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Changing the Game in Science and Mathematics Higher Education

Final Report 2014

Changing the game: A national approach to learning and teaching for science and mathematics

National Teaching Fellowship

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Website: <www.acds.edu.au/tlcentre>

Australian Council of Deans of Science

LA TROBE UNIVERSITY

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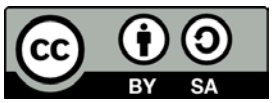

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Elizabeth Johnson

List of Acronyms

ACARA	Australian Curriculum, Assessment and Reporting Authority
ACDS	Australian Council of Deans of Science
ACDS AGM	Annual General Meetings of the ACDS
ACDS TL Centre	ACDS National Centre for Teaching and Learning
ACSME	Australian Conference for Science and Mathematics Education
ADTL	Associate Dean Teaching and Learning
ALTC	Australian Learning and Teaching Council
AMSLaT	Australian Mathematical Sciences Learning and Teaching Network
AQF	Australian Qualifications Framework
ATN	Australian Technology Network
Chemnet	Chemistry Discipline Network
CUBEnet	Collaborative Universities Biomedical Education network
DBER	discipline-based educational research
HEA	Higher Education Academy
HERDSA	Higher Education Research and Development Society of Australasia
HESP	Higher Education Standards Panel
IRU	Innovative Research Universities
LTAS	Learning and Teaching Academic Standards
OLT	Office for Learning and Teaching
MOOCs	Massive Open Online Courses
SaMnet	Science and Mathematics network of Australian university educators
SoTL	Scholarship of Teaching and Learning
TL	Teaching and Learning
TLO	Threshold Learning Outcome
VIBEnet	Vision and Innovation in Biology Education

Executive Summary

This report describes the construction of the **ACDS Teaching and Learning Centre** (ACDS TL Centre), a new national initiative in the learning and teaching of science and mathematics in Australian universities. The ACDS TL Centre and its activities are accessed through its website at <www.acds.edu.au/tlcentre>.

Widespread curriculum reform in science and mathematics in higher education has been elusive. Decades of research into learning and teaching have produced guiding principles for curriculum development. Pockets of excellent and innovative practice demonstrate the improvements in student learning outcomes that can be achieved. However, broad improvement of the standard of learning and teaching across the Australian higher education sector requires a shift in gear – from applauding innovation to raising the agreed standards across all institutions.

Improvement in student learning outcomes requires coordinated action from teachers and their host institutions. The institution has a profound effect on students and on teachers. It defines the learning environment, controls resources and sets policies and priorities. It is influenced by overlapping but distinct advice from the sources that influence individual teachers. Alignment of evidence-based advice to institutions with the advice to individuals will reinforce positive action and accelerate improvement. The ACDS Teaching and Learning Centre is a new national initiative whose charter is influencing and supporting Faculties of Science to improve learning outcomes across science and mathematics programs.

The Australian Council of Deans of Science proposed the establishment of the ACDS Teaching and Learning Centre in 2012. This new ACDS TL Centre would reach widely across the sector through its parent body which brings together Faculties of Science, or their equivalent, in 37 of the 39 Australian universities. This Centre would:

- construct and publish descriptions of **good practice** in learning and teaching in science and mathematical sciences
- provide **authoritative advice** to Faculties of Science and related disciplines to assist with curriculum reform
- provide advice to **regulatory, funding and policy bodies** to help align influences to encourage best practice
- construct and support **links** amongst science and maths education leaders and practitioners.

This fellowship **designed the ACDS Teaching and Learning Centre** with the active participation of leaders of learning and teaching in science and mathematics from Australian universities. Through iterative consultation on design, this project has:

- designed guiding principles for the operation and organisation of the Centre: distributed leadership, a network of networks and sustained operation
- designed an operating model for the Centre
- identified priorities for Centre activities
- identified preferred modes of interaction of stakeholders with the Centre.

Following design, this fellowship **constructed the new Centre and trialled its activities.** The ACDS TL Centre membership comprises leaders from Faculties of Science, primarily Associate Deans Teaching and Learning, and non-positional teaching and learning leaders. The Centre consists of three core activities: the Centre website, learning and teaching meetings, and ACDS learning and teaching projects. The new ACDS TL Centre came into public view with the launch of its website in February 2013. It has held three ACDS meetings during 2013 and has contributed to other activities. The first Centre project, support for the implementation of the national Science Threshold Learning Outcomes in Faculties, is underway. This fellowship has produced:

- the ACDS Teaching and Learning Centre website <www.acds.edu.au/tlcentre>
- a network of Associate Deans Learning and Teaching in Faculties of Science
- collaboration with learning and teaching leaders and innovators and science discipline education networks
- science and mathematics learning and teaching meetings: ACDS Teaching and Learning Conference, ACDS TLO workshop, Discipline Network Roundtable
- regular dissemination of teaching and learning projects, activities and issues in science and mathematics through the website and regular newsletters to ADTLs.

The ongoing activities of the Centre are reported on its website.

The fellowship also presents a **snapshot of curriculum reform in Faculties of Science** through the eyes of Associate Deans, Teaching and Learning from Faculties of Science. Curriculum reform is described as a complex and demanding activity dependent on the interplay of leadership, staff capacity, institutional priority and resourcing. Issues in curriculum reform identified for Faculties of Science are often common with university teaching and learning in general. Issues specific to science and mathematics are centred on specialist pedagogies around scientific practical programs in laboratories and fieldwork, and the decline in student interest in the physical sciences and advanced mathematics in schools.

This project has demonstrated the value of leveraging existing sector networks and organisations to create a complementary and reinforcing influence. Establishment of the ACDS TL Centre has been greeted with enthusiasm and active support by learning and teaching leaders in science and mathematics. The Centre is bringing disparate areas of excellence together to move towards a better standard which is shared widely.

In October 2013, following nine months of operation of the ACDS TL Centre, the Annual General Meeting of the Australian Council of Deans of Science expressed its strong support for te new Centre with a unanimous vote to increase the Centre's funding for 2014.

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Chapter 1: Changing the game

At the outset of this fellowship, the Australian Council of Deans of Science (ACDS) announced the establishment of the ACDS National Centre for Teaching and Learning (ACDS TL Centre). The intention was to develop a curated, credible national resource to foster curriculum renewal in Faculties of Science. The primary objective is to achieve broad-scale improvement in Australian science and mathematics curricula over the long-term.

Curriculum reform is a complex enterprise. In practice, the curriculum and the student experience are built by the action of individual teachers and the actions of their institutions. Curriculum, as referred to in this report, includes the structure and design of courses and subjects[1]; teaching and learning activities and their content, assessment and feedback; and enrichment and support programs. This broad definition reflects the close interconnection of curriculum elements derived from the idea of constructive alignment of intention, action and assessment (Biggs & Tang, 1999). An effective curriculum fosters student achievement of intended learning outcomes. The ACDS TL Centre seeks to raise the standard of teaching and associated activities to achieve widespread improvements in outcomes for students in science and mathematics.

This fellowship was funded to support establishment of the new ACDS TL Centre, to build stakeholder relationships with the Centre, and to test some strategies for engaging university science and mathematics in the work of the Centre. The first step in this journey was to conceptualise the role of the Centre and its relationships with other activities and groups. Through this process, a new model of support for curriculum reform has emerged. The model calls for complementary roles for universities, disciplines and teachers that reflect the complex interplay between each institution, teacher and student. This chapter describes the context for curriculum reform, the curriculum reform model and potential roles of supporting organisations.

The outcomes of this fellowship are:

- organisational and operational principles for the ACDS Teaching and Learning Centre built through consultation with stakeholders
- the ACDS TL Centre website, conferences and meetings
- consultation with science leaders in Australian universities
- a snapshot of curriculum reform in Faculties of Science
- the first ACDS TL Centre project, Embedding the Science Threshold Learning Outcomes.

[1] The nomenclature used to describe units of study varies among Australian universities. For the purposes of consistency, this report will use ‘course’ to describe a University award, ‘major’ to describe a coherent disciplinary sequence within an award and ‘subject’ to refer to the a unit of study which awards a final grade recorded independently on a University transcript.

Timeline for construction of the ACDS TL Centre

Construction of the ADCS TL Centre has been an iterative process of development, discussion and refinement throughout the fellowship (Figure 1.1). The ACDS approved a proposal to develop an ACDS TL Centre in February 2012, which was the starting point for this fellowship in June 2012. The first phase of the project was consultation with faculties, which took advantage of existing meetings, including the annual ACDS Teaching and Learning Conference (ACDS TL Conf), the Australian Conference for Science and Mathematics Education (ACSME) and the Annual General Meetings of the ACDS (ACDS AGM). Consultation was also achieved through interviews with individual Associate Deans Learning and Teaching and through a series of regional workshops in February 2013 with teaching and learning leaders in partnership with an OLT-funded leadership project (SaMnet).

In the second phase, the Centre came to life with the construction and publication of the Centre website in February 2013 and the launch of the first Centre project on the implementation of threshold learning outcomes (TLOs) in science (Centre TLO workshop, Centre TLO project) in March 2013. A second round of consultation with faculties completed the fellowship with the 2013 ACDS Teaching and Learning Conference and the 2013 Annual General Meeting of the ACDS.

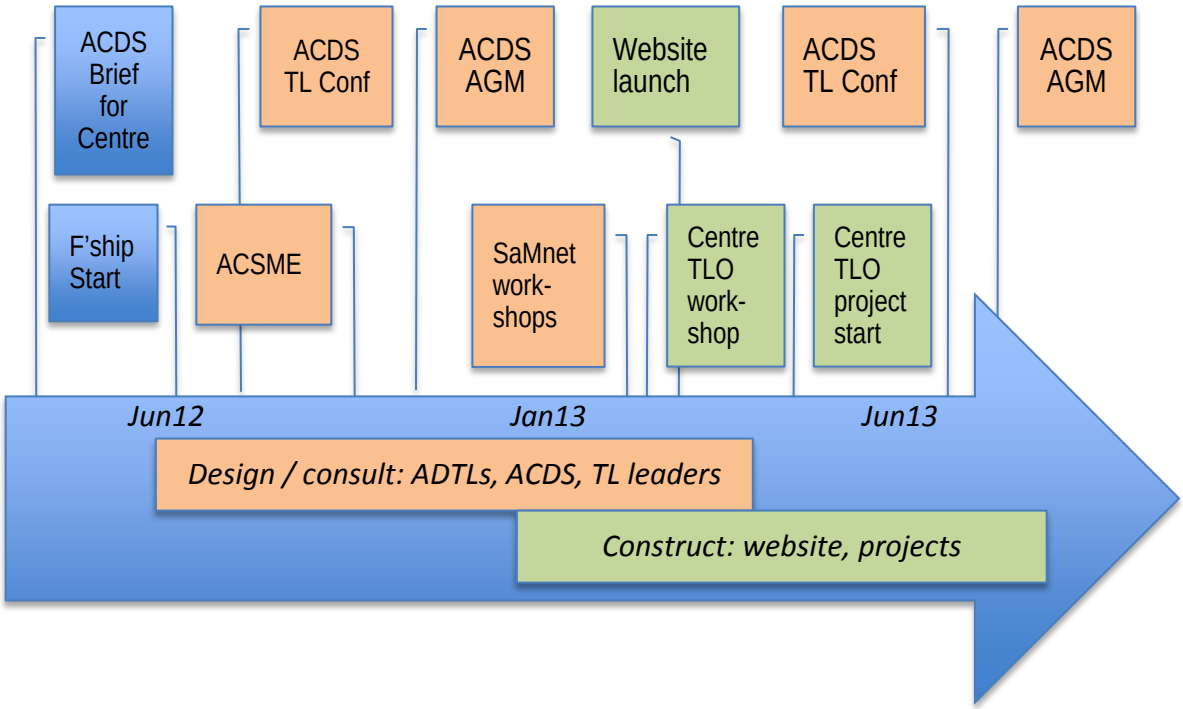

Figure 1.1: Timeline for fellowship activities

The first step in this journey was to conceptualise the role of the Centre and its relationship to other activities and groups. The context for curriculum in Faculties of Science is complex and dynamic. Curriculum reform must deal with the changing landscape of higher education and its regulation and funding, as well as a changing student cohort and specific challenges for science and mathematics. Awareness of its environment is fundamental to successful

advocacy by the new Centre. This chapter describes the context for curriculum reform in science and mathematics and proposes an integrated curriculum reform model.

The context for curriculum reform in Science and Mathematics

The pace of change in learning and teaching reform in science in higher education is frustratingly slow. Despite decades of higher education research, reform lags behind the evidence of practice and research (Handelsman et al., 2004), stimulating calls for national action in the US (Brewer & Smith, 2011) and Australia (Office of the Chief Scientist, 2012; Rice, Thomas and O'Toole, 2009) to improve student learning outcomes. In parallel, calls for increased emphasis on science and mathematics in schools highlight the importance of increased awareness of science in the general population as well as preparation for university science (Osborne & Dillon, 2008). Although multiple influences such as a student's prior experience and their approach to learning are clearly important factors in determining learning outcomes (Ramsden, 2003; Prosser & Trigwell, 1999), improvements in curriculum design, teaching practice and the student experience are the most direct tools at our disposal to improve student learning.

Particular challenges for science and mathematics curricula derive from both external and internal influences. The observed drop in student enrolments in enabling school studies in physics, chemistry and high level mathematics combined with an expansion of students studying in universities potentially increases the proportion of underprepared students (Goodrum, Druhan & Abbs, 2011). A national consensus statement on the learning outcomes for graduates of a Bachelor of Science degree has only recently been published (Jones, Yates & Kelder, 2011). A focus on ever-expanding scientific content at the expense of skill development and ways of thinking creates a crowded curriculum which can be a difficult environment for learning. Discipline-specific learning activities such as laboratory classes and fieldwork are relatively expensive to deliver and may have little relationship to authentic scientific practice (Rice, Thomas & O'Toole, 2009).

General issues also affect the capacity of Faculties of Science to develop more effective curriculum. Curriculum renewal is dependent on the capacity of staff to rebuild curricula and their willingness to engage in curriculum development, which, in turn, is affected by faculty leadership in learning and teaching. In a coherent curriculum, elements are highly inter-dependent, which means redesign can rapidly turn small projects into major ones. Some of these challenges are explored further below.

Balancing research and teaching: Academic workload

Science academics, like most academic appointees, are required to balance competing demands from teaching and research. Independent rankings of universities, which influence external reputation and internal investment decisions, give greater weighting to research outputs and income than to the quality of teaching. This emphasis is passed on to faculty leadership and individual teaching and research academics. This issue is particularly acute for Faculties of Science where the nature of research means it is a major contributor to research metrics.

However, universities also have ambitions to maintain or grow enrolments and to improve learning outcomes, retention and progression of students. Despite the need for good teaching practice to support educational outcomes, individual academics are influenced by real, or perceived, criteria for career advancement and promotion which privilege research performance (Bexley, James & Arkoudis, 2011; Probert, 2013). Academics report high workloads (Bexley et al., 2011) and, as a consequence, they may be reluctant to invest in innovation or changed teaching practice.

