Discipline learning outcomes: Design resource and quality assurance mechanism

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Key contributions

- This article reports on a multi-phase project to explore and document the adoption of the Science TLO statements (Jones et al., 2011) as the reference point for Australian science degree curricula.
- The research demonstrates that the Science TLOs have catalysed significant curriculum renewal and change across the Australian higher-education sector and have been widely adopted as reference points for quality assurance.
- The research identifies opportunities to further explore the gap between intent and practice and the opportunities presented through brokering curriculum conversations seen as relevant to stakeholders. A longer-term study is needed

to demonstrate whether this collegially accepted approach to quality assurance and curriculum design has translated into improved student learning outcomes.

Abstract

The use of learning outcome statements underpins contemporary university course design, yet their impact in practice is unclear. Threshold learning outcomes (TLOs) for Australian bachelor degrees in science were published in the Science Standards Statement in 2011. This paper reports how and where the Science TLOs have been adopted by science faculties across Australian universities as a case study in the broad-scale application of discipline learning outcomes in generalist degrees. The analysis draws on four data sources: a desktop survey of published course learning outcomes for science degrees; an online survey of learning and teaching leaders; semi-structured interviews with a sub-set of those leaders; and a citation analysis. The results show that the majority of Australian science faculties have embraced the Science TLOs both as a reference point for quality assurance and as the basis of curriculum design or redevelopment. The TLOs are perceived as a trusted external reference point, endorsed by the Australian Council of Deans of Science, and aligned to national legislative requirements. Some challenges remain, including staff resistance to change and a perception of curriculum reform as a 'top-down' process. Positional leaders clearly have a pivotal role as active brokers to lead positive change. However, in terms of national standards and quality assurance, we conclude that disciplinary learning outcome statements such as the Science TLOs build a bridge between intent and practice in curriculum reform.

Introduction

Intended learning outcomes have become an accepted ingredient of curriculum and learning design and of quality assurance. In specifying an endpoint, learning outcome statements guide both the development of learning and the measurement of achievement. An explicit statement of a curriculum's intent, articulated as learning outcomes, is core to conceptual approaches such as constructive alignment (Biggs,

2014) and backwards design (Wiggins & McTighe, 2005), and is widely translated into curriculum development approaches (Laurillard, 2013; Sweetman, 2019).

Nationally agreed qualifications frameworks based on learning outcomes are being applied as standards in auditing, quality assurance, and benchmarking of educational programmes (Delany et al., 2016; Sweetman, 2019), and an outcomes-driven approach to quality assurance is increasingly enshrined in legislation. In Australia, the Higher Education Standards (Commonwealth of Australia, 2015), which governs all Australian higher-education institutions, requires that:

> The expected learning outcomes for each course of study are specified, consistent with the level and field of education of the qualification awarded, and informed by national and international comparators.

Australian higher-education qualifications must also comply with the specifications of the Australian Qualifications Framework (AQF; https://www.aqf.edu.au/), which defines the level of an award across the broad categories of knowledge, skills, and application.

In response to these legislative requirements, Australian universities have adopted institutional statements of graduate capabilities or outcomes (Oliver & Jorre de St Jorre, 2018), which guide internal design and quality-assurance processes. Disciplines and professions may specify outcomes that are required for registered practice or that indicate standing in a field. For registered professions, learning outcomes are primarily concerned with public safety and efficacy of practice (AHPRA, 2018). For academic disciplines, learning outcome statements capture the identity and distinctiveness of the discipline (ALTC, 2010).

A complication is that learning outcomes operate with different meanings at different levels. Their application as instruments of policy, pedagogy, or organisation of educational institutions (Ure, 2019) can generate ambiguity and confusion due to the differing perspectives of university leaders, teaching academics, and students (Sweetman, 2019). Thus, adoption of learning outcomes as quality frameworks at the policy level does not necessarily translate into pedagogical practice (Lassnigg, 2012; Sweetman, 2019). At the pedagogical level, learning outcomes should support

curriculum design by providing clarity concerning course aims, learning activities, and assessment. However, the implementation of learning outcomes as effective tools for curriculum reform and development remains poorly researched and understood (Caspersen, Frølich, Karlsen, & Aamodt, 2014; Sweetman, 2019).

