Establishing STEM Educational Leadership: the RMIT SHEER Centre

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Abstract: *The disciplines of Science, Technology, Engineering and Mathematics (STEM) are critical for Australia's national productivity and global competitiveness. Demand for tertiary graduates with STEM skills will continue to exponentially exceed supply in Australia in the next 25 years. Leadership in the promotion of STEM learning and teaching is critical to the development of future graduates to meet these needs. Over the past three years, the College of Science, Engineering and Health at RMIT University has undertaken extensive consultations and research to develop a model of educational leadership for tertiary staff in the STEM disciplines. This paper reports upon the data collection and consultation processes involved in the establishment of a STEM educational research centre. By drawing together STEM discipline scholars, best practice learning and teaching and industry-led work-integrated learning, a Science, Health and Engineering Educational Research (SHEER) Centre has been created to provide leadership, management and strategic direction of STEM educational research. The new Centre is expanding cross-disciplinary learning opportunities through the introduction of workshops that connect industry, staff and students in emerging industry-focussed STEM initiatives.*
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1. Introduction

The importance of Science, Technology, Engineering and Mathematics (STEM) disciplines for the future economic and social well-being of all Australians cannot be under-estimated: 75% of the fastest growing occupations in Australia require STEM skills and knowledge (Becker & Park, 2011). Increased participation in STEM-related tertiary education is fundamental to the economic and social well-being of the individual and the nation. Australia is already behind other nations in the number of STEM graduates it produces from its tertiary institutions (OECD, 2011). The declining enrolment in STEM disciplines is creating an acute shortage of scientists and engineers in the Australian and global workforce (Gillard, 2011). The increasing demand for STEM graduates is a result of a number of factors:

- growing use and impact of information and communications technologies;
- rapid application of recent scientific advances in new products and processes;
- high rate of innovation across OECD countries;
- decline in the number of students studying STEM at high schools; and
- shift to more knowledge-intensive industries and services (OECD, 2011).

These factors are not exclusive to Australia. The need for a qualified workforce in STEM disciplines in Australia is reflected globally. The OECD (2011) have highlighted the supply of skilled multi-disciplinary professionals in STEM as an urgent problem, requiring leadership action.

Tertiary institutions have a crucial role to play in developing the workforce of the future. The Australian Council of Deans of Science (2012) have highlighted that Universities have a major role in outreach in science and science-related activities, and in recruitment and promotion of leadership in science learning. The Australian Government is also committed to expanding opportunities for STEM learning at tertiary institutions and in 2012 has established the Special Research Initiative for Science Learning Research Centre fund, which provides funding to eligible tertiary organisations to support cross-disciplinary research programmes (ARC, 2012). To deliver the Australian Government targets for tertiary education, the interconnection between relevant cross-disciplinary STEM learning and teaching and the future skills and knowledge requirements of industry will need to be enhanced. More than ever before STEM tertiary education has a crucial role to play in preparing students for the global economy and the workforce of the future.

Current educational trends in the learning and teaching of STEM disciplines focus upon the need for cross-disciplinary approaches to student learning, that maximise the opportunities for future employment and lifelong learning (Kuenzi, 2008). Research shows that integrative and cross-disciplinary approaches improve students' interest, engagement and learning in STEM (Reiss & Holman, 2007). Integrative and cross-disciplinary approaches are defined as "approaches that explore teaching and learning between/among any two or more of the STEM discipline areas" (Sanders, 2009, p. 21). Integrative approaches can also act as a motivator for learning and teaching in STEM concepts and provide cognitive benefits to students as well.

A growing body of research documents these positive effects of cross-disciplinary approaches among STEM disciplines upon the students' achievement, satisfaction and employability (Pang & Good, 2000). Attempts to employ integrated approaches to the learning and teaching of STEM disciplines using various methodologies is also well documented (Riskowski et al., 2009). But as Zubrowski (2002) notes, whilst there is some evidence that the integrative approach is common practice at secondary school levels in Australia, there are still a number of serious practical challenges to engaging cross-disciplinary best practice in tertiary institutions.