Foundation study in science and mathematics

The background students bring with them is crucial information for curriculum design. The picture for science and mathematics is troubling. Current trends show declining engagement with science and mathematics amongst Australian students (Goodrum, Druhan & Abbs, 2011). Not only can this decline reduce technological expertise and innovation in Australia, it can also reduce the capacity of citizens to make informed decisions about their world.

> *And, if as a nation we are to make bold, visionary and difficult decision we need a scientifically literate community. One that understands that there will be uncertainty, but one that knows to give appropriate weight to the consensus and to the critic. One that knows the critic is not always right – if not always wrong.*
> Chubb, 2011

There have been many calls for improved teaching at primary, secondary and undergraduate levels to make science more accessible and engaging for students – most recently from the Office of the Chief Scientist and the Australian Academy of Science (Goodrum et al., 2011; Office of the Chief Scientist, 2012). The advent of the new Australian Curriculum has created discussion between secondary and tertiary sectors. However, science academics remain substantially divorced from the secondary curriculum, as has been found in a recent project comparing Year 12 and first year biology subjects across Australia (Burke da Silva, Familiari, Rayner, Blanksby & Young, 2013). Again, the limited connections that exist are made by individuals rather than systematically.

Curriculum reform must also be undertaken cognisant of the experience and background of students. Recent efforts in Australia have created momentum for action to improve student experience and transition to study (Kift, 2009).

Agreed learning outcomes for science

Faculties of Science have only recently developed nationally agreed outcomes for graduates in science and mathematics. Previously, the curriculum for science and for mathematical sciences was simply the sum of individual interpretations of sub-disciplines. A Bachelor of Science was usually constructed from a set of largely independent majors and often from subjects operating independently. Alignment of expectations of learning outcomes, where it occurred, was the result of the efforts of individuals.

The construction of the Science Threshold Learning Outcomes (Jones, Yates and Kelder, 2011) as part of the Australian Learning and Teaching Council (ALTC) Learning and Teaching Academic Standards project (LTAS Report) is a landmark for science and mathematics curricula in Australia. For the first time, Australian universities have agreed on the minimum

learning outcomes that should be expected of a graduate of a Bachelor of Science (or equivalent) degree. The significance of this step is recognised in the draft national Higher Education Standards, which list the Threshold Learning Outcomes as an example of an appropriate reference point for university self-assessment. Now, national conversations have a shared language and can move beyond discussion of exception and diversity to discussion of purpose and standards of achievement. National regulatory arrangements and their institutional interpretations will have an obvious effect on the scope and character of curriculum reform.

Laboratory learning

Laboratory and fieldwork classes are a feature of science courses. They are relatively expensive to deliver in infrastructure (laboratories, equipment and chemicals) and in staffing. The return in learning outcomes on this investment in Australian universities has been criticised (Rice, Thomas & O'Toole, 2009) with the spread of recipe-style practicals which bear little relationship to contemporary scientific research. However, laboratory classes can be a highly productive learning environment, offering students multiple ways of learning and encouraging critical observation, inquiry and analysis (Hofstein & Lunetta, 2004). The ASELL project, <www.asell.org>, is an example of large-scale curriculum renewal in laboratories that has generated much interest in the Australian context. Evaluation and development of effective laboratory and fieldwork programs should be a priority for Faculties of Science.

Leadership and expertise in science and mathematics learning and teaching

Effective curriculum reform assumes that projects have access to sufficient expertise and leadership to achieve improved student learning outcomes. Student learning outcomes are influenced by the approach of academics to teaching and learning (Trigwell, Prosser, & Waterhouse, 1999) and their understanding of good teaching practice (Miller, Pfund, Pribbenow & Handelsman, 2008). It is reasonable to conclude that the capacity of teaching and research academics for curriculum reform is influenced by similar factors. In the US, a new field of discipline-based educational research (DBER) in science education is emerging (National Research Council, 2012) which offers new insight into the development of expertise amongst science and mathematics educators (Bush et al., 2011). These researchers are developing a body of knowledge and implicitly creating standards for teaching practice.

Expertise can be, and often is, also supplied to curriculum reform through specialists in higher education, academic development or educational design. Teaching and research academics do not necessarily look to specialists outside their discipline for assistance. Burke da Silva et al., 2008) found science academics were much more likely to seek advice and assistance from colleagues rather than external experts. Dancy and Henderson (2008) describe a gulf between agents of change, such as higher education researchers or educational designers, and science academics. They suggest respectful partnerships and a sense of ownership for science academics will improve uptake and successful use of good practice.

Active leadership by science faculties is essential to support widespread uptake of innovative teaching practice (Southwell &Morgan, 2010) and to encourage local ownership

of curriculum renewal. Leadership can be formalised through designated governance positions or can be informal and/or disseminated. The former has the advantage of alignment with management practice and the latter has the advantage of being close to practice and flexible (Johnson, Bird, Fyffe & Yench, 2012). In practice, leadership must be well-informed and appropriate to the local context. It must be a bridge between teaching practitioners, university leadership and external resources and expertise.

Curriculum development in a changing environment

Australian universities are dealing with a volatile environment. The sector has moved from elite to mass education and has been urged to increase the diversity of its students (Bradley, Noonan, Nugent, & Scales, 2009). The creation of a publicly accessible online world has fundamentally changed the provision of information and is changing modes of delivery of education. The traditional model of master-apprentice education, that characterised universities until the introduction in the 1970s of more open access to Australian universities, can no longer be the norm. Universities have become enterprises that need specialised expertise in learning and teaching and in educational leadership.

Funding models for universities are no longer certain. Universities are expected to increase measurable productivity and the level and composition of staffing are changing (Bexley, James & Arkoudis, 2011). Australian universities have become increasingly dependent on income generated from international enrolments. Independent rankings of universities, which influence reputation and investment decisions, give greater weighting to research than to the quality of teaching. At the same time, the Australian Government has made it very clear that universities are expected to meet sector standards of quality (*Tertiary Education Quality and Standards Agency Act, 2011*) across all domains of activity. For faculties, this very complex picture translates into difficult decisions about priorities for investment in student recruitment, research and the quality of the curriculum.

The challenge

Review of the outcomes of educational research and institutional change projects shows that construction and provision of innovative materials or strategies is not enough to effect lasting change. Henderson, Beach and Finkelstein (2011) investigated the effect of instructional change strategies in higher education published in the science education literature from 1995 to 2008. The authors found two major factors were associated with lack of effect: poor evaluation of the instructional strategy and a short-term time frame. They emphasise the importance of long-term commitment to cultural change. Individual champions, no matter how charismatic and convincing, cannot achieve sector-wide reform. Good ideas must be owned by future practitioners and supported by their institutions. The complexity of the problem forces a multifaceted answer. An integrated approach is needed to align action to a common goal of improved student learning outcomes.

An integrated approach to curriculum reform

Curriculum is constructed through the interplay of participants: students, teachers and institutions. It serves the interests of the participants and other stakeholders: employers, professional bodies, funding agencies, regulators who represent government and, eventually, the community. There are already many groups that aim to improve curriculum

in higher education; this raises the question of what a new initiative could offer. The new ACDS TL Centre must operate aware of the priorities and interests of those involved and build on the support that currently exists. In developing these concepts a new integrated model of support for curriculum reform in Australia has emerged. It suggests that broad-scale change in curriculum in science and mathematics needs effective and consistent advice at multiple levels: for institutions, disciplines, teachers and students.

The interaction between a teacher and a student is a personal relationship. The teacher brings their approach to teaching and their experience of being a student and a teacher. The student brings their own approach to learning, their personal circumstances and past experiences of learning. However, this interaction takes place in a context, which is largely controlled by the institution (Figure 1.2 below). What the institution and its sub-structures allow, promote or discourage, places boundaries around the curriculum.

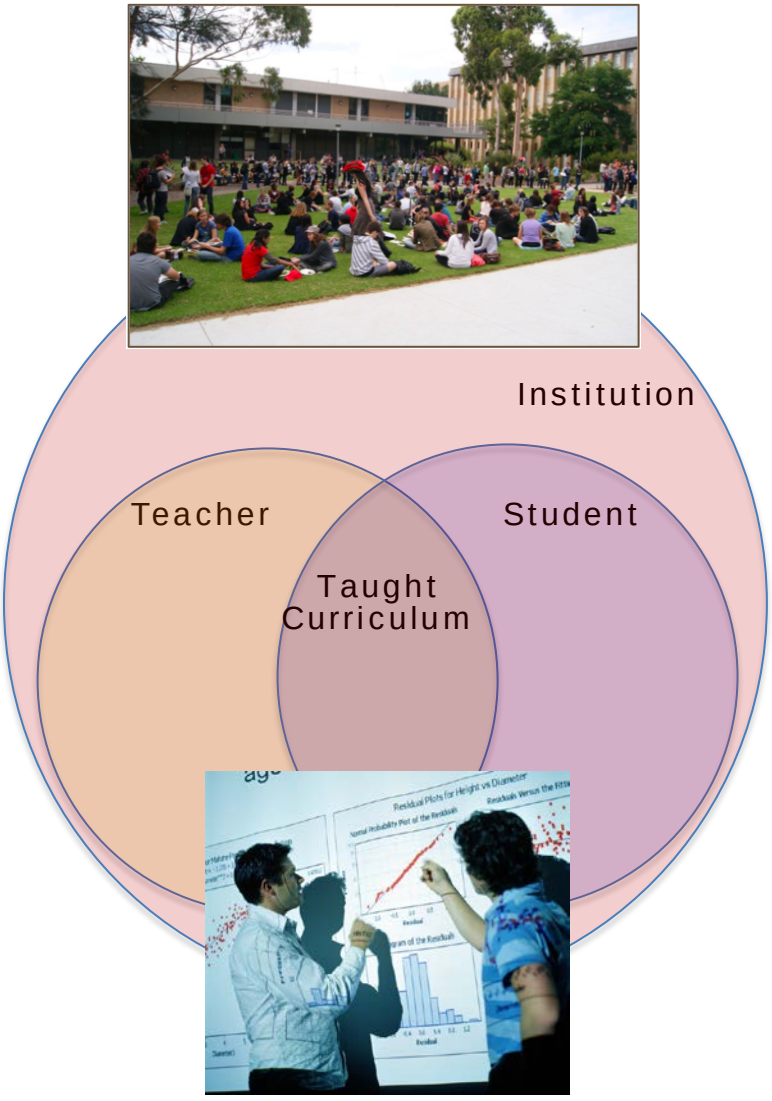

Figure 1.2: Model for institutional contribution to curriculum

The formal curriculum is designed and delivered within the context of an institution. Interactions between students, teachers and the institution operate within and outside the formal curriculum.

Different roles for students, teachers and institutions are also obvious in the process of curriculum reform. Institutions permit, promote and regulate curriculum reform. Teachers and educational specialists construct and revise learning experiences, hopefully with the active participation of students. Each group can draw information on curriculum reform from multiple sources. The likely sources of influence overlap but have different emphases reflecting the role of each group (Table 1.1 below). Trowler, Fanghanel and Wareham (2005) used similar descriptions of macro-, meso- and micro-levels of analysis in higher education and point out that each level needs to be aligned to effect change.

Table 1.1: Roles in curriculum reform with possible sources of influence / information

	Role in curriculum reform	***Sources of influence/information***
Student	• Participants in active learning • Feedback	***Internal:*** • Institution • Teachers • Peers and student organisations
Teacher (micro)	• Construction of learning experiences • Teaching practice (facilitation of learning) • Assessment and feedback • Evaluation and review	***Internal:*** • Discipline peers • Department (discipline) • Higher education specialists ***External:*** • Discipline educational research
Subject/ Department (meso)	• Discipline leadership of learning and teaching activities • Resource allocation • Quality assurance	***Internal:*** • Faculty • Institution ***External:*** • Science discipline associations • Professional accreditation bodies • Discipline educational research
Institution (macro)	• Resource allocation • Quality assurance • Policy and procedures • Institutional learning and teaching strategy • Staff professional development	***External:*** • Funding: State, federal government • Regulators: AQF, TEQSA

The institution and its leadership set priorities and control funding. The institution combines its own priorities and the requirements of funding and regulatory bodies as policy and practice. This creates the effective boundaries for teaching practice and sets expectations for the quality of practice. Policies can create the space for high quality education but do not ensure it.

The institution defines and constrains the learning environment. In science, the physical and virtual environment is particularly important, as experimental disciplines rely heavily on specialist equipment, tools and teaching laboratories. Teaching in this area is constrained by the provision of infrastructure. The institution also determines the range of courses offered and the resources allocated to them in academic workloads and support services.

Influences on curriculum development come internally from peers, educational specialists (academic developers, educational designers) and leadership. External influences come from research (discipline-based educational research or higher education literature), disciplinary associations, and funding and regulatory bodies. In Australia, the Australian Learning and Teaching Council (ALTC) and its successor the Office for Learning and Teaching (OLT) offer support and advice to both institutions and educators. The resource library of the OLT houses a considerable body of work focused on science and mathematics. However, this good work does not necessarily reach the numbers of practitioners required to create broad-scale change. A local leader encouraging local adoption is often needed.

Faculties sit at the interface between departments (meso-level) and their institution (macro-level). For discipline academics, their faculty is the local face of the institution. For the institution, the faculty represents disciplinary views and the reality of teaching practice. The faculty must merge disciplinary and institutional influences to interpret the institutional framework and advocate on behalf of its disciplines.

Efforts to create coordinated and consensus advice to disciplines has been trialled through the Subject Centres of the Higher Education Academy (HEA) in the United Kingdom. The HEA funded 24 Subject Centres with seven focused on science and mathematical sciences (Table 1.2 below). In 2011, the original subject centres were replaced by disciplinary streams in response to a review of activity and changes in funding.

Table 1.2: HEA-funded subject centres

HEA Subject Centres	Archived website
Bioscience	www.bioscience.heacademy.ac.uk/
Education in the Built Environment	www.heacademy.ac.uk/cebe/
Information and Computer Sciences	www.ics.heacademy.ac.uk/
Geography, Earth and Environmental Sciences	www.gees.ac.uk/
Materials Education	www.materials.ac.uk/
Mathematics, Statistics and Operational Research	www.heacademy.ac.uk/disciplines/maths-stats-or (current website)
Physical Sciences	www.heacademy.ac.uk/physsci/

Formal evaluation of the HEA Subject Centres in 2008 found “services of the Subject Centre network were one of the more prominent and valued aspects of the Academy at institutional level across all types of institution” (Oakleigh Consulting, 2008) and concluded that investment in the Subject Centre Network represented good value for money. Trowler, Fanghanel and Wareham (2005) in their evaluation of the effects of the HEA Subject Centres, identified positive outcomes but warned of the importance of aligning advice and intervention to multiple levels within higher education institutions. The authors suggest that

a lack of focus on the meso-level (department) blocks the effects of positive influences at micro- (individual academic) and macro- (whole-of-institution) levels.

