian network of university science educators

While not specifically a Mathematical Sciences project, the Leadership for Excellence grant of Sharma [11] is of interest as it relates to academics in the discipline through its focus on Science educators. Sharma was awarded a $216 000 Leadership for excellence grant with a view to improving teaching and learning in science and mathematics by establishing 100 'transformation leaders' engaged in 25 action learning projects over the course of the grant. These leaders, through the action learning projects and subsequent work, are expected to work with heads of schools and other leaders to foster

change in pedagogy in science and mathematics across the country. The Network, referred to as the Science and Mathematics Network of Australian University Educators, recently called for the first expressions of interest in this transformational leaders initiative.

Also of interest to academics in the Mathematical Sciences is that this Network has initiated the recent rebadging of the 18 year old UNISERVE science education conference as the "Australian Conference on Science and Mathematics Education", explicitly recognising the place of the Mathematical Sciences. The Network is collaboratively liaising with Deputy Vice-Chancellors (Academic and/or Teaching) around Australia to identify and publicise opportunities for dissemination and publication of educational research and teaching scholarship such as the Australian Conference on Science and Mathematics Education. The intention here being to enable academics with an interest in or focus on teaching and learning research to advance within the traditional reward structures of university science disciplines.

3.4 Mallet: Australian Mathematical Sciences Learning and Teaching Network

Most recently, and in the final allocation of ALTC funding, we were awarded $100 000 to build a discipline Learning and Teaching Network [8]. The Network, known as the Australian Mathematical Sciences Learning and Teaching Network (AMSLaTNet), aims to support and advance learning and teaching across the Mathematical Sciences subdisciplines in Australian higher education. AMSLaTNet intends to achieve this through the formation of an ongoing network of academics interested in learning and teaching in the Mathematical Sciences and by directing efforts and funding towards a number of key projects. These include:

- defining Threshold Learning Outcomes and Academic Standards for learning and teaching in the Mathematical Sciences;

- recognising and disseminating exemplary academic practice;
- raising the status of educational research for Mathematical Sciences at the tertiary level;
- embedding and raising awareness of previous ALTC project outcomes;
- collaborating with other Science Discipline Networks (for example, via the Science and Mathematics Network of Australian University Educators); and
- articulating the mathematics experience of learners.

The Network is in its infancy, commencing in earnest in December 2011, but through a number of workshops and conference presentations in late 2011 is already progressing quickly on most of these projects.

4 Conclusion

Since 2006, the Australian Learning and Teaching Council and its predecessor the Carrick Institute have provided over one million dollars for advancing learning and teaching in the Mathematical Sciences. This allocation supported the nine projects discussed in this article, each of which contributed in some way to building communities of practice, developing academic leaders, improving teaching practice and technology, cementing the place of learning support structures, and renewing the way mathematics and statistics are assessed and included in curricula. Although the outcomes of these projects have been extremely valuable, widespread application of the results has not always been observed.

While the closure of the ALTC was a blow to academics interested in learning and teaching and to the students whose education was improved by ALTC-related projects, the recent launch of the Office for Learning and Teaching (a section of the Commonwealth Department of Education, Employment and

Workplace Training) along with its $50 million, four year budget, brings renewed opportunity to support learning and teaching in higher education. The rich networks of interested scholars developed through projects such as AMSLaTNet have a responsibility to ensure the continued embedding of outcomes of completed ALTC projects and to encourage and support new work in teaching and learning improvement and educational research in the Mathematical Sciences.

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