STEM academics and their implementation of learning and teaching cross-disciplinary projects in tertiary institutions highly depends on their perceptions toward the advantages of an integrative approach, the organisational context and the leadership and support received in their teaching environment (Sahin, 2006). That is, the decision by STEM academics to implement cross-disciplinary learning and teaching approaches to improve student outcomes and engagement is heavily dependent upon the leadership opportunities that prevail in their institution. In addition, the nature of tertiary education STEM disciplines often mitigates cross-disciplinary approaches (Brown, 2010). That is, tertiary education is discipline-focussed and little, if any, time is consigned to the implementation of discipline skills and knowledge in cross-disciplinary settings.

Like most Australian universities, STEM qualifications at RMIT University also reflect this narrow single discipline approach, with little opportunity for students or staff to engage in cross-disciplinary STEM learning or teaching. Although there are opportunities for interaction with other disciplines in learning and teaching areas, time demands, resources and the discipline demands mean staff often remain isolated in discipline practice. Directed attention to the development of STEM cross-disciplinary learning and teaching approaches and the pursuit of the scholarship of learning and teaching in STEM to inform on-going practice is emerging as crucial for both the graduates of the future and the professional development of STEM staff.

2. The Development of a STEM Educational Research Centre at RMIT University

RMIT is a global university of technology and design and Australia's largest tertiary institution. RMIT has an international reputation and a long history of excellence in practical education where students are able to put theory into practice through work-integrated learning (WIL) opportunities and technological innovations. The University is organized into three Colleges, one of which is the College of Science, Engineering and Health (SEH). The SEH College comprises over 25,000 students and over 1000 staff in STEM disciplines across all tertiary levels from initial entry level training to post-graduate study at RMIT University. In recent years, the College has undertaken a number of cross-disciplinary STEM projects aimed at promoting leadership and learning and teaching scholarship. These projects have included:

- academic communities of practice;
- WIL projects involving professional organisations such as Engineers Without Borders;
- STEM learning and teaching small grants to academics;
- STEM cross-disciplinary student-focussed projects such as Remote Laboratories; and
- an annual learning and teaching STEM showcase and forum

This strong track record in STEM cross-disciplinary work at the College level meant the College was ideally placed to foster and develop further cross-disciplinary scholarly approaches to STEM learning and teaching leadership. A small steering group, led by the Deputy Pro-vice Chancellor, Learning and Teaching in the College, commenced examining the requirements for the establishment of an official RMIT Centre in the Scholarship of Learning and Teaching in STEM. The steering group recommended that the College commence proceedings for the establishment of a recognised RMIT Research Centre. In terms of status and university recognition, such a Centre would raise the profile of STEM both within the university and the wider Australian tertiary sector.

The RMIT Research and Innovation Plan (2011-2015) identifies the encouragement of academic staff and HDR students in making a research impact as a high priority for its 'Impact through Innovation' Plan. It was envisaged that the activities of the Centre would be aligned to the RMIT Research & Innovation Plan in the following ways:

- the involvement of the STEM research centre members in national and international networks of best practice learning and teaching;
- the enhancement of staff capability, and the promotion of research outcomes in the scholarship of learning and teaching;
- the use of seminars, workshops and symposiums to demonstrate innovative cross-disciplinary learning and teaching in STEM disciplines; and
- the use of the STEM schools in the College of SEH to trial innovations in learning and teaching.

The initiative was also propelled by three imperatives:

- the future critical need for STEM graduates in Australian and international workplaces;
- the significance and importance of providing an institutional cross-disciplinary leadership structure for STEM disciplines within RMIT; and
- the pedagogical need to develop integrated, cross-disciplinary approaches to STEM learning and teaching in engaging industry-driven projects for students.