The work of this fellowship starts with the premise that Faculties of Science are central to broad-scale curriculum reform in science and mathematics teaching and can align curriculum reform in departments and disciplines with institutional constraints. It targets the Associate Deans Teaching and Learning who are aware of the strategic context in which universities operate and who could, collectively, influence national agendas in teaching and learning. This fellowship explores an innovative model for national, collaborative peer leadership in science education, the ACDS Teaching and Learning Centre.

Chapter 2: A new idea for national engagement: designing the ACDS TL Centre

The ACDS initiative

The Australian Council of Deans of Science (ACDS) is the peak body for Faculties of Science and equivalents in Australian universities. Its stated purpose is to "promote the development of science through study and research in science faculties/schools/departments in universities throughout Australia" (ACDS, 2001). The ACDS, therefore, has a strong interest in the quality of learning and teaching in science and mathematical sciences. Since 2008, the ACDS has held an annual learning and teaching conference which brings together faculty leaders, Associate Deans Teaching and Learning (ADTL) and deans, with teaching and learning experts and innovators to discuss current key issues.

In 2012, the ACDS Executive commissioned a working group led by Executive Director, Professor John Rice, and eventually endorsed a proposal for the establishment of a Teaching and Learning Centre that would assist Faculties of Science to achieve improved learning outcomes for students. The founding proposal set out the agenda for the new ACDS TL Centre: it would "become the focal point for advice on matters concerning the quality of science teaching and learning, both for university science faculties and schools throughout Australia and for government agencies such as TEQSA" (refer Appendix A). The new ACDS TL Centre would have Science Faculty learning and teaching leaders as its core membership; Associate Deans Learning and Teaching driving activity; and Executive Deans in a governance role at a minimum. The proposed Centre would reach beyond Science Faculties to connect to discipline learning and teaching leaders, higher education scholars and other stakeholders. Establishment of the ACDS TL Centre was seen as a strategy to achieve widespread improvement in science and mathematics curriculum across universities.

Why the ACDS?

The Deans of Faculties occupy a pivotal position in the leadership of universities. They represent and lead their discipline and are a gateway into the senior leadership teams that shape policy and strategy. The ACDS invites membership from designated Science Faculties or equivalent bodies and also from universities where science is combined with other disciplines such as engineering, technology, health and arts. The ACDS includes representatives from 37 of the 39 Australian universities, and is an inclusive organisation with links to equivalent organisations in engineering, ICT and technology, and education. The ACDS is a peak body with strong links to government, regulators and university leadership. It has the capacity to influence both policy and practice.

The membership of the ACDS represents the broad sweep of science and mathematical sciences in universities. Science disciplines are inter-dependent and

share knowledge and approaches to investigation. Unsurprisingly, science students study foundation subjects in common and are normally expected to be literate, although not expert, in more than one scientific discipline. Most undergraduate students enroll in broad degrees, typified by the Bachelor of Science, which are built from a variety of majors and science sub-disciplines including mathematics, statistics, physics, chemistry and different forms of biology. Although distinct scientific and mathematical disciplines create natural groupings for academics and researchers, both research and teaching demand collaboration. The ACDS offers a cross-disciplinary platform to address broad issues in science learning and teaching and to bring scientific disciplines together.

The ACDS is a peer group, which posseses the potential for strong influence of its members. Peer review of evidence-based research and practice is a pillar of academic discourse. It encourages debate and collaboration and is substantially self-correcting. It is a widely accepted mechanism of quality assurance within the academic community, which means the influence of peers is profound. Adoption of evidence-based recommendations for good practice by the ACDS as a representative group lends authority to the recommendation and creates a sector benchmark.

These three capacities – influence, cross-disciplinarity and peer representation – make the ACDS an obvious and powerful sponsor for a sector-wide movement to improve university learning and teaching in science and mathematics.

Aims of the ACDS TL Centre

The aims of the new Centre were described in the initial proposal for its establishment as adopted by the ACDS. The primary objective of the Centre is to improve the quality of learning and teaching in science in Australian universities. It seeks to do this by influencing faculties and their activities and by influencing national issues that affect science and mathematics learning and teaching.

The establishment proposal suggested that the Centre would influence faculties by working with faculty leaders of learning and teaching – either formal leaders such as the Associate Deans Teaching and Learning or informal leaders who are proponents for quality in learning and teaching. It proposed that influence at a national level would grow out of the role of the ACDS in providing expert advice on issues of national significance to learning and teaching in science and mathematics.

During this fellowship, the aims of the ACDS TL Centre were refined through discussion with the original working group and the ACDS. This report proposes the ACDS TL Centre will achieve its aims by the:

- construction and publication of descriptions of **good practice** in learning and teaching in science and mathematical sciences
- provision of **authoritative advice** to Faculties of Science and related disciplines to assist with curriculum reform

- provision of advice to **regulatory, funding and policy bodies** to help align influences to encourage best practice
- construction and support of **links** amongst science and mathematics education leaders and practitioners.

Principles for the ACDS TL Centre

The first step in the construction of the ACDS TL Centre was to establish principles that would guide the development of the Centre. These principles had to reflect its aims, the realities of working with a group of independent organisations and a commitment to long-term engagement. This fellowship initially proposed three principles to guide the development of the ACDS TL Centre. These principles were tested through consultation with Associate Deans Learning and Teaching and science and mathematics teaching and learning leaders. (Refer Chapter 3).

1. Distributed leadership

Peer networks, such as the ACDS TL Centre, rely on the willing participation of colleagues with common interest and mutual respect. Such organisations fit with a flat leadership structure that empowers individuals and encourages collaboration. Distributed leadership is an organisational concept where participants recognise multiple forms of leadership and share authority amongst the group. The distributed model encourages responsibility and collaboration (Spillane, Halverson & Diamond 2001) and recognises informal leadership where expertise or interest creates a leader. It has emerged as an important concept for higher education (reviewed in Jones, Lefoe, Harvey & Ryland, 2012) and has been fostered in Australian higher education sector by a number of OLT-funded leadership projects.

A distributed leadership model encourages the emergence of local leaders. In a national organisation, local leadership is crucial to maintain activity across the sector and to ensure the local context is taken into account. Through its direct association with Faculties of Science, the ACDS TL Centre will be able to reach into all Australian universities that teach science and it will have the capacity to mentor new leaders in formal positions, such as Associate Deans Teaching and Learning, and informal leaders who can develop expertise. The ACDS TL Centre will need local champions who can adapt resources and ideas to the local environment and will feed back their experience of implementation.

In the context of the ACDS TL Centre, distributed leadership should translate into a rolling leadership group, transient leadership of projects and activities, mentoring of new or junior members and the local implementation of strategies.

2. A network of networks

The ACDS TL Centre has the potential to link existing expertise and support. A number of information sources and support groups already exist to support science learning and teaching. However, not all science disciplines or potential groups are included and access is scattered. Since the scope of the ACDS TL Centre includes all science and mathematics teaching, the Centre should be widely relevant. As it builds

a broad cross-section of participants, it will bring science disciplines and special interest groups together. This has two important advantages. Firstly, a consolidated access and information point has an obvious attraction for science educators and fosters cross-disciplinary collaboration. Secondly, the breadth of interaction allows the collection of opinion across science and mathematics and the synthesis of sector-wide responses, which will be useful in responding to external requests.

3. Sustainable support for learning and teaching development

Rapid changes in funding models for higher education highlight the precarious nature of funding for improvements in learning and teaching. The OLT has 'changed the game' by shifting grants, fellowships and awards for learning and teaching from the periphery to the mainstream of university action. However, funding is predominantly project-based, which assumes that the products of the project will be used and extended by practitioners when the funding ceases. More systematic encouragement is needed to move the specialist application of a project into routine and widespread practice.

Henderson et al (2011), in their review of instructional change strategies in science, note that change in teaching practice is slow and requires a time scale of many years. Project funding usually seeks results in a much shorter time frame, which means that important outcomes are often not measured and experience of implementation is limited. The ACDS TL Centre is in the unusual position of being decoupled from an externally defined project length. This independence offers the great advantage of a longer-term view and systematic progress towards goals that can be refined over time.

Relationships with external stakeholders

Many stakeholders have an interest in the improvement of learning and teaching in science in universities. Apart from students, teachers and the universities themselves, disciplinary associations, science organisations and government bodies are likely to be interested in the work of the ACDS Teaching and Learning Centre.

Science disciplinary bodies and networks

A number of science discipline associations use formal accreditation to regulate learning and teaching in their disciplines (Table 2.1A). These groups examine the curriculum of accredited institutions and set boundaries around the design and delivery of teaching in their disciplines. Other professional associations and societies have long-standing education groups, which are influential in defining disciplinary curricula in higher education and in leading practice (Table 2.1B overleaf). However, learning and teaching is often perceived as a minor activity for professional associations. Of the 46 disciplinary associations listed as members of the peak body, Science and Technology Australia, <scienceandtechnologyaustralia.org.au/>, 24 have no accreditation program or obvious focus on education recorded on their websites apart from research training. Many of those that do contribute education activities have a primary focus on research. However, academic science leaders have close ties

to discipline and professional associations and constitute the main link between disciplines and universities.

Table 2.1: Member associations of Science and Technology Australia active in education and training as recorded on association websites [2]

Table 2.1A: Associations offering formal accreditation to science courses and graduates

Australian Institute of Agricultural Science and Technology
Australian Institute of Physics
Australian Mathematical Society
Australian Psychological Society
Australasian Radiation Protection Society
Australian Society for Microbiology
Nutrition Society of Australia
Royal Australian Chemical Institute
Statistical Society of Australia

Table 2.1B: Associations listing education activities on the association website (excluding research training)

Association	Resources for educators / students	Education symposia and/or teaching awards
Astronomical Society of Australia	✓	✓
Australian Institute of Physics	✓	✓
Australian Mathematical Sciences Institute	✓	✓
Australian Meteorological and Oceanographic Society	✓	✓
Australian Psychological Society	✓	✓
Australian Society of Plant Scientists	✓	✓
Genetics Society of Australasia	✓	✓
Mathematics Education Research Group of Australasia	✓	✓
Nutrition Society of Australia	✓	✓
Royal Australian Chemical Institute	✓	✓
Society of Crystallographers in Australia and New Zealand	✓	✓
Statistical Society of Australia	✓	✓
Australasian Society of Clinical & Experimental Pharmacologists & Toxicologists	None listed	✓
Australian Archaeological Association	None listed	✓
Australian Mathematical Society	None listed	✓

[2] Information retrieved 4 July 2013.

Australian Neuroscience Society	None listed	✓
Australian Physiological Society	None listed	✓
Australian Society for Biochemistry and Molecular Biology	None listed	✓
Australian Society for Microbiology	None listed	✓
Institute of Australian Geographers	None listed	✓
Australian Institute of Agricultural Science and Technology	None listed	✓

Disciplinary groups offer opportunities to link learning and teaching with research in the discipline. Recently a suite of science discipline education networks has been established, primarily via funding from the Office for Learning and Teaching (Table 2.2 below). These new networks have concentrated on the teaching practice of individuals, which they seek to influence through disciplinary standards for learning outcomes and exemplars of good practice. A major effect of the new networks has been to foster discussion and collaboration amongst education-focused academics. This work is complementary to the proposed institutional focus of the ACDS TL Centre. Agreement among the disciplinary associations, education networks and the focus of the ACDS will align influences on the individual educator and the institution, creating a climate for real change.

Table 2.2: Science discipline education networks[3]

Peer network	Science discipline	Relevant educationally-active professional associations
The Australian Mathematical Sciences Learning and Teaching Network (AMSLaT)	Mathematical sciences	Australian Mathematical Sciences Institute Australian Mathematical Society Mathematics Education Research Group of Australasia Statistical Society of Australia
Collaborative Universities Biomedical Education network (CUBEnet)	Biomedical sciences	Australian Neuroscience Society Australian Physiological Society Australian Society for Biochemistry and Molecular Biology Australian Society for Microbiology Genetics Society of Australasia
Chemistry Discipline Network (Chemnet)	Chemistry	Royal Australian Chemical Institute
Physics Education Network	Physics	Astronomical Society of Australia Australian Institute of Physics Australian Meteorological & Oceanographic Society Society of Crystallographers in Australia and New Zealand
Vision and Innovation in	Biology	Genetics Society of Australasia Australian Society for Biochemistry and Molecular

[3]Additional science networks are emerging in Geoscience and Agricultural Science.

Biology Education (VIBEnet)		Biology Australian Society for Microbiology Australian Society of Plant Scientists

A recent OLT-funded leadership project, Science and Mathematics Education network (SaMnet), has built a cross-disciplinary network of learning and teaching innovators, <www.samnet.edu.au>. The project sought to test the idea of design teams with embedded complementary expertise through work on action learning projects in Faculties of Science across Australian universities. The teams include junior and senior science educators, a senior mentor and an educational designer. This network is particularly interesting as it offers inbuilt mentoring, a wide range of experience across the network and fosters cross-disciplinary links. SaMnet workshops in February 2013 were used to explore ideas about the ACDS TL Centre with learning and teaching innovators.

The ACDS TL Centre must build excellent relationships with disciplinary associations. Discipline leaders are often in positional leadership roles within universities; this creates an inbuilt link to faculties, the ACDS and the ACDS TL Centre. The Centre can offer a dissemination point for disciplinary activity and interaction with other disciplines. During the fellowship, this idea has been tested by collaboration between science and mathematics education networks.

Government: Office for Learning and Teaching, Office of the Chief Scientist and regulators

Government interactions are particularly important for science in universities. Funding models, priorities for government activity and regulation are all important factors in determining the environment for science learning and teaching. The ACDS TL Centre should engage with relevant government bodies.

The Chief Scientist of Australia is an advisory position to the Australian Government, <www.chiefscientist.gov.au/>. As well as providing advice, the Office of the Chief Scientist commissions and publicises reports on issues regarding science. Recently the Chief Scientist secured funding for the development of more functional links between science and school education through outreach and teacher training. The ACDS has a strong relationship with the Office of the Chief Scientist, which provides an important link to government policy development. The ACDS TL Centre will seek to collaborate with the Office of the Chief Scientist through constructive discussion, complementary projects and dissemination of the work of the Office of the Chief Scientist.

The ACDS has a long-standing relationship with the Office for Learning and Teaching (OLT), <www.olt.gov.au/> and its predecessor the Australian Learning and Teaching Council (ALTC). The OLT is housed within the Federal Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education. The OLT "promotes and supports change in higher education institutions for the enhancement of learning and teaching", <www.olt.gov.au/about-olt>. Through its grant programs and commissioned work, the OLT is an important funding source for

innovation in learning and teaching. Its resource library houses a wide range of resources for science. A snapshot of the library collected in May 2013, identified 40 reports directly addressing issues in science learning and teaching (Table 2.3 below). A further 50 reports included science as a keyword. In addition, leadership development projects provide advice and resources on the cultural change needed to support curriculum development.