This paper investigates how Australian universities are applying a learning-outcomes approach to quality assurance and curriculum design. Such an approach is predicated upon the availability of a mutually agreed set of standards. The national threshold learning outcomes (TLOs) generated during the Learning and Teaching Academic Standards (LTAS) Project (ALTC, 2010) provide such standards. Each set of TLOs describes the minimum level of discipline knowledge, discipline-specific skills, and professional capabilities that every graduate of the specified program must have achieved (ALTC, 2010; Ewan, 2010).

The Science TLOs, as articulated in the *Science Learning and Teaching Academic Standards Statement* (Jones et al., 2011), provide a set of high-level learning outcomes for bachelor-level degrees designed to form the foundation for curriculum design for a generalist science or mathematics degree. The Science TLOs are endorsed by the Australian Council of Deans of Science (ACDS) as representing national consensus on acceptable graduate outcomes (see Jones et al., 2011; Kelder & Jones, 2015). They therefore provide an agreed reference point (as used by the Higher Education Standards Framework, 2014, p. 12) for the formal quality assessment of learning outcomes for bachelor-level degrees in science.

This study explores the degree to which the Science TLOs have been adopted at faculty level as the fundamental basis of curriculum design, and how they are being used in formal quality assurance of science degrees. Since 2013, at annual conferences organised by the ACDS Teaching and Learning Centre (http://www.acds-tlcc.edu.au/events/) Associate Deans of Teaching and Learning for Science have engaged in robust discussions regarding implementation of the Science TLOs. These have centred on two key issues: (re)designing curricula with graduate learning outcomes aligned to the TLOs and assessing whether graduating students meet the TLOs. However, to date there is only anecdotal information on the degree to which individual universities have implemented the Science TLOs into curriculum design, assessment design, and/or quality assurance. Furthermore, the extent to which

awareness and uptake of the TLOs has penetrated amongst science academics directly involved in curriculum design and student assessment has not been investigated. In this paper we examine the impact of the Science TLOs on science curricula across the Australian higher-education sector.

Our specific research questions are:

1. To what extent are the Science TLOs currently applied in quality assurance at Australian universities?
2. What is the impact of the Science TLOs on curriculum design to date?
3. What are the gaps and obstacles to their implementation in curriculum design?

Methods

We used a multi-layered approach to data-gathering: a desktop survey of publicly accessible learning outcomes; an online survey of learning and teaching leaders; semi-structured interviews with a sub-set of those leaders; and a citation analysis of scholarly literature that references the Science TLOs (based on Jones et al., 2011). The study encompassed all Australian universities with faculties of science or equivalent organisational structures. The research, including survey and interview designs, was approved by the Faculty Human Ethics Advisory Group (HAEG) of Deakin University as STEC-20-2015-JOHNSON, titled ‘Implementation of Science TLOs’. The research instruments are available from the third researcher (J-AK) on request.

Desktop survey

A desktop review of publicly accessible learning outcomes for bachelor-level science courses (BSc) or equivalents was performed in September 2016, with a follow-up review in January 2020. Learning outcome statements were collected from the public websites of the 37 Australian institutions offering a BSc. In 2016, 22 universities had publicly published course learning outcome statements. By 2020, an additional six universities had published statements and five had updated previously published statements. Course learning outcome (CLO) statements were compared with the Science TLO statements to identify shared elements using equivalent keywords.

Where a single CLO covered multiple elements, it was aligned with multiple Science TLO statements; CLOs with no common elements were collected as 'other'.

Online survey

The online survey was designed in and delivered via SurveyMonkey™ in 2015. The Associate Dean (Science) for each of the 37 Australian universities identified in the first desktop survey was asked to identify staff holding positional responsibility for learning and teaching in undergraduate science and/or mathematical science degrees or majors. Those academics were invited to participate in the survey, which asked them to identify and assess their use of the TLOs for curriculum development and quality assurance. They also identified strengths and challenges (free text) and rated the importance of the Science TLOs for a range of specified purposes (accreditation, quality assurance, curriculum development, curriculum renewal/reform) using a Likert Scale of 1 (not important) to 5 (very important). Questions on awareness and use of the TLOs were yes/no. Each survey question had free-text options for further comment or explanation.

Interviews

We conducted semi-structured interviews with five academics who self-identified as potential interviewees via the online survey. Interviews focused on how the TLOs were applied in curricula and were conducted by one researcher (SMJ) using the software Zoom™. Core questions in the interview protocol were supplemented by probing questions. Interviews were audio-recorded, transcribed, and checked by the interviewee.