Given these three imperatives the steering group commenced the consultation and data collection process.

2.1. The Consultation Process

The consultation and data collection process was undertaken during 2011 in two distinct parts, with both parts overlapping in time. The first part was the collection of data relating to existing STEM educational activity by College staff. This data collection was necessary to establish a platform of existing scholarly activity that could support the application for the establishment of a STEM educational research centre. The second part of the process was formal consultations with STEM schools within the College framework to establish interest and build stakeholders in the Centre.

2.2. The STEM Staff Survey

The first part of the process was the STEM academic and teaching staff survey. SEH College staff were invited to complete an online survey asking for responses to the following four questions:

- What are your STEM educational research outputs in the area of peer-reviewed publications?
- What are your STEM educational research outputs in the area of external research funding?
- How many HDR (higher degree research) candidates do you supervise?
- What are your specific interests in the scholarship of learning and teaching in STEM?

Respondents were required to identify themselves, as data collected would form the basis of a formal University application, where details about membership of the Centre would be required. Online responses were collated, with a total of 95 initial respondents providing data. A further 6 respondents were later invited to provide data, who were targeted as key academics who had missed the original survey, or were recently employed by the university. These responses are noted separately only because they were individually invited, by comparison to the general invitation issued to the first group of respondents. The high number of responses from STEM staff indicated a desire by a significant number (101) of

STEM staff to be part of an educational leadership model in STEM disciplines. Table 1 indicates the responses collected to the first three questions.

Table 1: STEM staff survey

	Total number respondents	Respondents with STEM educational peer-reviewed publications	Respondents with STEM educational research funding	Respondents with HDR supervision
Initial Survey	95	28	4	23
Invited Respondents	6	6	0	5

The survey revealed two key facts: firstly the large number of STEM educational research outputs already being undertaken by College academics; and secondly, the low number of STEM educational research grants (external) currently sourced by College staff. The survey results indicated the high numbers of STEM staff who were creating learning and teaching outputs in isolation of each other and with little peer support or leadership. Whilst the results were encouraging, they highlighted the need to formalize these outputs and external funding applications to capitalise upon opportunities of cross-disciplinary STEM partnerships.

In addition to responding to the three key questions within the survey, STEM staff were also asked to indicate their learning and teaching scholarship interests in STEM. The results of this open-ended question are listed in Table 2 below. The results indicate a wide range of educational research areas including a number of cross-disciplinary opportunities such as peer mentoring and technology. These responses were later used by the College to focus upon on-going professional development and to establish Communities of Practice.

Table 2: Responses to open-ended question: scholarship of learning and teaching interests in STEM

Response by category	**Number of Respondees***
New technologies in STEM L&T	24
Measurement & evaluation of STEM L&T outcomes	15
Staff/student assessment & feedback issues	15
Transition/first year experience in STEM disciplines	8
e-Learning/best practice in STEM	7
Student engagement issues in STEM	6
Peer mentoring in STEM	4
Improving teaching/professional development in STEM	4

*staff could list more than one area.

The data collection process had raised additional awareness amongst STEM academics of the existing educational research activity and the opportunities for greater collaboration and cross-discipline learning and teaching activity. This awareness was further enhanced in the school meetings (see section 2.3 below).

2.3. School Meetings

An important part of the consultation and information process was the involvement of STEM academics in supporting the Centre and indicating their desire for a leadership model in STEM education within the university. Formal presentations and meetings were held with all STEM staff across all ten schools in the College. At these meetings, opinions were canvassed about the need for a STEM leadership model and feedback was sought about recognition of the scholarship of learning and teaching in STEM. The meetings built stakeholder interest and motivation in developing a STEM educational research centre. Both processes of College data collection and consultation had yielded important data, but the College was still required to meet the RMIT University recognition process for a research centre.

