LEARNING AND TEACHING ACADEMIC STANDARDS FOR SCIENCE: WHERE ARE WE NOW?

Susan M. Jones[a], Brian F. Yates[b], Jo-Anne Kelder[c]

Presenting Authors: Susan M. Jones (S.M.Jones@utas.edu.au), Brian F. Yates (Brian.Yates@utas.edu.au)
[a]School of Zoology, University of Tasmania, Hobart TAS 7001, Australia
[b]School of Chemistry, University of Tasmania, Hobart TAS 7001, Australia
[c]School of Health Sciences, University of Tasmania, Hobart TAS 7001, Australia

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ABSTRACT
One year on from the ALTC Learning and Teaching Academic Standards (LTAS) Project for Science, it is time to take stock of how the outcomes of that project are being implemented. In this paper, we shall discuss the current national regulatory environment, and what it might mean for us as practitioners in science education. We present examples of how the Science Threshold Learning Outcomes (TLOs) are being used in curriculum review and renewal and how they are being adapted to different disciplinary contexts.

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INTRODUCTION AND BACKGROUND
This paper reports and reflects on the Science Learning and Teaching Academic Standards (LTAS) Project that was funded by the Australian Learning and Teaching Council (ALTC). We discuss the tangible and non-tangible outcomes of the funded project, and report on how these are being implemented at the national level. We contend that the Science LTAS Project has catalysed the review, refinement and reinvigoration of science curricula at Australian universities, and is thus contributing to current debate on the challenges in adapting science education to meet the needs of society in the twenty-first century.

The LTAS Project was commissioned by the ALTC in response to the Australian Federal Government's announcement that it intended to establish the Tertiary Education Quality Standards Authority (TEQSA) that would audit Australian tertiary institutions against five sets of academic standards, including learning and teaching standards. As a proactive strategic initiative, the ALTC funded this major project to demonstrate that disciplinary communities could work together to develop learning and teaching standards (defined as learning outcomes) and achieve endorsement and commitment to integrate those standards into educational practice. The underlying assumption was that a discipline-led, collegial approach would more likely produce an outcome that would be acceptable and usable by educators and aligned to employer and student needs (Ewan 2010). For each participating discipline in the LTAS Project, threshold learning outcomes (TLOs) would be defined in terms of the discipline-specific knowledge, skills and professional capabilities to be achieved by pass-level graduates.

THE LTAS PROJECT FOR SCIENCE
PROCESS
A key driver for the Science LTAS Project was its championing by the Australian Council of Deans of Science (ACDS). Indeed, Science was not in the group of disciplines originally selected to take part in LTAS Project. However lobbying of the ALTC by the ACDS ensured that Science was included. We (Yates & Jones) were appointed as co-Discipline Scholars for Science, and Jo-Anne Kelder was selected as the Project Officer. Our project was funded for one year, from July 1st 2010 to June 30th 2011. Our inaugural workshop was presented by the LTAS Project Director Prof. Christine Ewan and the Discipline Scholars at the ACDS Teaching and Learning Forum (Sydney, July 15th, 2010). The audience for this initial presentation was the Associate Deans (Teaching and Learning) for Science, which ensured that this important group of 'gatekeepers' (Holmes & Freeman, 2012) were engaged and involved right from the start of the project. At the conclusion of that workshop, the overall approach for the Project was articulated and endorsed by the Executive of the ACDS.

The core project aim was to define Threshold Learning Outcomes (TLOs) for Australian graduates of bachelor level degrees in science (not necessarily a Bachelor of Science): that is, a set of TLOs that are applicable to all sub-disciplines encompassed within the Science cluster. Additionally, *Chemistry* and *Mathematics* were selected as appropriate groups to test the adaptability and applicability of the Science TLOs to their particular sub-disciplinary context. Chemistry and Mathematics represent, respectively, an experimental and a non-experimental discipline. In addition, there is substantial international documentation on standards (i.e. learning outcomes) for Chemistry and Mathematics graduates in, for example, the Tuning Europe Project (http://www.unideusto.org/tuningeu/) and the UK Quality Assurance Agency (QAA) (http://www.qaa.ac.uk/Pages/default.aspx).