Table 2.3: **Snapshot of OLT completed projects directly addressing issues in science learning and teaching – OLT Resource Library**

Major focus of OLT project on science learning and teaching	Number resources/reports
Curriculum development	5
Academic support	3
Assessment	3
Pedagogies for teaching	11
Tools for teaching	12
Leadership and staff development	4
Overview of ALTC science projects	2
Total	**40**

Current at 23 May 2013.

All projects linked to the search term science were reviewed to identify those directly working with science learning and teaching. Projects were categorised by functional focus. A complete listing of identified projects is included at Appendix B.

The ACDS TL Centre will work collaboratively with the OLT. The Centre offers an extra dissemination point for OLT projects to encourage participation and future impact. During the fellowship, current OLT projects and fellowships were promoted through Centre meetings and on the Centre website. Future Centre projects will link more science and mathematics educators to the OLT resource repository.

Other stakeholders

The ACDS provides advice to a number of government bodies on specific issues. It has been active in the development of the Australian National Curriculum, working collaboratively with Australian Curriculum, Assessment and Reporting Authority (ACARA) to assist with review of curriculum descriptors. In 2013, a working party of the nascent ACDS TL Centre constructed advice for the ACDS on the draft higher education standards of the Higher Education Standards Panel on learning outcomes and course design. This advice was adopted by the ACDS and submitted as feedback to the Higher Education Standards Panel (HESP).

As the ACDS TL Centre becomes more established, it will develop capacity to respond to specific issues either with formal advice to stakeholders via the ACDS or through information dissemination from external stakeholders to faculties.

From design to construction

The initial phase of this project established an outline for the construction of the ACDS Learning and Teaching Centre. The phase produced:

1. aims for the ACDS TL Centre
2. organisational principles regarding distributed leadership, network operation and sustainability
3. a list of stakeholders who should be considered in development of the Centre.

The next phase of the fellowship was to test and further develop these ideas and to invite proposals for future activities for the Centre. Consultation was undertaken with Associate Deans Learning and Teaching from Faculties of Science, with a group of learning and teaching innovators in science and with the ACDS. The views collected through consultation were used to refine construction of the Centre, to shape trial activities and to construct a final proposal for the ongoing operation of the Centre.

Chapter 3: Views from Learning and Teaching leaders

Curriculum reform is intimately enmeshed in cultural change. It is the attitudes and experience of teachers, leaders of teaching and those that support teaching, which can limit ideas about what can be achieved. Influencing change requires meaningful and sustained interaction with players and stakeholders. To be effective, the ACDS TL Centre must be relevant, visible and responsive to science and mathematics educators and faculties.

A primary task of this fellowship was to build relationships between the new Centre and its stakeholders. Initial ideas developed through the ACDS Working Group were presented and discussed with science learning and teaching leaders through conferences, workshops and individual interviews. Stakeholders, with a particular emphasis on Science Faculty leaders, were invited to participate in the construction of the Centre and to suggest priority projects. This iterative process refined the concept for the Centre, gathered new ideas and, perhaps most importantly, raised awareness of the project and invited engagement.

The second subject of discussion was the nature of curriculum reform in Science Faculties in Australian universities. Understanding the scope and complexity of curriculum reform invites consideration of effective resources to support reform and possible ACDS TL Centre activity. A preliminary snapshot of curriculum reform was collated from seven Faculties of Science to describe the kind of reform projects underway, factors which impede and facilitate curriculum reform, and the capacity of staff to engage with reform projects.

Stakeholders invited to contribute to the conversation included: Associate Deans Teaching and Learning from Science Faculties; teaching and learning leaders engaged in curriculum reform projects; and Deans of Faculties of Science. The ACDS Executive acted as a reference group for the work of the fellowship, most importantly through the ongoing, active participation of the Executive Director, Professor John Rice.

Associate Deans Teaching and Learning

The role of the Associate Dean Teaching and Learning (ADTL) is a relatively new position in Australian universities. The roles of “learning leaders” were explored in a landmark study by Scott, Coates and Anderson (2008), which compared the focus and challenges of roles at middle and senior levels in Australian universities and the implications for leading change. Participants distinguished between management described as “more operational”, and leadership described as “more strategic”, which the authors note aligns with the reported literature (Scott et al, 2008, p2–3). Scott et al (2008) found that Associate Deans reported the most important components of their role, in ranked order, as: strategic planning, policy development, reviewing teaching activities, participating in meetings and developing organisational processes. Associate Deans believe they have an important strategic role.

The role of the Associate Dean Teaching and Learning was also explored by Southwell, West and Scoufis (2008). Reported feedback from ADTL participants in leadership development workshops described a broad, complex role, "everything strategic and operational to do with teaching – if it isn't research then it is ours" (Southwell, West, & Scoufis, 2008, p49). This role is interpreted and enacted variously at different universities, with complementary roles such as Associate Dean, Engagement also emerging. Straw polls of participants at ACDS teaching and learning meetings in 2012 and 2013 indicate the time fraction and scope allocated to the ADTL role is variable. Wherever it occurs, the ADTL position or its equivalent has direct relationships with those enacting curriculum (schools, departments and program coordinators) and those responsible for the institutional environment (Deans, Deputy Vice-Chancellor Academic, Pro Vice-Chancellor Education).

Heads of schools and departments are the line managers of teaching staff. They are the gatekeepers to human resources and must balance the competing workforce priorities of teaching and research. They may be "baronial" in defending their own disciplines (Scott, Coates and Anderson, 2008). The collaboration required to deliver cross-disciplinary and generalist degrees is likely to reside with faculties rather than schools or departments. Associate Deans, who are appointed at faculty level, are in the right position to navigate the competing priorities of individual schools and departments within a faculty, to find common ground and lead concerted action towards a shared position. The ADTLS, therefore, sit at the crux of curriculum reform in Science Faculties and must be a primary target for involvement in broad scale reform.

Informal leaders in learning and teaching

Informal leaders are also important drivers of curriculum reform. Leaders of innovation in learning and teaching are potentially at all levels within a faculty, from individual academic and professional staff passionate about learning and teaching to educational researchers and curriculum specialists. Innovative practice can be particularly influential in engaging peers or positional leaders. Burke da Silva et al. (2008), in a study of influences on science academics in three Australian universities, found the participating academics were more likely to pay attention to the practice of scientific peers than others. Roberts, Butcher and Brooker (2011) describe unit (subject) coordinators as informal leaders who practice leadership in the design of teaching and in the work of teaching teams.

In seeking to achieve sector-wide curriculum reform, the ACDS TL Centre needs to engage with positional leaders and with influential innovators. Disseminated leadership models recognise the value of diverse expertise and empowering potential leaders. Engagement with innovative academics recognises their potential for leadership and expands the modes through which the objectives of the Centre can be met.

Collection of perspectives on the ACDS TL Centre

For this study, two groups were invited to discuss the role and potential of the ACDS TL Centre: Associate Deans Teaching and Learning and learning and teaching innovators from the Science and Mathematics network of Australian university educators (SaMnet) educational leadership project. A full list of dissemination and discussion activities is included at Appendix C.

The role and operation of the ACDS TL Centre was explored through three activities.

a) Workshops at the ACDS TL conferences

The ACDS Teaching and Learning Conferences bring together Associate Deans Learning and Teaching from Science Faculties or equivalent positions. The conferences also include leaders of major learning and teaching projects in science as guests and presenters. In 2012, the conference brought together 54 representatives from 26 Australian universities. In 2013, 54 representatives from 23 universities attended.

Each meeting held group discussions on the ACDS TL Centre. Comments from the discussions have been combined to present the range of contributions on particular topics as discussions were free-ranging on both occasions. Each session began with short introductory presentations on the proposal for the ACDS Centre (2012) and the development of the Centre (2013). Small group discussions of six to eight participants were initiated with prompt questions followed by feedback to the whole group and open discussion. At the 2012 meeting, the prompts for open discussion were: *What could the ACDS Centre usefully do for you?* and *How should we ensure quality for the ACDS Centre?*. At the 2013 meeting, the prompt questions were: *How should the ACDS TL Centre operate? What should be the top three priorities for the ACDS TL Centre?* In 2013, participants were able to add further comments online during the remainder of the conference.

b) Workshops with SaMnet scholars

The Science and Mathematics network of Australian university educators (SaMnet) is an OLT-funded project which aims to develop leadership amongst science and mathematics academics through action-learning projects. Twenty-three SaMnet project teams worked across 16 Australian Universities during 2012–2013 (see <samnetaustralia.blogspot.com.au/>). The SaMnet scholars represent a cross-section of teaching academics since each action-learning project includes a junior academic, a more senior academic, a faculty leader and an educational designer. SaMnet workshops held in February 2013 in Melbourne, Adelaide, Perth, Sydney and Brisbane were used as a vehicle for discussion of the ACDS TL Centre. Following a presentation on the proposal for the ACDS TL Centre, each workshop reached a consensus on key points through open discussion. Consensus points were recorded during the session, agreed by the group and collated for analysis.

c) Interviews with Faculty ADTLs

Interviews were held with a cross-section of Associate Deans Teaching and Learning from Science faculties from 12 universities including representatives from Group of 8 universities (4), Australian Technology Network (ATN) universities (4), Innovative Research Universities (IRU) (2) and unaligned universities (2 including one regional university). The interviews probed 'hot' issues for faculties in learning and teaching of science and mathematics and potential interactions with the ACDS TL Centre. Associate Deans were asked to respond to three questions:

- *What are the key issues for Science and Maths learning in your faculty?*
- *What information or advice on TL would be most valuable to you and your faculty?*
- *How would you choose to interact with the ACDS teaching and learning centre?*

Responses were recorded in field notes which were checked by interviewees before collation for analysis. Collected data from workshops and interviews were analysed by thematic analysis to identify key points (Cousin G, 2009).

Developing the ACDS TL Centre

1. How should the ACDS Centre operate?

Views on the character and operation of the ACDS Centre were collected during ACDS Teaching and Learning Conferences in 2012 and 2013 (Table 3.1) and in individual interviews with a cross-section of ADTLs. The individual interviews echoed the range of suggestions collected from the ACDS Conferences. Feedback from participants was collected via open text comments submitted individually on paper (2012) or online (2013) during group discussion sessions.

Table 3.1: Summary of suggestions for the operation of the ACDS TL Centre

Character
• Voice and vision for science • Connectivity across distance, link isolated discipline academics/ leaders • Inter/cross disciplinary • Sustainable, adaptable • Distributed leadership
Operations
Centre leadership • Establish ACDS TL Centre leadership group: rotating team structure representing diversity and mentoring junior leaders • Centre should include support for individual academics • Include 'retired' ADTL to expand capacity • Employ central organiser and website manager
Relationships and participation • Link research to teaching • Stimulate engagement between disciplines and networks

• Work with academic development units • Enable cross-institutional teaching • Public support for OLT grants that align with Centre objectives • Use peer review + editorial board for review • Establish a college of experts which can set priorities, validate best practice, recognise leaders • Maintain a membership database
Communication • General information: funding sources, conferences, contact lists, publication opportunities • Contact via, for example, autofeed from website, regular newsletter/updates via listserv/email, twitter with rotating authorship
Meetings • More informal conversations via web/skype/blogs Add Centre meetings to existing conferences and invite other HE disciplines/groups • Provide grants for sponsored visits
Products
Explanations • Shared information: clearing house, issues/problems, discussion • "pedagogy one pagers" • Commentary on higher education and tools for evaluating quality
Case studies/Good Practice Guides • Collections of evaluated best practice as: good practice guides, teaching strategies/approaches, innovations/tools • Examples of successful and unsuccessful broad strategies • Incorporate peer review to expand dissemination • Presentation of case studies in Faculty level learning and teaching
Faculty leadership • Leadership development workshops for ADTLs • Provide evidence and advice for deans.

The ACDS TL Conference participants saw the TL Centre as a peer network with a strong commitment to inclusion and connection. It was described as “network central”; the hub that joins disciplines and dispersed individuals, and links to important external players in Australian or overseas. These discussions proposed a flat and minimal organisational structure with distributed leadership amongst ADTLs and learning and teaching leaders. The Centre was also seen as an opportunity to publicly recognise expertise in learning and teaching through public endorsement of good work or identification of experts.

ACDS TL Conference discussions suggested a range of activities for the ACDS TL Centre including identification of best practice in learning and teaching, and providing links to curated resources. The idea of authoritative advice was welcomed for multiple reasons: as a respected information source for institutional discussion, as peer pressure for better learning outcomes, and as a provider of succinct and pertinent advice that is oriented towards science and mathematics. The major

concept was of the Centre as a reviewer or an information broker rather than conducting primary investigation.

Individual interviews with ADTLs also explored the potential for participation in the activities of the Centre. All ADTLs interviewed were interested in participating to some degree. All agreed they would be interested in regular newsletters and most were willing to contribute to them with local updates or articles. The ADTLs emphasised the importance of an authoritative voice for the Centre through peer review and/or expert review. Some were willing to act as peer reviewers for submitted materials.

The ADTLS supported the concept of ACDS TL Centre projects to distil advice or develop a position. Most of those interviewed were willing to contribute to project work providing the commitment was contained. All of the ADTLs noted that time pressures and workload would limit their involvement in projects. Two of the interviewees noted that institutional recognition of a contribution at national level would make it easier for ADTLs as well as teaching and research academics to be more active.

2. Issues in learning and teaching for science

The influence of the ACDS Teaching and Learning Centre will depend on the congruence of its activities with the major concerns of Science Faculties. Views on the major issues facing Faculties of Science were collected from individual interviews with ADTLs (Table 3.2)

Table 3.2: Key issues for Science Faculties nominated by ADTLs

What are the key issues for science and mathematics learning in your faculty?
Effective pedagogies (raised in 6/12 interviews) • Interventions to support and manage underprepared students (x3) • Adjusting practice to an information-rich environment (x2) • Maintaining focus on experiential learning in laboratories and skills development.
Course design (raised in 4/12 interviews) • Construction of curriculum maps to inform design • Embedding the national Science TLOs across diverse science programs and in capstone subjects • Achieving constructive alignment in practice (between intended learning outcomes, teaching activities and assessment).
Course management (raised in 4/12 interviews) • Managing pressure to reduce teaching costs, especially laboratory classes (x2) • Managing diverse disciplines in a single faculty • Retention of students into honours and higher research degrees.
Standards, regulation (raised in 3/12 interviews) • Identification of convincing evidence for achievement of standards through assessment • Most effective use of standards in curriculum design • Resolving differences between Level 9 non-cognate degrees and AQF assumption of level of learning.

Teaching and Learning capacity (raised in 3/12 interviews) • Facilitating access to and engagement with best practice in learning and teaching (x2) • Involving research-focused staff.

The range of issues nominated reflects the breadth of the role of the ADTLs, which includes supporting and leading effective teaching and course design, governance issues and building capacity amongst staff. The most pressing issues appeared to relate to identifying and promulgating effective learning design and teaching practice.

