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Recognising a beacon of teaching and learning leadership in Australian chemistry

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ABSTRACT

This Highlight article considers key contributions made by Professor Brian Yates to the Australian chemistry academic community in recognition of his seminal leadership that led to the establishment of the Chemistry Threshold Learning Outcomes (CTLOs) as national assessment standards. These CTLOs currently underpin the Royal Australian Chemical Institute (RACI) process of the professional accreditation of chemistry majors in Australian tertiary institutions and, hence, provide benchmarks of learning in our discipline. Examples of contemporary assessment approaches in chemistry are presented to inform academics who are seeking to assess learning outcomes beyond threshold standards and to inspire future innovative assessment approaches.

Keywords: academic leadership, accreditation, assessment, assessment standards, benchmarking, Brian Yates, chemistry education, chemistry threshold learning outcomes, community of practice, CTLOs, leadership in education.

Introduction

One factor that makes the process of engaging academics in changing their assessment practices difficult is resistance to change.[1] This process is challenging within a single department, so achieving changes in disciplinary assessment on a national level, involving multiple institutions, demands a unique combination of leadership skills and qualities. This Highlight article recognises these strengths in the leadership of Brian Yates who, in partnership with Susan Jones, embarked on this journey during their respective appointments as Australian Learning and Teaching Council (ALTC) Discipline Scholars for Science. They achieved systematic and sustained change through their mission to establish threshold standards for learning outcomes in science, technology, engineering and mathematics (STEM) programs – these learning and teaching academic standards (LTAS) informed the process of institutional registration by the Tertiary Education Quality Standards Authority (TEQSA). Brian held further responsibility for engaging the chemistry community in developing chemistry threshold learning outcomes (CTLOs). The underlying notion of structured formative and summative assessments aggregated across a chemistry major in a program of study to demonstrate graduate level achievement was unprecedented. Many disciplines in the tertiary sector grappled with the challenge initially.[2] Since 2011, the process of the design and implementation of Science TLOs has underpinned significant curricular change and enabled benchmarking for quality assurance.[3]

In 2011, the Chief Commissioner of TEQSA indicated that this body would align with existing professional accreditation processes. At this point, the RACI was also revisiting the metrics that were applied to accredit chemistry majors in recognised tertiary programs. Brian engaged the chemistry teaching community in the process of developing these CTLO statements.

Brian had participated in, and contributed to, several productive chemistry education initiatives that had emerged in Australia aiming to achieve change in tertiary chemistry teaching and learning practices.[4] In these projects, teams of invested academics led

Collection: Dedication to Brian Yates.

others through engaged dissemination involving workshops and websites and they flourished for a while, but once funding ended, so did their activity. Brian recognised that for the LTAS project, a different approach in leadership was required to establish standards in assessment practice that would be understood and accepted widely in the academic community. The inception of the Chemistry Discipline Network took place shortly after the National Chemistry TLOs were published in July 2011.[5] This initiative, concerned with improving communication in the Australian chemistry academic community, was opportune and concurrent with these developments.

One of the difficulties in constructing the CTLO statements was that each defined CTLO needed to be specific enough to be fit for purpose, while being sufficiently broad to account for the inherent diversity in the national tertiary chemistry curriculum.[6] Thus, the CTLOs were devised as broad principles by design to allow for flexibility in their interpretation. It was understood that there were many different pathways available to institutions through which the CTLOs could be achieved. This focus was driven by the emphasis that was placed on higher-level graduate outcomes rather than concentrating on granular competencies.

Implementing a leadership model for effective academic engagement and sustained change in practice

Leadership in teaching and learning contexts that influences student outcomes is typically categorised as either instructional or transformational.[7] This research had been based in elementary, middle and high school contexts; however, in the tertiary sector, the complexity of both leadership hierarchies and institutional structure is likely to dilute the impact of individual teaching and learning leaders. The concept of leadership in higher education has been portrayed in multiple ways including through discourses of autonomy involving masculinity and professionalism.[8] Relational leadership that engages teams in action has emerged as a preferred model and been advocated as more desirable.[8,9]

In STEM education, the predominant model for engaging academics in the process of adoption and translation of innovative pedagogies and assessment practice is that of distributed leadership.[10] This model requires the establishment of communities of practice (CoPs), which in itself can create challenges of sustainability.[11] It has become evident that CoPs had been central to the successful design of the TLOs.[3]

The process of engaging chemistry academics across multiple institutions in conversations to establish consensus regarding measuring CTLOs required a unique leadership approach. Brian leveraged his Discipline Scholar role to provide relational, distributed and collaborative leadership by initiating and supporting chemistry CoPs (Fig. 1). These CoPs germinated teams of academics who led further conversations and secured funding for teaching and learning initiatives focussed on distilling the core chemistry TLOs and how best to assess these.