The project was designed around three cycles of engagement focused on developing the discipline-specific content of the *Science Standards Statement*, in particular, the threshold learning outcomes (TLOs). We employed three mechanisms for inviting stakeholder commentary: consultation workshops, an online survey and written submissions. This approach ensured that a broad range of peer review and commentary was gathered. In addition, five formal groups were established very early to directly support the work of the Discipline Scholars.

1. The *Science Discipline Reference Group* (RG) was established vey early in the project. Its role was to support the Discipline Scholars in the development of TLOs for Science graduates at Bachelor degree level. Membership of the RG was carefully designed to be broadly representative of the Science sub-disciplines and include representatives from professional bodies and representatives of other stakeholders including employers of Science graduates and students. The terms of reference included the provision of advice to the Discipline Scholars on the direction and implementation of the Science LTAS project. They were also required to approve the Science TLOs prior to their dissemination to the broader discipline communities, and to facilitate such dissemination through their professional networks.

2. A *Science Discipline Advisory Group* (AG) was a small group of expert colleagues recruited to act as a high level working party of 'critical friends'. Their responsibilities were to provide the Discipline Scholars with timely, high level feedback on drafts of TLOs and associated documents, and to provide expert advice throughout the project. In particular, the AG worked with the Discipline Scholars to develop a draft set of TLOs for Honours degrees in Science that are included as an Appendix to the *Science Standards Statement*.

3. The *Local Reference Group*, consisting of representatives of the science-based disciplines in the University of Tasmania's Faculty of Science, Engineering and Technology were recruited to act as a readily available sounding board of peers. As well as commenting on drafts of the *Science Standards Statement*, members were pilot participants for the consultation workshops and the online survey, providing feedback that informed revision of the final designs.

4 & 5. Selected disciplinary experts with educational expertise were invited to form the *Chemistry and Mathematics Working Parties* associated with the Science LTAS Project. They were commissioned to adapt the (then draft) Science TLOs to develop parallel TLO statements for their own disciplines and to report and reflect on any difficulties or challenges with that task. They served as models for other disciplinary groups that might take on such a task.

Engaging stakeholders in consultation

The communication and consultation strategy included several strands of activities designed to: 1) identify relevant individuals and organisations (particularly 'gate keepers' who could connect us to wider groups); 2) design and implement communication mechanisms to contact stakeholders (contributing to the national project newsletter and website, writing our own newsletters, conference presentations and workshops); 3) consultation workshops offered to every Australian university delivering a science degree program; 4) survey to elicit anonymous and detailed commentary on the draft *Science Standards Statement* (SSS); 5) growing a database of contacts to disseminate information about the project to those interested, especially how to engage.

In all, the project team arranged over fifty meetings with groups of stakeholders (Table 1). In particular, eighteen meetings were held with the Reference Group or Advisory Group to develop the draft *SSS*. Once the draft *SSS* was formally endorsed by the Reference Group, the project moved into actively soliciting feedback and commentary from the wider Science Discipline community. The draft

SSS was published on the ALTC's website for the LTAS project with the invitation to engage in its development via formal email submissions, the survey and consultation workshops.

Table 1: Consultation activities undertaken during the Science Learning and Teaching Academic Standards (LTAS) project (July 2010 – June 2011) (adapted from Jones, Yates, & Kelder, 2011).