The same question, when put to the learning and teaching leader workshops, drew similar suggestions for operation of the ACDS TL Centre and priorities for its work. These SaMnet workshop participants included junior academics, senior academics and some positional leaders. Group discussion in five workshops was prompted by three questions: *What should the ACDS TL Centre do? How could the ACDS TL Centre help you? What are the key issues for science and maths learning and teaching?* Each workshop reached a consensus list that was then compiled thematically (Table 3.3).

Table 3.3: Summary of issues in learning and teaching for science and mathematics collected at SaMnet workshops

What are the key issues for science and mathematics learning and teaching?
Building staff capacity • achieving cultural change and encouraging new leaders of learning and teaching • increasing engagement for learning and teaching from university leaders • improving understanding of teaching and learning and good practice
Improving teaching practice • expertise required for teaching very large classes • balancing different teaching modes (face-to-face vs online) • dealing with under-preparation for university study (especially in quantitative skills) • constructing assessment as evidence for learning and teaching outcomes
Dealing with new technologies • responding to the ubiquity of information • managing intellectual property in learning and teaching (especially online learning) • responding to the perception of online pedagogies as a means to cut costs.

There was considerable overlap in the issues identified by learning and teaching leaders and those identified by ADTLs. Most issues are common across disciplines in universities and much concern is about the translation of these issues into the context of science and mathematics.

Two areas are specific to science and mathematics; – the specialist pedagogies around scientific practical programs in laboratories and fieldwork, and the decline in student interest in physical sciences and advanced mathematics in schools which has been well documented (Barrington, 2013; Goodrum, Druhan, & Abbs, 2011). Individual Faculties of Science have limited capacity to influence science education in

schools. However, a strong representative voice to external bodies can be very effective, notably the recent advocacy of the Chief Scientist, Professor Ian Chubb.

3. Proposals for ACDS TL Centre projects

In 2013, ADTLs at the ACDS TL Conference and learning and teaching leaders at SaMnet workshops were asked to nominate the most important projects that the new Centre could undertake (Table 3.4). The projects specify potential products from the Centre that address current concerns amongst the ADTLs. They include enabling activities (practice exchange, facilitation of external peer review or benchmarking), information (assessment resources, critique of Massive Open Online Courses (MOOCs), advice/guides), teaching resources (mapping tools, repository) and professional development activities for leaders.

Table 3.4: Summary of nominations for projects for the ACDS TL Centre

Possible projects for ACDS TL Centre	ACDS TL conference	TL leaders
Curriculum design and quality assurance		
Standards, benchmarking and TLOs		
TLO best practice guides/ case studies to be supported by assessment practice and design	☐	☐
Develop TLOs for sub-disciplines	☐	
Facilitating benchmarking between institutions and/or internationally	☐	☐
Develop possible quality indicators: evidence base, comments from users, impact statements from ADTL	☐	
Curriculum tools: Visual, easy to use mapping tool for curriculum TLOs	☐	
Sharing know-how		
Executive summaries / Good practice guides on key ideas and issues for learning and teaching in science and maths	☐	☐
Ideas/Practice Exchange which is curated, searchable, and has abstracts, case studies, problem database, rating system	☐	
Facilitating seminars and workshops with learning and teaching experts		☐
Assessment resources: Evaluated exemplars of formative and summative practices, feedback, the use of portfolios and evidence provided by students (shared responsibility), best practice guides	☐	
Student engagement: Extra-curricular activity hub for science students	☐	
Developing capacity in teaching and learning		
Leadership development		
Leadership development workshops for ADTLs	☐	
Online development modules with electronic badges for completion		
Recognise and foster leaders, early career mentoring	☐	☐
Consolidate information on sector trends and development		☐
Investigate the role of education-focused academic positions		☐

Faculty operations: Examples of governance/management efficiencies	☐	
Fostering scholarship: Collection of evaluation tools for teaching and curriculum projects SoTL workshop and/or writing retreats	 ☐	☐
Peer review of LT: External peer review of LT facilitated by the Centre	☐	☐
Tools for teaching/ teaching practice		
Science teaching resources Build a practice/ideas exchange to foster discussion and innovation Build a repository of teaching materials core to science Tools for teaching communication skills Advice/guides on supporting underprepared students	 ☐ ☐ ☐ ☐	☐
Online learning/ MOOCs: Systematic critique of MOOCs and their potential to impact upon learning and teaching science over the next 5 years Advice on managing intellectual property online	☐	 ☐
Graduate employment: Advice on Career Development Learning/ links to employment in science.	☐	

Summary of consultation

The consultation phase of this project showed strong enthusiasm for the ACDS Teaching and Learning Centre with all respondents welcoming a national space for science and mathematics in universities. Leaders of curriculum projects and faculty leaders could see immediate benefits for themselves and colleagues, for their institutions and for the sector.

Respondents strongly supported the idea of an activity hub to link and consolidate material, which was thought to be a most effective way of disseminating and encouraging good practice. Authoritative advice was a major goal, for distillation and for reliability. Respondents described the need for advice for both teaching practitioners and for university managers and leaders.

The proposed organisational principles were reinforced by comments during consultation. Features of distributed leadership appeared in descriptions of peer-to-peer activities, and the recognition of expertise by peers. The network of networks was represented by comments about a ‘one-stop shop’ and link to resources. The potential for ongoing support was seen as an advantage for the new Centre to build over the long term.

Suggestions for ACDS activity reflected the issues nominated as important for science and mathematics. Respondents were looking for answers to specific issues but also for help to achieve a step-change in practice. There was a hunger for information, ideas and sharing with peers.

Chapter 4: What does curriculum reform look like in Science?

A fundamental issue relevant to curriculum improvement initiatives is the current extent of reform efforts. As part of the fellowship consultation, a small number of extended interviews with ADTLs were held to construct some understanding of the scope and scale of curriculum development occurring in Faculties of Science. The objective was to identify issues in curriculum reform for Science Faculties and to help the ACDS TL Centre to target its activities more effectively.

A snapshot of curriculum reform in Science

A preliminary discussion of curriculum reform occurred at the 2012 ACDS Teaching and Learning meeting as part of a session exploring the use of the Science Threshold Learning Outcomes (Jones, Yates and Kelder, 2011) in curriculum reform. Feedback recorded from 12 participants was used to construct prompt questions for subsequent interviews with Associate Deans Teaching and Learning.

Interviews were held with Associate Deans Teaching and Learning from a range of institutions: a regional university, an Australian Technology Network (ATN) university, an Innovative Research University (IRU), three Group of Eight universities and a non-aligned institution. All interviewees were active participants in ACDS and/or OLT initiatives. Interviewees were asked to: define curriculum reform; describe current curriculum reform projects in their institution; describe staff attitudes and capacity for reform; and to comment on impediments and tools for curriculum reform. Other topics that emerged during interviews were the roles of learning and teaching champions and leadership skills.

Curriculum reform

ADTLs had a broad view of curriculum reform, which they felt included anything that was concerned with learning and teaching and covered content, assessment and delivery.

> *"Curriculum to me is absolutely anything that involves student learning. So it is the formal classroom structures as well as the things that we wrap around it like mentoring and so on."*
> Interview 3

> *"Well, my view is that it includes everything so it includes all things to do with content, even the type of courses that you want to run – the content of those programs, reform being reviewing and renewing, – and then it is also around teaching practice, delivery, assessment in particular, and the student experience."*
> Interview 6

> *"How I think of it is like opening up to full open consideration of why we teach, and then figuring out from that the best options moving forward, and looking at*

how is the best way to teach that within the context of the discipline and contemporary methods of teaching and the technology that's available."
Interview 1

Individual comments noted the very tight interconnection between the curriculum components that forces consideration of multiple issues at once. Interviewees expressed a desire to focus on outcomes and to be forward-looking. Several interviewees noted an institutional emphasis on course structures and on "ticking boxes". Reducing the number of subjects and/or courses offered is seen as a means to decrease costs and increase productivity for the institution.

When asked about current curriculum reform in their institution, four (of seven) interviewees described large-scale projects initiated at university-level. In one case, major initiatives were driven entirely from faculty-level and required substantial effort to convince institutional leaders to support the projects. All interviewees described considerable adaptation of institutional reform agendas at faculty-level and talked about interpretation within the discipline of Science.

Most interviewees had used university priorities or processes to drive a reform agenda within the faculty. External imperatives, driven by regulation (e.g. Australian Qualifications Framework (AQF)) or the institution (e.g. periodic course review), were seen as opportunities to tackle multiple issues. For example, review of a large course offers an opportunity to drive a concerted campaign to embed shared curriculum design principles such as constructive alignment. In another case, new laboratories created an opportunity to redesign laboratory programs.

"… using the science review for example, that's how we did it last year, when we did the budget of science review we said 'This is an opportunity to do a mini review for each of our areas of study.' So we at the faculty level can look at the structure of what the Bachelor of Science sees, what other requirements we ask students to complete…"
Interview 7

"…at the moment we're focusing on practicals, on lab experience. The reason that's come about is because we've just built a brand new building which is our new labs. It's an opportunity to allow us to change the way we teach in labs so we as a school, through both my and [Head of School]'s push, is to get all academic staff within the school to rethink the way we teach in the lab environment."
Interview 2

The focus of the reported curriculum reform projects was on curriculum design. Four interviewees explicitly described design projects to align curriculum with graduate attributes or outcomes. The introduction of the AQF, the establishment of TEQSA, the Learning and Teaching Academic Standards project, and the recent work of the HESP have stimulated conversation and interest in graduate learning outcomes at national level. It is not surprising that action has followed in faculties. Other

priorities were assessment practice, managing student diversity and under-preparation, laboratory programs, and new technologies.

Staff attitudes and local leaders

All ADTLs emphasised the importance of learning and teaching leaders and champions in driving innovation and leading by example.

> *"But the best thing was, he'd been teaching for 30 years and he's been using technology to fill the gaps in what he wanted to do in his teaching. He got his (teaching) award and the next minute, I look up, he's up on a hill looking at a plant somewhere. He's passionate. So he's a shining example, so I can send other people to him, there's that personal approach. If I tell people something, I'm known as a bit of a techno-geek. So anything I say about technology, they think, 'Well (they) can do it, but I can't'. Well, he's also a respected educator and seen as being an in-the-field botanist, so I think by prioritising that and then having him get those sort of awards, and the teaching team pick up an award, that has a flow-on effect that's going to be more effective than any top down approach."*
> Interview 1

> *"And again one of the strategies that we're using here is we're actually, rather than trying to convince people that this is something that they need to do, we're working with the ones who are more than happy to go there and then what that's doing is where it's working really with the students and that's the key thing. So actually the students are the drivers of change now, rather than us."*
> Interview 4

Leaders who could link staff with good educational practice or who could interpret into the local implementation were seen as crucial for effective reform. Interviewees commented that peer learning between discipline academics was an important mode for dissemination of good practice. Discipline staff were thought to be less likely to listen to educational designers external to the faculty, although in at least two cases, an educational designer working collaboratively within the disciplinary group was described as a huge asset. This issue has been reported in the literature (Dancy & Henderson, 2008).

> *"I think they would resist quite strongly, any kind of teaching and learning people being imposed on them."*
> Interview 4

> *"A major resource for curriculum reform is [the] …Faculty educational designer who understands their role is to support academics, much more effective than the central TL unit."*
> Interview 5

Perceptions of the motivation for discipline staff to engage with reform were mixed. One ADTL commented that innovative teachers are motivated by personal interest in the work and that student expectations can drive uptake of innovative pedagogy.

Another suggested that good performance in teaching is often associated with good research performance probably because the staff member is simply more capable. In two cases, directives from the institution were seen as the means to force engagement from all discipline academics.

Education-focused roles also produced a mixed response. These positions are new to the sector and are interpreted variably even within the same institution (for review, see Probert, 2013). These roles exist at three of the institutions discussed and are under consideration at a fourth. Education-focused roles were noted as examples of recognition of learning and teaching rather than as providing leadership for curriculum development. Three interviewees said that science discipline research is still seen as the pathway to promotion as promotion criteria and/or processes do not reward teaching excellence. One ADTL reported that teaching-focused roles were seen as a punishment for poor achievement in research. However, a fourth interviewee reported that recognition for excellence in learning and teaching through awards encouraged innovation and fostering leadership.

Impediments and drivers

All ADTLS reported high workload and lack of creative time as the major impediments to curriculum reform. High academic staff workloads force difficult decisions about allocating time between research, delivery of the current curriculum and innovation.

> *"I think the institution needs to provide the resourcing, either financial in terms of time release or support people to work side by side with the academics – and that's the other bit. The support people can't reform the curriculum. It's the academics who have to reform the curriculum."*
> Interview 6

When maintaining the status quo is seen as the least disruptive course of action, institutional priorities can create incentives for participation or at least can remove disincentives. One ADTL had found that relatively small investments of funding and resources were sufficient to foster innovation. Another commented that time must be matched with increasing staff capability to get value out of reform.

Resources that supported reform included the development of staff skills as well as construction of curriculum and teaching materials. Sharing educational knowledge and skills either through peer networks, effective staff training or through technical support encourage innovation and, depending on the project, can be critical. Curriculum mapping tools, information management and open educational resources were nominated as important tools for curriculum renewal.

The ADTLs commented on the importance of supportive leaders. Almost all interviewees felt that the active support of heads of schools and departments was essential to get any commitment from staff. To achieve broad change, leaders must develop a collective vision that motivates discipline staff to work on curriculum.

Three ADTLs described their own role as facilitating change and managing up and down.

> *"The expertise is always in the schools; schools are the custodians of their discipline so they are the experts, they are the ones who know what and how they should deliver their programs (majors). …Ultimately it's the head of school who is responsible for the delivery of the majors that are offered within the school."*
> Interview 6

> *"So nobody's going to do (curriculum reform), unless they're absolutely directed to by the Head of School."*
> Interview 4.

Findings

Curriculum reform, as described in these interviews, is a complex, demanding task. It takes place in a fluid environment subject to competing priorities and restricted funding. It requires a sophisticated understanding of the interconnected influences of the institutional context and staff capacity and engagement.

The scope of curriculum reform in Science Faculties is quite variable, changing in scale from single degrees to whole-of-institution projects. Impetus for curriculum reform was derived from a range of sources: institutional priorities, local opportunities, new resources and normal review processes. However, the objectives for curriculum reform were consistent: improved student outcomes, effective teaching delivery and confidence in assessment.

In discussing curriculum reform and renewal, this group of Associate Deans Learning and Teaching were obviously experienced users of major concepts from the scholarship of learning and teaching that underpin ffective teaching design such as constructive alignment (Biggs & Tang, 1999). They tended to dwell on the enormity of the tasks they thought should be tackled rather than reflecting positively on progress so far. However, in designing curriculum projects, they were both opportunists and realists, seizing opportunities to advance underlying priorities, shaping the ambitions of their projects to a local scale and translating from broad-brush ideas to the detail of teaching delivery.