2.4. The University Recognition Process

The application for the recognition of a Research Centre in STEM Educational Leadership at RMIT University was required to follow the internal University procedures for establishment. The application had to address the following:

- the members of the proposed Centre had to meet the minimum expectations/thresholds outlined in RMIT Research Structures Guidelines;
- the Centre's activities had to align with RMIT's five "Research Focus Areas" and/or the aspirations outlined in the University Research & Innovation Plan;
- there had to be a minimum of 6 members (headcount) who were RMIT academic staff;
- each Centre should have at least $AUS300,000 in external research income over the previous 3 years;
- each Centre must have produced 40 ERA (Excellence in Research Australia)-recognised research outputs over the previous 3 years; and
- normally a minimum of 1.5 HDR supervisions per member was required.

The data collection process and the consultation process confirmed that the College would be able to meet the formal establishment requirements of an RMIT University Centre. This gave the Research Centre status as a fully recognised centre and allowed the Centre to independently pursue STEM initiatives and educational scholarship. The steering group prepared the application papers and commenced inviting STEM academics who satisfied the university criteria to take formal membership within the Centre.

3. The SHEER Centre as a Model of STEM Educational Leadership

The results of the STEM academic staff survey, along with the lengthy consultation process through the ten College schools, indicated the need for a dynamic, research-informed, knowledge-based leadership model for the strategic orientation and promotion of the scholarship of learning and teaching in the STEM discipline areas at RMIT. In 2012, the SHEER (Science, Health and Engineering Educational Research) Centre was created to fulfil this need.

The centre is focussed upon the creation of cross-disciplinary, formal networks concentrating upon the systematic integrated development of excellence in learning and teaching scholarship in these disciplines. The formal network of researchers now identified as members of the SHEER centre had previously been operating in fragmented or ad-hoc STEM educational scholarship, leading to isolation, duplication of ideas, limited grant opportunities, and uncoordinated scholarly applications. The membership of the Centre is by invitation or nomination. Full membership is available to RMIT staff who demonstrate an interest in learning and teaching in SEH and two of the following criteria:

- at least two peer-reviewed publications per annum in the scholarship of learning and teaching, and/or;
- externally generated income in the scholarship of learning and teaching, and/or;
- supervision of at least one current HDR student in scholarship of learning and teaching in SEH.

Associate membership of the Centre is by invitation to RMIT staff who demonstrate an interest in the scholarship of learning and teaching in SEH and have at least one learning and teaching publication over a three-year period.

The benefits to the College and RMIT are the modelling and promotion of learning and teaching scholarship at a higher leadership level of national and international recognition. The Centre provides a platform for the discussion, collaboration and feedback of scholarly pursuits in the learning and teaching of STEM disciplines, such as competitive grants, publications and peer recognition. It allows nurturing and critical appraisal of initiatives and scholarly pursuits. It also acts as a leadership model for the scholarship of learning and teaching for STEM staff and the wider university. The SHEER Centre adds value to the SEH College through leadership based upon peer example and the on-going promotion of best practice, innovations in learning and teaching and the dissemination of such innovations through the increased engagement of SEH staff. These leadership elements are reflected in the Centre mission:

The Science, Health and Engineering Educational Research (SHEER) Centre at RMIT University celebrates and endorses excellence in the research of learning and teaching in tertiary education in Science, Engineering and Health disciplines. Through the harnessing, nurturing and promotion of scholarship, the centre will be both a national and international leader in learning and teaching in these disciplines.

As a representative body, the Centre will provide a forum for initiative and practice supporting the proactive engagement of RMIT and external staff in the pursuit of scholarship of learning and teaching in STEM disciplines. The centre will support and develop staff in researching learning and teaching initiatives in and across the discipline areas. It will provide for the integration of practical and theoretical knowledge into scholarly outputs such as national and international peer-reviewed publications, competitive grants and external recognition such as conferences and seminars. The Centre will also seek to establish an identity as a national leader in the scholarship of learning and teaching in STEM disciplines. The Centre aims to achieve the following outcomes in STEM discipline areas:

- cross-disciplinary, integrated approaches to learning and teaching initiatives;
- an active network of researchers both nationally and internationally recognised in the scholarship of learning and teaching;
- increased outputs in publications and grant applications in learning and teaching;
- the formulation and initiation of research projects in learning and teaching; and
- increased attraction and support of HDR students.