Brian was a member of the core project team that initiated ChemNet, a network of Australian chemistry educators, which provided the connectivity between members of the broader community and an online hub for shared resources (http://www.chemnet.edu.au/). This network and community of practice[12] continues to be an important point of dissemination through newsletters and shared resources, which is now managed and sustained by the RACI Chemical Education Division.

CTLOs: shifting the focus on assessment practices

One of the greatest achievements of the process that was undertaken to develop the CTLOs, and the associated CoPs that evolved around this initiative, was the stronger

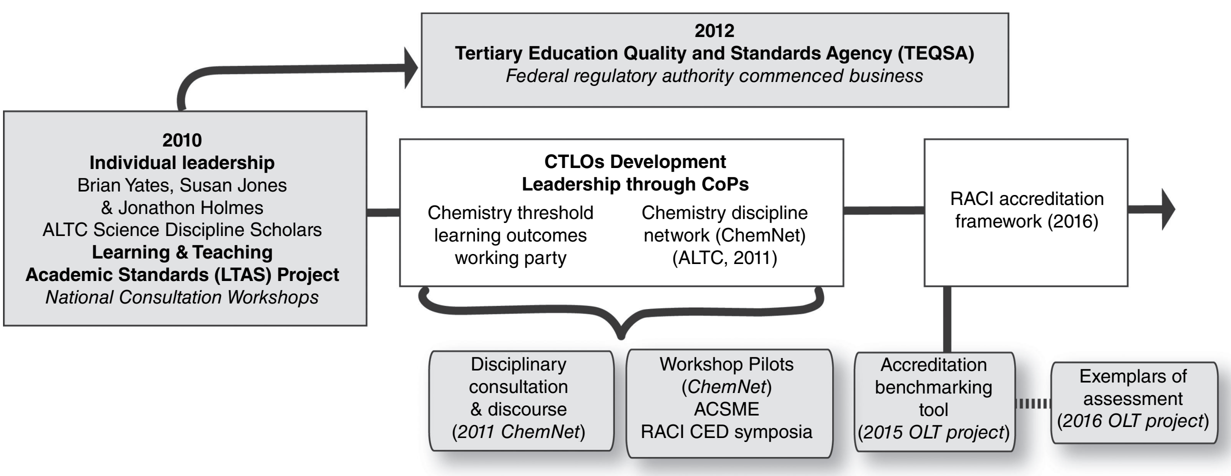

Fig. 1. Emergence of CoPs to develop CTLOs initiated by the ALTC Discipline Scholars and LTAS Project providing the foundation for future work.

connections established between Australian chemists across the country.[5] This replaced the more *ad hoc* arrangements that existed previously and introduced a curriculum framework.[13] Although this outcome is less tangible than some of the other achievements from this time, the importance and tremendous benefits of bringing people together and opening lines of communication between quite disparate sub-discipline groupings cannot be overstated. The Australian chemistry academic community has been enhanced as a result of these improved interactions over the past 10–15 years.

The adoption of the current version of the CTLOs[14] for quality assurance as part of the RACI accreditation framework inherently initiates conversations between academics who teach chemistry majors within a single institution. The pre-accreditation preparation, which focuses on how CTLOs are assessed, invites reflection by both the teaching staff and the review panel on assessment forms and structures. Although examinations and quizzes tend to focus on CTLO 2.1, in which disciplinary content knowledge is recognised, written laboratory reports can evidence a student's demonstration of understanding of laboratory procedures, data display, analysis and communication of results. However, many of the historically used assessments such as quizzes, laboratory reports and examinations did not evidence many of the currently defined CTLOs – there needed to be new approaches to summative assessment practice to measure the broader suite of student learning outcomes.