These interviews and the feedback from the ACDS Teaching and Learning meetings suggest there is enthusiasm and capacity for curriculum renewal among faculty learning and teaching leaders. Broad-scale improvement is limited by resourcing, the capacity of teaching and research academics to undertake reform, and conflicting priorities of institutions to manage cost and promote reputation through research. These issues are not confined to science although they are probably exacerbated by the emphasis on research excellence in a highly competitive research environment and the relatively costly provision of experimental science teaching. Science needs a strong collective voice to 'manage up', to demonstrate the value of curriculum reform in science, and to argue for renewed investment in learning and teaching excellence.

Chapter 5: The ACDS Teaching and Learning Centre

The ACDS Teaching and Learning Centre was constructed and trialled during this fellowship. Its public face, the website, was launched in February 2013 and the Centre has run a number of meetings and projects during 2013. It is the first national organisation in Australia that seeks to include university teaching and learning leaders from all disciplines of science and mathematics. The Centre has demonstrated its potential to become the national hub for practice, leadership and innovation in university science and mathematics education. Through the ACDS, the Centre will reach into every Australian university. It has strong links with other stakeholders such as the Office for Learning and Teaching, and the Higher Education Standards Panel. The Centre has excellent relationships with leaders of learning and teaching in science and mathematics who are now seeking to work collaboratively with the Centre.

This fellowship has produced:

- the ACDS Teaching and Learning Centre website <www.acds.edu.au/tlcentre>
- a network of Associate Deans Learning and Teaching in Faculties of Science
- collaboration with leaders of learning and teaching and science discipline education networks
- Science and Mathematics learning and teaching meetings: ACDS Teaching and Learning Conference, ACDS TLO workshop, Discipline Network Roundtable
- regular dissemination of teaching and learning projects, activities and issues in science and mathematics through the website and regular newsletters to ADTLs.

This following description presents the ACDS TL Centre and the trial activities delivered during this fellowship. It was presented as a proposal for ongoing funding to the Annual General Meeting of the ACDS in October 2013. The proposal was endorsed by the ACDS and funding for the Centre confirmed for 2014.

Structure of the ACDS Teaching and Learning Centre

The ACDS TL Centre exists as a virtual entity. It is built from three areas of activity: the Centre website, ACDS Teaching and Learning meetings and ACDS TL projects (Figure 5.1). All elements interact functionally and conceptually. The Centre currently comprises a network of science teaching and learning leaders from Science Faculties in Australian universities, primarily Associate Deans Learning and Teaching.

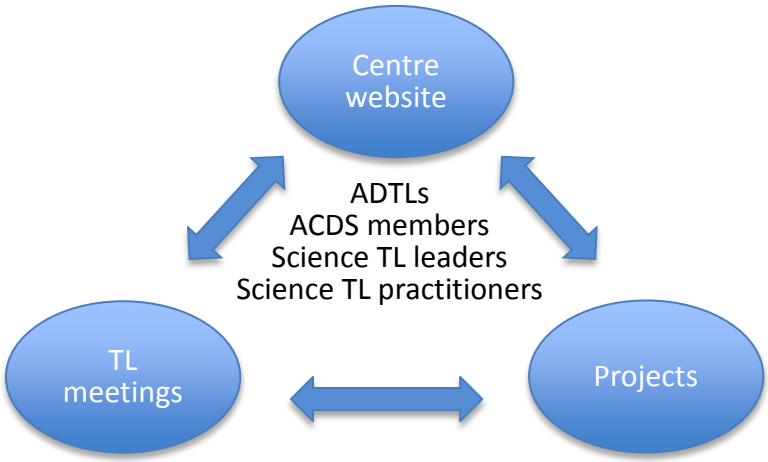

Figure 5.1: Structure of the ACDS Teaching and Learning Centre

Centre membership

The membership of the ACDS TL Centre reflects its objectives and activities. All ACDS members are members of the Centre with Associate Deans Teaching and Learning representing faculty leadership in most instances. Apart from positional leaders, the ACDS TL Centre will also invite broader participation from teaching and learning innovators, researchers and practitioners. This will maintain the Centre's focus on multiple forms of leadership for teaching and learning and also will give it a supportive role for all those working in the area.

During consultation about the ACDS TL Centre, the assembly of an expert group was suggested. The proposal was to establish a reference group of recognised experts who could review the resources produced by members and assist with Centre projects. The objectives were to give authority to review and to recognise (and therefore reward) experts in university science learning and teaching. This suggestion builds on the concept of peer review in publication and assessment of grant funding which is well understood by academics.

Creation of an expert group assumes that: experts can be readily and accurately identified; recognition as an expert has external value; and experts would be willing to donate their time to useful activity. Identification and recognition of leaders of learning and teaching currently occurs through a variety of organisations, notably the Office for Learning and Teaching, the Higher Education Research and Development Society of Australasia (HERDSA), national science disciplinary associations and individual universities. Each of these has an established reputation in learning and teaching that lends value to its awards. It may be more appropriate to re-visit this idea when the ACDS TL Centre in the higher education sector is well-established and has gained respect. The Centre also needs to consider what it can reasonably expect of a future expert group.

The ADTL network

Associate Deans Learning and Teaching and equivalent positions have responsibility within Faculties of Science for leading learning and teaching. Their responsibilities

span development, delivery and quality assurance of teaching and may include leadership of student engagement and the student experience. They must work collaboratively with line managers (heads of school, heads of discipline) and university leadership. They form the core of the ACDS TL Centre because of their central faculty role.

Allocation of time and support for this ADTL role anecdotally appears quite variable between institutions. The ACDS TL Centre will provide an additional support mechanism. The ACDS has initiated peer interactions between Science ADTLs through its annual ACDS Teaching and Learning meetings. The ACDS TL Centre has now built an ongoing ADTL network to facilitate ongoing peer-to-peer contact, sharing of practice and dissemination of current issues.

Centre organisation

The ACDS TL Centre is governed and funded by the ACDS. The ACDS executive also comprises the governing Board of the Centre, which ensures regular and effective communication between the Centre and the ACDS (Figure 5.2 overleaf).

Activities of the Centre will be led by Centre members with the support of a facilitating centralised position. The Centre Director will be responsible for leadership of Centre activities, maintenance of relationships and regular reporting to the ACDS Executive as the governing body of the Centre. The disseminated nature of the activity of the Centre and its national scope make facilitation through a continuing centralised leadership very important. The first year of activity for the Centre has been possible through this OLT fellowship. Experience during this year suggests that, without a funded position, Centre activities will be considerably restricted.

Different (and transient) groups within the Centre will be responsible for and contribute to various activities. This approach has the benefit of limiting responsibility and workload for any one contributor. Centre members will be able to contribute according to their capacity. For this model to work well, mentoring and effective handover between contributors must be ensured, again reinforcing the importance of the central facilitating position.

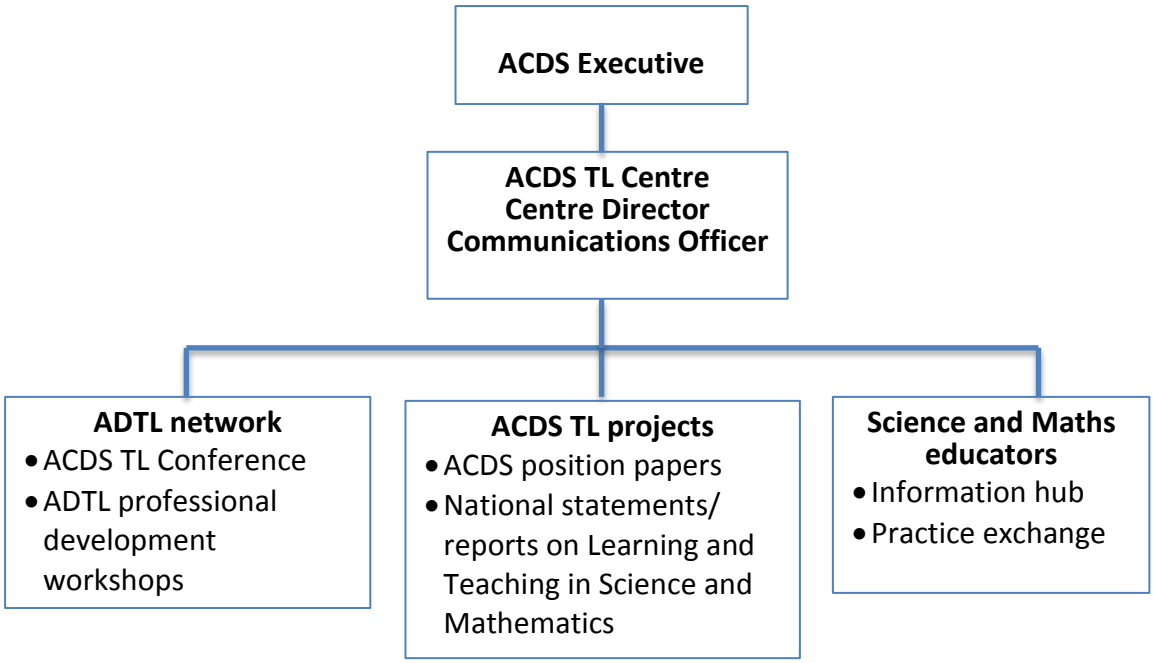

Figure 5.2: Organisational map – ACDS Teaching and Learning Centre

Centre activities

The ACDS TL Centre will achieve its objectives through its interrelated activities.

1. The ACDS TL Centre website

The Centre website is the 'public face' of the Centre and its means of communication with members. The website is a central hub for dissemination and communication. It provides information at multiple levels: news and events, links to people and resources, condensed information about topics of interest and ACDS-authorised statements and products from projects. In the future, it could become more interactive via shared online discussion and project work spaces.

The ACDS TL Centre website, <www.acds.edu.au/tlcentre>, features current events and news on its home page. News items link readers to the activities of the Centre and to other events of interest. Other pages on the site provide links to Centre projects and ACDS publications, science education networks, teaching and learning projects and notable resources in science and mathematics teaching and learning.

2. ACDS TL Centre meetings

Centre meetings create opportunities to promote discussion, develop issues of interest and to disseminate information. Meetings and workshops are also important professional development opportunities for teaching and learning leaders in science and mathematics. ACDS meetings include:

a) ACDS Teaching and Learning Conference: an annual meeting of Science Faculty teaching and learning leaders, primarily Associate Deans Teaching

and Learning or equivalents. This conference is particularly important to set priorities for Centre activities as it captures current issues for faculties.

b) ACDS workshops: focused meetings on specific issues. The first of these was held in February 2013 to develop national understanding on using the Science Threshold Learning Outcomes in curriculum renewal. A second workshop to link the OLT-funded science discipline education networks was held in July 2013. Future workshops could include professional development opportunities for new faculty TL leaders.

c) ACDS involvement in other relevant meetings: the ACDS TL Centre supports or directly participates in occasional meetings (ACDS/ACDS joint meeting on science and mathematics education in schools, March 2013) and regular sector meetings (ACSME: Australian Conference for Science and Mathematics Education, annually in September).

3. ACDS TL Centre projects

Centre projects address significant issues in university teaching and learning in science and mathematics. The primary goal of the projects is to construct useful and authoritative advice for Faculties of Science and leaders of learning and teaching. Complementary outputs could include resource lists/databases, case studies and exemplars of good practice. In an effort to avoid duplication, Centre projects are not designed to construct learning and teaching objects but rather to re-use the work of existing (and future) learning and teaching projects, which may be international, national, institutional or disciplinary. Centre projects will often be translational. The ACDS TL Centre is unlikely to have sufficient resources to fund or manage complex or long-term projects.

Issues will be identified in a variety of ways: arising from learning and teaching meetings, workshops, discussion between members and stakeholders or from external requests. Centre projects will focus on science and mathematics, and particularly on issues which are either unique to science and mathematics or are particularly important to these disciplines. These topics are likely to have parallels in related discipline such as applied sciences, health and engineering.

The ACDS has commissioned a number of significant reports and investigations in the past. Future projects could be commissioned by the Centre on behalf of the ACDS. The Centre will also produce position papers and national statements for consideration by the ACDS. A pilot project has been initiated in 2013 on constructing advice for faculties on embedding the Science Threshold Learning Outcomes in science and mathematics curricula. This project will produce a curriculum renewal resource for faculty teaching and learning leaders. Priorities for ACDS TL Projects will be reviewed regularly by the ACDS.

Testing the ACDS TL Centre model

Centre activities were trialled during this fellowship. The Centre website was launched in February 2013. The first ACDS Centre project, ACDS TLOs in Science,

began with a workshop at the same time followed by establishment of a working party in April 2013. The ACDS Teaching and Learning Conference 2013 featured the new Centre, which has become the dissemination point for ACDS TL meetings.

ACDS TL Centre website

The ACDS TL Centre website, <www.acds.edu.au/tlcentre/>, is fundamental to the Centre's operation and is its primary means of external interaction. It is a website within the ACDS website to ensure close connectivity between the Centre and the ACDS and to give stability to the website. The objectives of the website were to:

- highlight information about current activity in science and mathematics learning and teaching
- link to other relevant information and projects
- stimulate discussion of curriculum renewal
- provide a platform for interaction with the ACDS TL Centre.

The intention was to build interaction with the ACDS TL Centre slowly to ensure that interaction was relevant to participants.

Design

The website was built on a WordPress platform to facilitate construction with a professional web designer. The front page was designed to feature current activity in science and mathematics in higher education, to stimulate interest, and to disseminate information. Other areas of the site provide an archive of news stories (***News***), information and updates on Centre projects (***Centre Projects***), information on ACDS meetings and other associated events (***Events***), information on science education networks and newsletters for the ADTL network, ADTL Connections (***Networks***), and a list of ***Links and Publications***.

Outcomes

Some indicators of activity on the ACDS website are compiled overleaf (Table 5.1). Interaction with the ACDS TL site has been modest, which at least partially reflects its ambition to build its base amongst the science ADTLs and learning and teaching leaders in the first instance. A potential pool of ~90 participants is recorded in the Centre relationship database with 30–50 of those attending ACDS TL Centre meetings.

To date, contributions to the website have been largely from this fellowship with quite limited contribution from others. It is clear that participation must be scaffolded to convert an idea into a publication. During discussion, ADTLs and teaching and learning leaders expressed interest in participation but were concerned about a significant commitment. Since July 2013, two external articles for the site have been published.

Table 5.1: Selected outcomes from the ACDS TL website

Website Products	18 news stories 3 news features including extended video footage
Website Interactions	News stories or major links have been published for: 2 current OLT projects in science and mathematics 4 OLT fellowships 6 Science peer networks
Visibility	A ClustrMap online tool recorded 223 visitors to the site in the three months 14 July to 12 October 2013

Next steps

The next major steps for the website are to build more sustainable interactivity with current and prospective Centre members, and to revisit the site design to improve visibility of links to information and resources. A future ACDS TL Centre project could make recommendations for links to practice exchange and/or teaching and learning resources in science which was a recurrent theme during consultation.

ACDS TL Centre project: TLOs in Science

The first ACDS TL Centre project is to construct advice for Faculties of Science on using the national Science Threshold Learning Outcomes (Science TLOs) in course design (see <www.acds.edu.au/tlcentre/centreprojects/current/>). The impetus for this project came from the ACDS Teaching and Learning Conference 2012 and was reinforced by the nomination of the Science TLOs as reference points in the draft Higher Education Standards.