To achieve these outcomes, the Centre plans the following activities/outcomes:

- research publications in nationally and internationally recognised journals and conferences;
- the sponsorship of conferences, forums and seminars in the scholarship of learning and teaching;
- the acquisition of external grants and competitive funding; and
- the development of a monograph in the scholarship of learning and teaching in the Centre’s (STEM) disciplines.

4. Future Directions

If Australia is to be a productive and progressive economy in the future, a workforce of scientifically and technologically literate people is required. With identified shortages across the engineering, science and technology professions, there is also a growing need for a highly trained pool of academic staff who can, through learning and teaching initiatives, impart, not only their own discipline but also cross-disciplinary, STEM opportunities for the current students who will go on to workplaces of the future. With rapid technological change in industry, it is likely that skills demanded in the future will differ from those required in the past. Beyond meeting immediate or short-term skills and knowledge demands, there is a need to change thinking about discipline-specific STEM skills acquisition and consider the importance of lifelong learning approaches to learning and teaching in STEM disciplines. The cross-disciplinary STEM skills required to adapt to jobs and technologies that don't yet exist will be increasingly important, in addition to the specific skills required in the job market. The establishment of a STEM educational research centre, the SHEER Centre, at RMIT University, will create increased emphasis on the relationship between STEM education and workplaces of the future and a targeted focus upon STEM disciplines as a key to national productivity and international competitiveness.

References

Australian Council of Deans of Science. (2012). *Australian Council of the Deans of Science Policy Framework*. Retrieved from http://www.acds.edu.au/ACDS_policy_2004.html

Australian Research Council. (2012). *Special Research Initiative for a Science of Learning Research Centre.* Retrieved from http://www.arc.gov.au/ncgp/sri/slrc.htm

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education 12*(5&6) July–September 2011.

Brown, M. (2010). *BEING 'STEM-LIKE': Analysing some STEM-like programs in secondary schools*. Science, Technology, Engineering and Mathematics in Education Conference, Brisbane.

Gillard, J. (2011). *Greater opportunity for all Australians*. Retrieved from http://www.pm.gov.au/press-office/budget-offers-greater-job-security-and-opportunity-more-australians

Kuenzi, J. (2008). Science, Technology, Engineering, and Mathematics (STEM) Education: Background, federal policy, and legislative action. Congressional Research Service Report for Congress (RL33434).

Organisation for Economic Co-operation and Development. (2011). Over-Qualified or Under-Skilled: A Review of Existing Literature, OECD Social, Employment and Migration Working Papers. No. 121, OECD Publishing Paris.

Pang, J. S., & Good, R. (2000). A review of the integration of science and mathematics: Implications for further research. School Science and Mathematics, 100(2), 73–82.

Reiss, M., & Holman, J. (2007). S-T-E-M working together for schools and colleges. 1–8, The Royal Society.

Riskowski, J., Todd, C., Wee, B., Dark, M., & Harbor J. (2009). Exploring the Effectiveness of an

Interdisciplinary Water Resources Engineering Module in a Grade Science Course. International. Journal. Engineering Education 25(1), 181-195.

Sahin, I. (2006). Detailed review of Rogers' diffusion of innovations theory and educational technology-related studies based on Rogers' theory. The Turkish Online Journal of Educational Technology, 5(2), article 3. Retrieved from http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/3d/cb/47

Sanders, M. (2009). STEM, STEM education, STEM mania. Technology Teacher, 68(4), 20–26.

Zubrowski, B. (2002). Integrating science into design technology projects: Using a standard model in the design process. Journal of Technology Education, 13(2), 48–67.