Analysis of the transcripts was carried out using NVivo™. The second researcher (EJ) initially reviewed the transcripts to create a long-list of 36 keywords and emergent themes. Themes were then consolidated to three overarching areas (*Course Design*, *Links between Standard Statements*, and *People and Processes*), with a limited number of sub-themes for each theme. Interviewee comments were assigned exclusively to each theme to ensure a spread of evidence. The scope of each theme was reviewed during assignment of comments to ensure that they were distinct. Evidentiary comments selected to be included in publications were de-identified and recorded in an evidence log alongside each theme. The third researcher (J-AK) independently analysed the raw data to validate the themes. Free-text responses from

the survey were compared with interviewee answers. As a final step, the research team discussed the three analysis threads and finalised the themes and sub-themes. Our consensus analysis presents the range of themes but does not attempt to prioritise importance.

Citation analysis

A citation analysis was performed to indicate the influence of the Science TLOs on the scholarship of learning and teaching. Google Scholar™ and ResearchGate™ were searched 25 February 2020 to find scholarly publications (refereed journal papers, refereed conference papers, books, technical reports) citing the Learning and Teaching Science Standards Statement (Jones et al., 2011). ResearchGate citations were sourced from the personal page of S. Jones (Jones, 2020). The two lists of articles were merged, duplicates removed, and the articles grouped thematically.

Results

Desktop survey: Course learning outcomes for science degrees

The desktop survey indicated that 37 of 42 Australian universities offer a bachelor of science (BSc) (Figure 1). In 2016, 18 institutions (49% of Australian universities) had published course learning outcomes on their public website; this had risen to 25 institutions (60%) in 2020. One additional institution published learning outcomes for science majors (sub-course level) rather than a bachelor-level course. Eleven universities (26%) did not publicly list their BSc learning outcomes on their website or provided only sub-disciplinary learning outcomes, which were not included in this analysis.

All published course learning outcome statements used elements of the Science TLOs to varying degrees (Figure 1). By 2020, five universities (12%) were using the Science TLOs in their original published form as their course learning outcomes; the learning outcomes for the BSc of seven further universities (11%) aligned to all domains and many of the sub-themes of the Science TLOs. In nine cases (21%), the institutional science learning outcomes referenced the themes of the Science TLOs with a limited number of common elements.

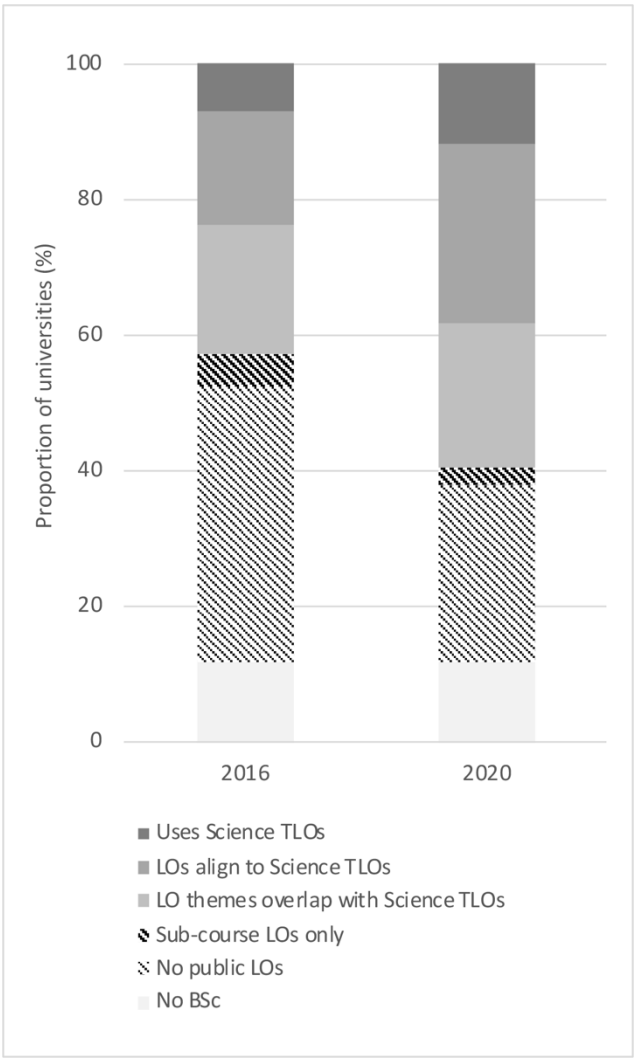

Figure 1: Proportion of universities whose publicly available BSc course learning outcomes reference the Science Threshold Learning Outcomes