Outcomes

The project was initiated with an ACDS TLO workshop in February 2013 and formally launched by the ACDS in March 2013 with modest funding for one or two face-to-face meetings[4]. It produced formal advice to the ACDS on the draft Higher Education Standards for course design and for learning outcomes, which the ACDS accepted and submitted to the consultation process for the Higher Education Standards. The second product from the project will be a good practice guide for faculties on curriculum renewal with the Science TLOs. The guide will not reproduce or replace the many excellent resources available on curriculum renewal. It will be a summary document that references other valuable resources. It will complement recently completed good practice guides on each of the Science TLOs prepared as an extension of the original Learning and Teaching Academic Standards: Science project. The project is due for completion at the end of 2013.

[4] Project team: A/Prof. Adam Bridgman, The University of Sydney; A/Prof. John Holdsworth, The University of Newcastle; A/Prof. Liz Johnson (Chair), La Trobe University; A/Prof. Simon Pyke, The University of Adelaide; Jane Sneesby, Curtin University of Technology; A/Prof. Cristina Varsavsky, Monash University.

Next steps
The project has highlighted the importance of a coordinating and scaffolding role for ACDS TL Centre projects. Project members are contributing their time with no funding available for buy-out from normal duties which, in any case, is difficult to enact in a short time frame. A central coordinator with allocated workload ensures timely progression of the project.

The strength of the project lies in the expertise and engagement of the project members and selection of an objective that is highly relevant to participants and links to current work in the sector. Successful completion of this project will provide a template for future projects.

ACDS TL Centre as facilitator: Science discipline networks

The cross-disciplinary nature of the ACDS TL Centre makes it a good candidate to facilitate cross-disciplinary interactions in science and mathematics education. This has been explored through work with the science and mathematics education networks which include five disciplinary networks (Chemnet, CUBEnet, VIBEnet, AMSLaTNet and the Physics Education Network and the SaMnet leadership network).

Outcomes
The ACDS TL Centre has supported the science education networks through:

- web links on a dedicated page on the ACDS TL Centre website <www.acds.edu.au/tlcentre/networks/discipline-networks/>
- coordination and publication of interim reports on the construction of disciplinary interpretation of the Science TLOs <www.acds.edu.au/tlcentre/networks/discipline-networks/>
- dissemination and discussion meetings: ACDS TLO workshop (February 2013), Discipline Network Roundtable (July 2013).

Next steps
The interaction between the science and mathematics education networks and the ACDS has proved very valuable. The discipline networks strongly appreciated the opportunities provided by the ACDS to interact with each other. The interaction has encouraged the disciplines to identify what they are best able to contribute to improvement in learning and teaching and where disciplinary expertise is most important. Cross-talk between parallel networks is crucially important for faculties which must manage multiple disciplines and often through the same degree.

The leadership network, SaMnet, has highlighted consideration of staff capacity in leadership and mentoring and recognition of excellence in learning and teaching. SaMnet was particularly important to this fellowship as it facilitated discussion with a cross-section of informal learning and teaching leaders.

The future of the science discipline networks and the SaMnet network is uncertain. It is clear there is an important role for disciplinary expertise, in science and

mathematics learning and teaching particularly, in fostering innovation and developing individual staff capacity through peer exchange. The ACDS TL Centre will continue to support the explicit involvement of disciplinary learning and teaching groups.

ACDS ADTL Network

The ACDS TL Centre has created a named ADTL Network that has been connected through regular publication of a newsletter, *ADTL Connections* (archived at <www.acds.edu.au/tlcentre/networks/adtl-connections/>), and through ACDS meetings.

Outcomes

Outcomes from the network are difficult to evaluate at this stage. ACDS teaching and learning meetings have been vibrant with good informal feedback from participants. The strong and stable attendance at the ACDS TL Conferences and workshops indicates good support for the network and a perception that the meetings are valuable.

In 2013, a senior member of the ADTL network was invited to chair the organisation of the annual ACDS Teaching and Learning Conference to further develop leadership from this group. This conference was particularly successful and suggests this approach may provide a focus for leadership activity in the network.

There has been relatively little feedback from newsletters and the website which may indicate disengagement or simply a lack of time for interaction. Discussions at meetings and in interviews with ADTLs suggest lack of time is a significant disincentive for participation.

Next steps

Appropriate scaffolding of activity from members will be important for sustaining engagement with the ACDS TL Network. Experience during this fellowship suggests ADTLs are willing to contribute but are time-poor. Limited but effective participation is likely to be the most sustainable pattern of engagement.

There was support for the formation of a leadership group for the network and this should be explored for 2014, with consideration of succession planning and appropriate mentoring of junior members of the group. One of the possible future projects for the ACDS TL Centre is an induction workshop for new ADTLs which would increase capacity in the network and also be beneficial for the home institution.

Chapter 6: Fellowship outcomes

During this fellowship, my aim was to create a space for the advancement of learning and teaching across the broad fields of science and mathematical sciences in higher education. Australia is a relatively small higher education community with substantial links between universities created by common goals and by movement of staff between institutions. Our Faculties of Science have far more in common with each other than distinctive differences. We face similar problems in the practicalities of effective science teaching and in translating the advice flowing from the scholarship of learning and teaching and other disciplines into our classrooms. We share many of these issues with international colleagues who are also keen to find effective solutions.

Our relatively small size and shared experiences offer a particularly valuable opportunity to work collaboratively. The ACDS TL Centre was conceived as a strategy to use peers and peer influence to shift the accepted practice for a whole discipline towards more effective learning and teaching. My fellowship has successfully established the ACDS TL Centre, has grown links with faculties and learning and teaching leaders, and has trialled Centre activities. It has demonstrated the potential of the new Centre to address the challenge of "changing the game" for science and mathematics learning and teaching in higher education. My reflections on the project are summarised in three areas: future directions for the ACDS TL Centre, the role of sector-wide bodies and the importance of champions to drive change.

Looking forward for the ACDS TL Centre

The ACDS TL Centre is a practical answer to the challenge of driving widespread improvement in science and mathematics teaching practice across Australian universities. Consultation with stakeholders has uncovered a real need for the ACDS TL Centre. Our initial ideas of a role for the ACDS TL Centre that complements current resources for learning and teaching were validated in discussion with faculty and learning and teaching leaders. Faculties are looking for authoritative and consolidated advice. The many resources available in Australia and internationally are not obvious or conveniently packaged for institutional leaders. The Centre has the potential to facilitate alignment of influences at institutional, discipline and practitioner level.

The future of the Centre requires sustained investment from its parent body, the Australian Council of Deans of Science. While freed from the limitations of finite project funding, the Centre must prove its value on an ongoing basis, which should keep the Centre relevant and efficient. Its flat structure and distributed leadership model must be carefully monitored to make sure that succession planning is adequate and that a culture of shared responsibility is embraced. The Centre should grow its activities steadily with a keen eye on maintaining quality. The Centre has begun with much goodwill, which it must now sustain for the longer term.

The outcomes of the trial activities for the ACDS TL Centre have been largely successful. The Centre website is operational and growing; the first Centre project

has delivered one outcome and is on track to deliver its second output; Centre meetings have been well-attended and productive; and the ADTL network has formalised links between Associate Deans Teaching and Learning and suggested some concrete steps for further development. Most importantly, these experiences reinforce the selection of starting principles for ACDS TL Centre and broadly support the viability of its design.

A second role has emerged from the design and construction of the Centre and its trial activities. The cross-disciplinary nature of the Centre and its reach, through the ACDS, into almost all Australian universities creates awareness of what is happening in partner science disciplines and produces very valuable discussion of what is shared amongst sciences and mathematics. The Centre can, and should, be a hub for activity in science and mathematics learning and teaching. It must connect people, projects, resources and stakeholders.

Working with peak bodies

Two groups were crucial to this project: the Australian Council of Deans of Science and the associate deans teaching and learning (ADTLs) from faculties of science. My fellowship has demonstrated the power of working through peak bodies and of investing in relationship building. The Centre was designed to build on existing groups and mechanisms. I found it fundamentally important to recognise existing commitments and to acknowledge the limits of taking on new ventures.

The original proposal for the Centre came from the ACDS. Their reach into all Australian universities through faculties of science (or equivalent) was a necessary pre-requisite for the project. Working with the ACDS was a pleasure. The wealth of experience of the deans and in particular of the Executive Director, Professor John Rice, built critical review into the fabric of the project. Likewise, the ADTLs in faculties of science were very generous. They embraced our proposal and enthusiastically contributed to its development. However, both groups were cautious about possible time commitments and emphasised the importance of acknowledgement of institutional and sector priorities.

The experience of my fellowship points to two considerations for future projects:
1. The Australian higher education sector is small and interconnected enough to create inclusive collaborations across a whole discipline;
2. Australian academics and academic leaders are time-poor which restricts their capacity to take on significant work in learning and teaching in addition to their institutional roles.

My fellowship has demonstrated the value of a close collaboration between an OLT project and an active higher education sector partner. The OLT fellowship has given depth and breadth to the development of the ACDS Centre. Interaction with other OLT projects and ALTC/OLT fellows has informed the project and helps to link science and mathematics learning and teaching with scholarly research and new ideas. The ACDS initiated the project, is the subject of the work and will be responsible for future development of the Centre. It will be very interesting to see if

similar partnerships with other disciplinary peak groups emerge in Australia to build a sustainable network of support for learning and teaching in higher education.

Champions and leaders

Leadership is fundamental to adoption of good practice. My fellowship is built on the premise that alignment of purpose amongst varied leaders makes change much more effective. The parallel need is that leaders have the time and energy to invest in driving change. Consultation during my fellowship showed academics are looking for leadership in learning and teaching. They want authoritative and relevant advice, preferably from someone with personal experience who can uncover pitfalls and opportunities.

Although my fellowship has concentrated on formal leadership roles in faculties of science, I believe a range of leadership roles are needed to help academics. Learning and teaching leaders include those who study higher education, outstanding teacher practitioners, those who synthesis disciplinary core and those who facilitate change. To 'change the game', leaders must acknowledge each other's expertise and contribution and create a shared compelling vision. I hope the ACDS TL Centre will publicly recognise multiple forms of leadership in learning and teaching in the disciplines of science and mathematical sciences. I also hope that peer recognition will be one of the rewards for the contribution of learning and teaching leaders to a shared national effort.

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Appendices

Appendix A: Proposal establishment ACDS Teaching and Learning Centre

February 2012
Professor John Rice, Executive Director ACDS
ACDS Working Party,

Aims of the Centre

The Centre aims to become the focal point for advice on matters concerning the quality of science teaching and learning, both for university science faculties and schools throughout Australia and for government agencies such as TEQSA.

It will achieve this by drawing the efforts of faculty teaching and learning leaders into a coherent national expression of what quality means in science teaching and learning, and by developing their capacity to effect change.

The Centre will generate management tools for defining, monitoring and improving the quality of teaching and learning in the course of developing leadership and management skills in staff responsible for applying them. The Centre will support an action learning approach that enriches the understanding of individuals, focuses on effective implementation, and in turn encourages critical reappraisal of the ideas fostered by the Centre.

The Centre will grow its notions of quality and how to manage it through peer review and evaluation of grass roots practice. It will be committed to the growth and use of an evidence base in these processes, and to challenging grass roots practice with relevant education and management theory. As is the case with academic culture in general, it expects peer processes to act in a way that brings practitioners along with the ideas developed, and allow for a range of perspectives.

As a result of its activities the Centre can also be expected to provide an accessible and useful repository of good ideas and best practice in university science teaching and learning.

Background

At its 2011 AGM last October the ACDS resolved to develop a proposal to establish an ACDS national centre for science teaching and learning, with a budget in the order of $0.5m per annum, funded by a substantial increase in subscriptions. The imperative for such a centre derives from the anticipated influence of TEQSA, the Higher Education Standards Panel and university compact negotiations.

Faculties are responsible for delivering quality courses, for maintaining the resources necessary for that delivery and for demonstrating quality outcomes. Currently faculties argue their case within their institutions, making reference to informal notions of best practice, discipline standards and occasional benchmarking. Within their institutions faculties are the repository of wisdom on these matters and exert considerable authority.

The Federal Government has now enacted the Higher Education Standards Framework, approved by the Minister for Tertiary Education after advice from the Higher Education Standards Panel. TEQSA is responsible for regulation and quality assurance in the context of this Framework, in effect to interpret the Panel's standards and report on their efficacy. To quote their website

> *With a dual focus on ensuring that higher education providers meet minimum standards as well as promoting best practice and improving the quality of the higher education sector as a whole, TEQSA is a 'next generation' regulator and a truly unique organisation.*

The claims that faculties make for the quality of their courses and for the resources necessary to maintain that quality will be argued with increasing reference to TEQSA's role. TEQSA does not assess the quality merely of individual higher education providers, it also has the power and the intention to undertake 'thematic' reviews, for example of the quality of science teaching, or of laboratory and field instruction across a group of institutions. An indication of this direction has already appeared, with the CEO of TEQSA warning in *The Australian* (Feb 1st) that it will keep an eye on universities recruiting students with low entry scores, to make sure that they were being provided with a suitable level of learning support.

Science can expect eventually to face significant challenges in this environment. Many of its disciplines have failure and attrition rates considered unacceptably high. Its subjects are considered 'content heavy' and generally leave little room for student-driven enquiry. Its degree programs very often focus on discipline specialization. While this is justified in terms of the high research profile and high research performance expected of science faculties, it stands at odds with the diversity of students that enter their courses, and who populate the large first year, second year and service teaching classes that substantially underpin faculty operating costs.

Laboratory and fieldwork are of particular concern. They supply the differential between science and other subject funding, funding which supports technical staff, laboratory space, field sites, and equipment. They are argued to be essential to a science education on the grounds that science is empirical in nature, and because they provide a unique learning environment that supports graduate attributes, such as independent learning, group work and communication skills. This position can be expected to come under concerted challenge on the basis that the majority of students enrolled in science subjects will never work in the field or in laboratories, while graduate attributes can be acquired more cheaply in other ways. A piecemeal defense and appeal to past norms is unlikely to withstand such a challenge.

Science needs to be in a position to influence TEQSA reviews in relation to such issues, indeed to be a significant force in guiding and advising on them. Its credibility in such a national arena will be judged by its own practice on a national scale, not institution by institution, and by its ability to role model the advice that it provides.

The ACDS therefore needs a body that draws the efforts of its teaching and learning leaders into a coherent expression of what quality means for science teaching and learning, and develops their capacity to effect change. It is by this means that the ACDS can influence TEQSA in a constructive and legitimate way, and provide strong support for the position of science in individual universities across Australia.