Exemplars of assessment practice

Only one of the national CTLOs explicitly relates to knowledge of chemistry; the remaining four are concerned with the development of skills and capabilities regarded as important in chemistry practice, the majority of which are highly transferable to an array of diverse professional settings.[6]

The articulation of these transferable skills has afforded many educators within Australia the opportunity to reflect on their assessment practices and guide their subsequent education practice innovations. Over the past 10 years, there have been numerous studies (representative examples are detailed in Table 1) in which the CTLOs were utilised as a starting point for considering localised practice within chemistry. It is important to note that rarely does a single assessment task measure a student's achievement of a CTLO to graduate level; instead, a student's demonstration of CTLOs is measured through the aggregation of multiple summative assessment tasks embedded across the curriculum.

The focus on assessment in the CTLOs mirrors the influence of the science TLOs in affecting practices across other disciplines within STEM and resulting assessment initiatives have the potential to be translated into chemistry assessment contexts based on common intended learning outcomes. A study by Burgacic and coworkers[19] explored the effectiveness of a TLO-guided rubric developed to better guide and assess scientific argumentation skills of biomedical science students through oral presentation (science TLOs 3.4, 4.1).

Table 1. Selected studies utilising CLTOs within chemistry programs in Australia.

Authors	Type of assessment	CTLOs addressed	Outcome
Pullen *et al.*[15]	In-person competency-based laboratory assessment	1.1, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 4.1, 4.2	Developed a rubric for first-year chemistry teaching laboratory programs aiming to clarify the intended outcomes for students and teachers. The rubric in question was designed to align with both the unit-specific learning outcomes and the national CTLOs
Smith and Reid[16]	Digital badging as a means to identify and evidence transferable skills for employability	1.1, 1.2, 1.3, 4.1, 4.2, 5.1, 5.2, 5.3	Within a broader study centred on the development of Work Integrated Learning (WIL) activities at the University of New England, Smith and Reid underpin their work through the use of the CTLOs. The CTLOs were critical in articulating the transferable skills that would determine the desired outcomes for students undertaking WIL activities as part of the degree structure
Schultz *et al.*[17]	Peer and self-evaluation of contributions to team work alongside written reflections; Wiki-based laboratory notebook capturing laboratory and transferable skills and a meta-assessment through a portfolio of previous assessments compared against the CTLOs	3.5, 4.1	Report the development of an assessment tool to evaluate how well a task assesses CTLOs. Case study examples are provided for assessment of two specific CTLOs
Lawrie *et al.*[18]	Student generated video-based explanations encompassing teamwork and scientific reasoning	1.3, 3.1, 4.1, 5.1, 5.4	The design, implementation and evaluation of interdisciplinary, collaborative, open-ended, inquiry-based, problem-solving tasks in very large first-year chemistry cohorts is described. The CTLOs are addressed through a focus on a suite of intended learning outcomes that informed task design

Two more effective examples of science TLOs informing assessment innovations can be seen from the field of agricultural science. Tan *et al.*[20] developed and analysed problem-based activities for first-year agricultural science students. Outcomes of this study indicated an improvement in student ability to both define and recommend approaches to problems in addition to fostering transferable skills such as the ability to work in a team, confidence in their work and science communication skills (Science TLOs 2.1, 3.1, 4.1, 5.2). Wilkes and Reid[21] explored the development of a set of Quantitative Skills (QS) aligned with the science TLOs in the context of agriculture as a discipline, subsequently mapping these QS to a first-year agriculture unit (Science TLOs 2.1, 3.1, 3.2, 3.3, 3.4). For a deeper exploration of the development and ongoing evolution of the science TLOs, we encourage readers to explore the article by Schultz *et al.*[22] in the 'Dedication to Brian Yates' special issue.[A]

Conclusion

A new version of the science TLOs was released in September 2023 and an important change has been to measure student learning outcomes relating to the embedding of Indigenous knowledges and cultures into curriculum. It is anticipated that the CTLOs used nationally in RACI accreditation will undergo a minor revision in the near future to translate these changes into our disciplinary context. The original CTLO framework continues to be highly relevant and forms the foundation for this future work. This is despite the considerable structural change that continues to take place in learning and teaching across higher education. For example, this includes the growing shift to blended and distance learning in response to the ever-changing needs of students, contemporary society and financial pressures within the sector that have been accelerated and exacerbated by complications arising from the after-effects of the COVID-19 pandemic. In summary, the challenge for chemistry educators around the country will relate to ensuring that new approaches to learning and associated innovations in teaching that are incorporated into modern chemistry curricula constructively align with the CTLOs.

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Data availability. The data that support this study are available in the article.

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