Online survey: Science faculty learning and teaching leaders

The survey indicated the use of systematic approaches using the Science TLOs in course design and governance. Completed surveys were returned by 18 (48%) of the 37 learning and teaching leaders invited. Of these, 14 (82%) reported that their faculty currently used the Science TLOs for some element of quality assurance, and 10 (62%) reported that the Science TLOs were used in curriculum design. Across institutions, the Science TLOs were variously applied in drafting TLOs for BSc degree programs; prompting discussion of curricula; designing assessment standards; and/or conducting

learning design. Qualitative responses indicated strong support for the Science TLOs and the nationwide collaborative process through which they were developed:

> ...the TLO's are logical, sensible, well thought out, and the subject of limited debate because the intent is clear; and, that they provide a nationally agreed "benchmark" for science learning that allows comparison across institutions and state boundaries. (Example response 1)

Quality assurance: 14/18 (82%) of survey respondents reported use of the Science TLOs in quality-assurance processes, including: formally mandated auditing by Australia's independent national quality assurance and regulatory agency for higher education, the Tertiary Education Quality and Standards Agency (TEQSA); compliance mapping; benchmarking between institutions; and course review. The TLOs were rated as most important for AQF compliance, TEQSA audits, curriculum mapping, and benchmarking, and least important for external accreditation and institutional approval processes.

> We are in the process of using the Science TLOs as part of an overall restructuring of the BSc programs in response to external and internal reviews. (Example response 2)

The identified strengths of the Science TLOs in quality assurance included: their establishment of a useful external reference point; their endorsement by a peak body; and their ability to link to a nationally recognised framework. For example:

> ...we have participated in a RACI accreditation of the Chemistry major recently, and the TLOs are now central to that accreditation process. (Example response 3)

Perceived challenges included the time needed for staff to understand their meaning,

> gauging what is meant by "threshold" in the standard; very general, so not hugely useful. (Example response 4)

Curriculum design: 10 (62%) leaders reported that the Science TLOs were being used in curriculum design. They were applied in: drafting TLOs for BSc programs; prompting discussion of curricula; designing assessment standards; supporting assessment and

learning design; mapping existing curricula; and ensuring that new designs fit the TLOs.

> Programs were examined to determine if they met the TLOs. If not, courses and assessments were adapted to accommodate the missing TLOs. (Example response 5)

The TLOs were seen as most important for drafting course or unit learning outcomes (scoring 4.70 and 4.10, respectively, on a scale of 1-5), and of least importance in designing assessment rubrics and learning activities (scoring 3.3). The Science TLOs ranked slightly below university-level learning outcomes in their importance in curriculum design (4 on the five-point scale versus 4.2), probably reflecting internal approval processes. Several respondents commented that the process of using the TLOs in mapping and in curriculum design was 'straightforward to do' if designing a new degree program, but retrofitting an existing curriculum to the TLOs, fitting generic Science TLOs to specialised science degrees, or incorporating compulsory institutional learning outcomes was challenging.

Semi-structured interviews

The interviews provided rich descriptions of using the Science TLOs in practice. The thematic analysis identified three themes: *course design*, *connecting standards*, and *people and culture*. Sub-themes were identified for each theme (Figure 2).

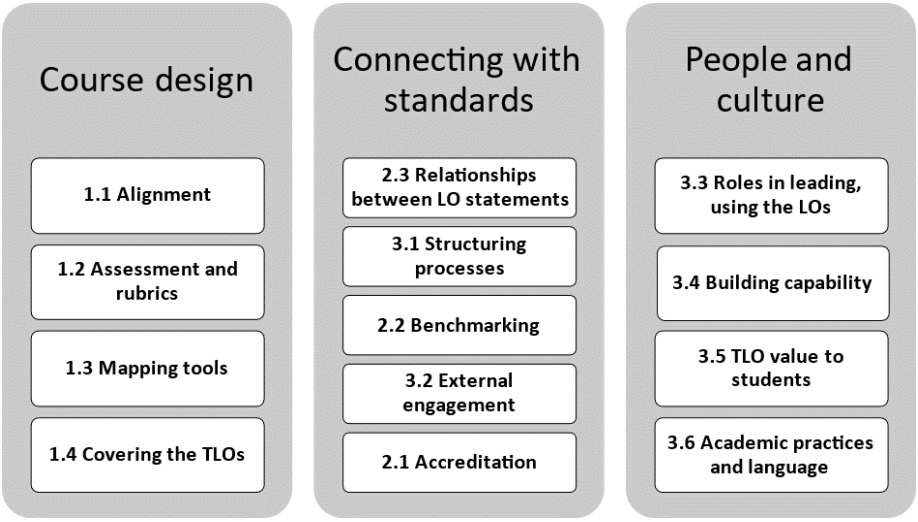

Figure 2: Interview themes and sub-themes (implementing the Science TLOs)