Consultation activities	Number	Explanatory comments
Total number of meetings held:	50 meetings	18 meetings to develop draft TLOs; 32 consultation workshops
Total number of attendees at meetings (estimate):	750	350 to develop draft TLOs; 400 consultation workshops
Number of visits (consultation workshops) to each state/territory:	NSW: 7 QLD: 3 SA: 2 WA: 4 TAS: 1 VIC: 8 ACT: 2 NT: 1	All but two of the Australian Universities delivering a science program hosted or co-hosted a workshop, or their staff attended workshop at other institutions. We also had separate meetings with Science students at Charles Darwin University, La Trobe University, University of Sydney and University of New England.
Number of persons on the project's email contact list:	412	39 on email database; additional 373 via consultation workshop attendance.
Survey participants:	122	Online survey on the draft TLOs
Written Submissions:	6 formal responses 3 informal email comments	• Association of Mining and Exploration Companies • Australian Institute of Geoscientists • Geological Society of Australia • Chemskill • Peter Meier; UTS response • Peter Adams, Chair Mathematics Working Party

OUTCOMES

The tangible product of the Science LTAS Project was the *Science Standards Statement* (Jones, Yates, & Kelder, 2011), which is now available as a downloadable pdf booklet from http://disciplinestandards.pbworks.com/w/page/52767997/Science, as well as from the Australian Government's Office for Learning and Teaching (OLT) website (Resources section). The core of the booklet contains the statement on the Nature of Science, the Science Threshold Learning Outcomes (p.23) and explanatory notes upon them. The contents of the booklet represent the consensus views of the Science discipline community. The *Science Standards Statement* is endorsed by the ACDS as "a generic high-level statement of Bachelor of Science threshold learning outcomes", and the ACDS also commended the consultative process and its outcomes.

The less tangible outcomes of the project include an enhanced focus on learning outcomes as a major tool for curriculum review and design across the national disciplinary sector, and the establishment of sub-disciplinary groups (i.e. representing disciplines under the Science umbrella) whose aims include the adaptation of the Science TLOS to achieve TLOs specific to their discipline.

During the life of the Science LTAS Project, it became clear that the Science TLOS could form an effective framework for curriculum review or revision. Indeed, the use of learning outcomes emphasises that curriculum planning should begin with the student, and what is learned, rather than with what is taught (Allan, 2006). For example, we (Jones & Yates, as Discipline Scholars for Science) were invited to contribute as external experts to formal curriculum planning workshops at the University of Western Sydney and at La Trobe University, and we currently lead a project at our own University that is mapping the current BSc curriculum against the Science TLOs as a prelude to a major curriculum review.

ADAPTING THE SCIENCE TLOS FOR SPECIFIC DISCIPLINES

The Chemistry Standards Statement included as an appendix to the *Science Standards Statement* (Jones et al., 2011) was an overt demonstration that the Science TLOs can be adapted to a specific disciplinary context. This process was led by the Chemistry Working Party, with considerable input from the relevant peak professional bodies. The Chemistry TLOS overtly reference the Science TLOS but also reflect the 'nature of Chemistry' and the 'ways of working' in that discipline.

The challenge of defining TLOS for particular disciplines has, to date, been taken up by a range of disciplines, including, for example, Biology, Physics, Mathematics and Agricultural Science. These groups either represent ALTC/OLT-funded Discipline networks (VIBE.net for Biology; Mathematics), or networks supported by deans' councils, professional societies, or, in the case of Agricultural Science for example, an initiative by one School at one institution (University of Tasmania). For example, VIBE.net recently held a national workshop at which draft Biology TLOs were peer-reviewed, while Chemistry is contemplating how the Chemistry TLOs will articulate with accreditation requirements.

The next step is development of exemplars of learning activities that will support students to achieve these TLOS, and assessment tasks that will allow educators to demonstrate that their students have met the TLOS. Such work should draw from the work of previous ALTC-funded projects, for example: *Enhancing the assessment of learning in Australian Higher Education: Biological Sciences; Forging new directions in physics education in Australian Universities; Tertiary science education in the 21st century;* or *Advancing science by enhancing learning in the laboratory (ASELL)(*details of these and other relevant projects are available on the OLT website: http://www.olt.gov.au/resources?page=1&text=science

FUTURE STEPS

There is a great deal of creative work to be done if the impetus of the Science LTAS project is to continue, and if this work is to realize its potential for improving tertiary science education in Australia. To this end, we (Yates & Jones) were successful in gaining ALTC funding for one year to continue our own leadership and advocacy through an Implementation project. The specific aims of that project were:

- To continue to act as advocates and role models for an approach to curriculum design that is firmly focused on student learning outcomes;
- To personally lead two core implementation projects;
- To champion and advise on a range of implementation projects by other colleagues.