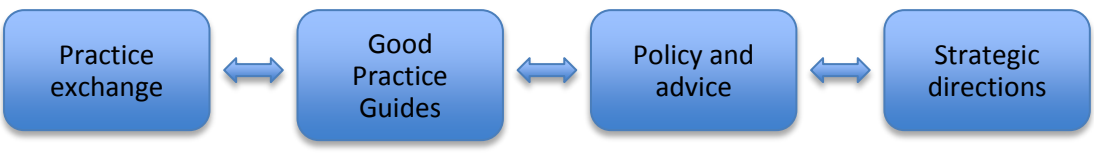
Governance

The Centre will be governed by a Board comprising four members of the ACDS, the Centre director and three others representing broader stakeholders, for example a high profile DVC T&L, or a TEQSA appointee. The Board will report to the Executive of the ACDS.

The Board will approve the strategic plan of the Centre and its annual budget. In particular the strategic plan will prioritise key issues and outcomes expected for them during the planning period. The Board will review

The Centre will have a director who reports to the Board, and a website/communications manager who reports to the director.

Structure and Operation



Best Practice

The Centre will operate on the principle that good policy advice is distilled from and in turn influences good practice. Its activities around practice will stimulate participation and identify and disseminate best practice in science teaching and learning in science for the sector. It will construct two key resources.

a) ***Practice Exchange*** will encourage dissemination of good practice and provide an incentive through publication for academics to interact with the Centre. The exchange would be equivalent to an archive or clearing house for projects in science teaching and learning Submissions to the exchange will represent a pool of current and leading practice in science teaching and learning. The exchange will also provide information to the Centre on emerging issues and the relative impact of TL themes and issues. Operation of the exchange will include:

- submission template to ensure minimum information standards
- organization into TL themes and excellent keyword searching capacity
- feedback from users through like/dislike ratings and/or hits
- periodic filter to ensure useful materials "rise to the top" and unsuccessful ideas drop out

Potential models for the practice exchange include ASELL and Merlot (IT).

b) ***Good Practice Guides*** will draw together evidence for best practice and distil TL advice for science academics. These guides will build on the model of the ALTC good practice guides, drawing evidence, information and ideas from published material (TL journals, conference reports, ALTC projects), the Centre practice exchange and international sources. Construction of the good practice guides will use peer review by selected experts.

Good practice guides will be commissioned by the Centre and funded either by the Centre or possibly via joint funding with external partners. Themes and priorities for good practice guides will be determined by the Board of Directors/Steering Committee and will reflect issues in the sector. Recognised experts in teaching & learning and science will be invited to lead construction of individual guides and also to be affiliated with the Centre as part of a prestigious College of Experts.

Potential models for the good practice guides include ALTC good practice guides and the Higher Education Academies (UK) and affiliated centres.

Policy and advice

The Centre will provide timely advice for the ACDS on teaching and learning matters. This is particularly important in the current environment where regulation of universities is under review and new criteria for teaching and learning standards in development. There is also an ongoing and growing issue with dropping engagement with science amongst prospective students and possibly in the community at large.

Reports and responses will be developed by the Centre through its College of Experts and/or commissioned work. Issues to be explored will be determined by the Board of Directors/Steering Committee and will be responsive to initiatives from the federal government (TEQSA, DIISR, OLT and currently the project "Achieving Quality in Higher Education), state governments, industry and professional associations.

Enabling activities

The Centre will construct vehicles for its activities, which will include:

a) website for communication and dissemination including a searchable database for the practice exchange

b) communication hub for participants to encourage participation (including calendar of events and similar activities)
c) College of Experts to recognise science TL experts (identified by moderated peer review) and to establish an affiliation with expertise that can be used for Centre activities

Key themes for science teaching and learning

Current issues in teaching and learning for Deans of Science can be grouped using some of the areas being explored by Government reviews of performance in higher education. These key issues will inform the themes for centre activities. The Centre will begin with projects that focus on science and mathematics education, have resources & information available for use and can have immediate impact. That is, the Centre will begin with the "low-hanging fruit".

1. **Performance Based Funding and Measures**

a) Recent discussion papers from the federal government departments responsible for higher education (DEEWR/DIISRTE) propose new performance measures for teaching and learning through its project Achieving Quality in Higher Education (AQHE). Teaching performance indicators are proposed as input measures including the professional development of staff, resources for teaching and the conduct of teaching. Learning performance indicators are couched as output measures of student learning. Performance measures for both areas are still in development.

b) The proposal for a single external measure for learning outcomes is of concern as disciplinary difference may affect the measure. The discussion papers have noted the value of future contributions to development from disciplinary groups. The measurement of learning outcomes has a direct relationship to the recently published threshold learning outcomes (TLOs) for Science from the ALTC's Learning and Teaching Academic Standards project. Science TLOs are now being further developed by disciplinary groups within science.

c) Possible themes for this area are:

- learning standards for science
- measurement of graduate capabilities
- professional development and training for science academics and educators (mentoring and succession planning)

2. **Retention and Progression**

a) Retention and progression of students are key indicators of the success of a program and also have direct bearing on the financial viability of science faculties. There has been considerable work on factors that affect retention and progression including the student experience of higher education (notably the first year experience), student engagement, curriculum design and pedagogies for effective teaching and learning. The wide variety of reported strategies to improve retention and progression pose a challenge to science faculties to select the most effective interventions and tailor them to local situations.

b) Key issues in effective teaching and learning strategies for science include:

- engagement of prospective students with science (and demand-driven funding)
- assessment (possibly building on projects such as the Bio-Assess website)

- teaching for non-majors and managing diversity in large classes (working with under-prepared students)
- effective pedagogies for science teaching (incorporating work on inquiry learning, threshold concepts and other major initiatives)
- curriculum development (eg National Centre for Academic Transformation)

3. **The Laboratory Learning Experience**

a) Practical teaching programs pose a particular challenge in science. Experimental disciplines use large-scale laboratory classes and fieldwork which is expensive and demanding for both staff and students. Base level funding for science disciplines in part reflects this cost. Funding for practical programs is under threat particularly if there are no obvious or clearly articulated learning outcomes which can only be delivered by these programs.

b) The ASELL program is a very successful program to improve the quality of teaching and learning in practical programs. It has developed criteria for documenting and evaluating practical classes and has collected a very large database of student perceptions of practical classes and interventions to improve them. Involvement in the program encourages productive reflection from staff. More recently, ASELL has successfully extended its format across multiple science disciplines.

c) Possible themes for this area are:

- articulation of the value of practical programs
- improvement of practical programs
- teaching scientific inquiry learning

John Rice, Executive Director, ACDS
February 13th 2012

The ideas for the structure and operation of the Centre were developed by a steering group convened for that purpose. Its members are:

Elizabeth Johnson	ADT&L, La Trobe University
Siobhan Lenihan	Head of Programs, Office for Learning and Teaching
Will Price	Dean of Science, Wollongong University
Manjula Sharma	Director, IISME, The University of Sydney
Roy Tasker	Australian university teacher of the year 2011, University of Western Sydney
Cristina Varsavsky	ADT&L, Monash University
Jo Ward	Dean of Science, Curtin University of Technolgy

Appendix B: Snapshot OLT projects, fellowship, reports – project type and discipline

Table Appendix B.1: OLT projects, fellowships and reports

Category	Lead Author	Title	Lead Institution	Report Yr	Discipline
academic support	Felicia Zhang	A cross-disciplinary approach to language support for first year students in the science disciplines	University of Canberra	2011	science
academic support	Helen MacGillivray	Learning support in mathematics and statistics in Australian universities: a guide for the university sector	Queensland University of Technology	2008	maths
academic support	Helen MacGillivray,	Quantitative diversity: disciplinary and cross-disciplinary mathematics and statistics support in Australian universities	Queensland University of Technology	2008	maths
assessment	Kerri-Lee Krause	Enhancing the assessment in the Biological Sciences	The University of Melbourne	2007	bioscience
assessment	John Rice	Good Practice Report: Assessment of science, technology, engineering and mathematics (STEM) students	ALTC	2011	science
assessment	Tony Wright,	Diagnostic assessment for biological sciences – development of a concept inventory	The University of Queensland	2011	bioscience
leadership and staff development	Anne Porter	Building leadership capacity for development and sharing of mathematics learning resources across disciplines and universities	University of Wollongong	2013	maths
leadership and staff development	Danny R Bedgood Jr	Developing leaders of change in the teaching of large university chemistry classes	Charles Sturt University	2012	chemistry
leadership and staff development	Karen Burke da Silva	Raising the profile of teaching and learning: scientists teaching scientists	Flinders University	2009	science
leadership and staff development	Tori Vu	A national discipline-specific professional development program for lecturers and tutors in the mathematical sciences	Macquarie University	2011	maths
overview of projects	ALTC	Funded Science Projects	ALTC	2007	science
overview of projects	ALTC	What's happening in Science?	ALTC	2007	science
pedagogy	Les Kirkup	Inquiry-oriented learning in science: transforming practice through forging new partnerships and perspectives	University of Technology, Sydney	2013	science
pedagogy	Peter Adams	Embedding quantitative principles in life science education	The University of Queensland	2010	maths
pedagogy	Lawrence Gahan	IS-IT learning? Online interdisciplinary scenario-inquiry tasks for active learning in large, first year STEM courses	The University of Queensland	2011	science
pedagogy	John W Rice	Tertiary science education in the 21st century	University of Canberra	2009	science
pedagogy	Scott Kable	Advancing science by enhancing learning in the laboratory (ASELL)	The University of Sydney	2012	science

pedagogy	Les Kirkup	New perspectives on service teaching: tapping into the student experience	University of Technology, Sydney	2009	science
pedagogy	Charlotte Taylor	Using threshold concepts to generate a new understanding of teaching and learning biology	The University of Sydney	2011	bioscience
pedagogy	Michael Bulmer	Technology for Nurture in Large Classes	The University of Queensland	2010	maths
pedagogy	Helen MacGillivray	The teaching and assessment of statistical thinking within and across disciplines	Queensland University of Technology	2009	maths
pedagogy	Kristine Elliott	Teaching scientific inquiry skills: a handbook for bioscience educators in Australian universities	The University of Melbourne	2010	science
pedagogy	Robert D Loss	Improving learning in undergraduate physics using integrated 'studio' environments to replace traditional lectures, laboratories and tutorials	Curtin University of Technology	1997	physics
review of discipline/curriculum	David Merritt	A national curriculum for entomology: capacity-building through collaborative, web-based delivery	The University of Queensland	2011	entomology
review of discipline/curriculum	Steve Selig	Curriculum renewal in exercise science	Victoria University	2011	exercise science
review of discipline/curriculum	Damien Field	A national soil science curriculum in response to the needs of students, academic staff, industry, and the wider community	The University of Sydney	2012	soil science
review of discipline/curriculum	David Hills	Learning Outcomes and Curriculum Development in Physics	Monash University	2005	physics
review of discipline/curriculum	Sue Jones, Brian Yate	Science Learning and Teaching Academic Standards Statement	ALTC	2011	science
tools	Les Kirkup	Forging new directions in physics education in Australian Universities	University of Technology, Sydney	2009	physics
tools	Julie Clark	Promoting new ways of teaching and learning in science education with student-created digital animations	University of Wollongong	2012	science
tools	Geoffrey Meyer	Building a network of academics who use, contribute to and disseminate, an online, cost-effective histology learning and teaching resource	The University of Western Australia	2011	pathology
tools	Helen Drury	Creating a student-centred online learning environment for report writing in the sciences and engineering	The University of Sydney	2009	science
tools	Peter Adams	A new enabling technology for learning and teaching quantitative skills	The University of Queensland	2008	maths
tools	George Hatsidimitris	Physclips - multi-level, multi-media resources for teaching first year university physics: Final Report	The University of New South Wales	2007	physics
tools	Joe Wolfe	Physclips II - Waves and sound: an integrated set of multi-level multimedia resources and laboratory experiments: Website	The University of New South Wales	2011	physics
tools	Damian Hine	Extending Teaching and Learning initiatives in the cross-disciplinary field of	The University of Queensland	2008	biotechnology

		Biotechnology			
tools	Camile Farah	The Virtual Slidebox - a new learning paradigm for exploring the microscopic world	The University of Queensland	2010	science
tools	Craig Savage	Teaching physics using virtual reality	The Australian National University	2010	physics
tools	CAUT	Model for the teaching of occupational health and safety and risk management within the science curriculum	The University of Adelaide	1999	science
tools	Jan Meyer	Online Assessment Feedback as an Instrument of Reflective Learning Practice in Human Biology	The University of Western Australia	2008	bioscience

Appendix C: Fellowship activities 2012–13: Dissemination and discussion

Table Appendix C.1: Fellowship activities 2012–13 – dissemination and discussion

Date	Event title, Location (city only)	Brief description of purpose of the event	Number participants	Number higher education institutions represented	Number other institutions represented
Jul 3-6	HERDSA, Hobart	Dissemination and discussion	~25	National conference	?
Jul 19-20	ACDS TL meeting, Sydney	Fellowship workshops Dissemination and discussion	54	26	3
Sep 26-28	ACSME, Sydney	Dissemination and discussion	~100	National conference	?
Oct 22-23	ACDS AGM, Brisbane	Presentation to key stakeholder Dissemination and discussion	26	~20	2
Oct 29	PEI workshop Melbourne	Dissemination	~60	7	?
Nov 6	U Ballarat School of Health Sciences retreat	Dissemination and discussion	~60	1	-
Nov 19	University of Canberra, Science Learning and Teaching Group Seminar	Dissemination and discussion	8	1	-
Dec 5	La Trobe Quantitative Skills Workshop	Dissemination and discussion	20	1	-
Feb 4	SaMnet leadership workshop, Melbourne	Fellowship workshop Dissemination and discussion	20	5	-
Feb 5	SaMnet leadership workshop, Adelaide	Fellowship workshop Dissemination and discussion	12	3	-
Feb 6	SaMnet leadership workshop, Perth	Fellowship workshop Dissemination and discussion	9	1	-
Feb 7	WA TL Forum	Fellowship workshop Dissemination and discussion	12	National conference	?
Feb 11	SaMnet leadership workshop, Sydney	Fellowship workshop Dissemination and discussion	11	3	-
Feb 15	SaMnet leadership	Fellowship workshop	9	3	-

	workshop, Brisbane	Dissemination and discussion			
Feb 22	ACDS TLOs in Science workshop, Melbourne	Fellowship Centre project	~45	National meeting	?
Jun 21	First Year in Maths Workshop, University of Melbourne	Dissemination and discussion	32	National meeting	?
June 12	ALTF Fellows Forum	Discussion	~40	National meeting	?
	VIBE workshop	Meeting Organiser Dissemination and discussion	~80	National meeting	?
Jul 17	ACDS Discipline Network Roundtable, UTS Sydney	Fellowship workshop	19	13	2
Jul 19-20	ACDS TL conference, Mercure Hotel, Sydney	Fellowship workshops Dissemination and discussion	54	23	4
Jul 26	ASCEPT Education Workshop, Melbourne	Dissemination and discussion	20	9	-
Sep 19 -21	ACSME, Sydney	Poster presentation	~100	National conference	?
Sep 29 -Oct 3	ComBio Conference, Perth	Invited presentation	~30	National conference	?

**These meetings directly address fellowship outcomes.*