We are currently engaged in two specific implementation projects:

1. Develop examples of teaching activities and assessment that demonstrate student achievement of Science TLO 1.1.

The need for exemplars of teaching and assessment strategies that are clearly linked to specific Science TLOs has been frequently raised as a key issue in discussions of how we, as a community of science educators, may be able to overtly demonstrate that our students do meet the Science TLOs.

In particular, colleagues frequently commented that, while we as a community strongly agree that we want our science graduates to understand and appreciate the methods and philosophy of science (expressed as TLO 1.1: Understanding Science: see Jones et al., 2011, p.23), this is usually not taught explicitly, and is rarely assessed. Indeed, many science academics we talked to during the LTAS project for Science admitted that they expect their students to absorb such ideas "by osmosis". Some courses do include a capstone research unit and/or a first year level unit on science as a broad discipline, but there appear to be few examples of a structured scaffolded approach to developing students' appreciation of science across the degree programme. There is therefore a clear need for a project that will identify and critique learning activities that specifically address Science TLO 1.1, as a basis for developing a teaching resource for other academics. Following the example of Sally Kift (Discipline Scholar for Law), we have therefore embarked on the production of a series of Good Practice Guides (Kift, 2012). In the first instance, we have commissioned Robyn Yucel (La Trobe University) to produce a Good Practice Guide for TLO 1.1.

In addition, we convened a workshop for Associate Deans (Teaching and Learning) for Science in February 2012 at which we considered strategies for implementing TLO 3: Inquiry and problem –

solving. This workshop drew on the expertise of Les Kirkup (ALTC National Teaching Fellow), whose Fellowship topic is *Inquiry-Orientated Learning in Science*. The outcomes of this workshop are available at: http://www.iolinscience.com.au/2012/03/science-tlos/. The production of a full set of Good Practice Guides addressing each Science TLO is a priority for the next implementation phase.

2. Production of a "student friendly" version of the Science Standards Statement.
Essentially the Science TLOS describe a graduate of an Australian science degree, and therefore should form good grounds for discussing with students the benefits of a science degree – which may not necessarily lead to working as a professional scientist. The recent Report from the Office of the Chief Scientist (2012: p.10) commented that: "Science-related study prepares a student for a lifetime of critical thinking and promotes a drive to find evidence and develop an understanding of how our society fits into the broader picture of the world." However, talking with students during our project, it was clear that they do not and will not relate to the formal expression of the Science TLOs as expressed in the Science Standards Statement. A simplified version, in the form of a coloured brochure, will provide useful, succinct and accessible information for both potential and current students, their parents or employers, school teachers and career advisors. Such a publication is under development with the input and feedback of potential and current undergraduate students of science.

In conclusion, the Science LTAs project has laid the groundwork for educational change by catalyzing a national discussion of learning outcomes for Australian science graduates. What are needed now are practical examples of the way the TLOs can be used by Associate Deans and degree coordinators to facilitate curriculum renewal in their degree programs and across Faculties, practical exemplars for lecturers and teaching staff of the way the TLOs can be addressed through teaching activities and assessment tasks, and practical examples of student work that can help Deans of Science develop an understanding of the learning and teaching academic standards that are expected if a student is to meet these TLOs. Much activity in each of these areas is currently occurring in science faculties across the country, and we will continue to provide examples to help stimulate the discussion of ideas with other teaching and learning champions. This collective and work will position the sector to meet the new quality agenda represented by TEQSA's Teaching and Learning Standards Framework. However for many academics the primary driver will be the motivation to enhance their teaching programs and their students' learning outcomes.

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