Theme 1: Course design

Course design was the primary context in which the Science TLOs were reported as having both direct and indirect impact. Interviewees frequently commented on issues related to alignment (constructive alignment of curriculum content and assessment with learning outcomes, defined at course and subject level). Connected to alignment, course-design elements such as rubrics to guide grading assessment tasks and wording of learning outcome statements were also discussed. A variety of purposes for curriculum mapping, in terms of mapping as both process and product, were reported.

> I think one of the virtues of [the TLOs], personally, is that they're almost like a checklist where you don't want to leave any of those things out.… I think they're very useful in many ways…[and] these criteria are sensible and logical. (Interviewee 5)

1.1 Constructive alignment

The *alignment* sub-theme connected with several aspects of course design that interviewees discussed. This is not surprising, as Biggs's influential concept 'constructive alignment' (Biggs & Tang, 2011) explicitly connects curriculum content and assessment design with learning outcomes. The specific task of designing course learning outcomes for alignment with the Science TLOs was described as having different effects influenced by purpose, with the process either reinforcing existing processes, providing opportunities for professional learning about learning outcomes, or contributing to confusion where influences were perceived to compete.

The interview participants' key points were (in paraphrase for this and subsequent sub-themes):

- Course rebuild or renewal offers opportunities for thorough alignment of TLOs with assessment and embedding in curriculum.
- Alignment between multiple levels of learning outcomes can be reinforcing, explanatory, or confusing.
- Alignment issues are managed by a range of strategies and include seeking alignment with assessment and curriculum mapping.
- Academic governance is used to record alignment between course and unit learning outcomes and between outcomes and assessment.

- Maintenance of sub-discipline distinctiveness is a prompt to modify the Science TLOs to fit specific courses.

1.2 Assessment and rubrics

The *assessment and rubrics* sub-theme highlighted a substantial component of course design not explicitly addressed by the Science Standards Statement (Jones et al., 2011). Thus, it is not surprising that interview participants' comments revealed a lag between revising course learning outcomes to align with the TLOs and reviewing or redesigning assessment tasks at the subject/unit level. Difficulties in achieving comprehensive assessment design changes were noted, as well as the role of academic governance (and documentation) requirements in prompting review and change. Rubric design was used to drive alignment but did not feature in monitoring or documentation requirements.

Key points:

- Changing assessment tasks to reflect the TLOs often lags behind mapping and course design, although it can be prompted by course and unit documentation.
- Uneven understanding of the TLOs is a problem for assessment (need whole-of-course adoption).
- Assessment changes over time and needs regular review.
- Rubric templates can drive alignment with TLOs.
- Assessment rubrics are not monitored for alignment with TLOs.

1.3 Mapping tools

The analysis revealed that *mapping tools* vary in usefulness and functionality, with consequent variation in perceived usefulness and effectiveness. Mapping, even at a basic level with a spreadsheet, is used for a variety of purposes in relation to course design. A curriculum map is a product that can be referenced for course review and quality-assurance activities such as external accreditation. In terms of process, interviewees reported that a curriculum-mapping tool can engender both positive effects (guiding and engaging staff in valuable conversations) and negative (constituting a barrier to redesign and contributing to staff disengagement and minimal effort).

Key points:

- Mapping is used for design, review, and accreditation, with accreditation a driver for mapping practice in some disciplines.
- Helpful mapping tools guide teaching staff and force engagement; poor tools engender disengagement and box-ticking on course documentation.
- Limitations of software create barriers to reorganisation of course structures.
- Mapping software is a driver for use in review and reporting and a prompt for conversation for all staff to engage in review.

1.4 Covering the TLOs

The sub-theme *covering the TLOs* illuminated attempts to encapsulate interconnections between learning outcome statements, and to acknowledge different tiers of concepts. Additional learning outcomes reflected the wish to embed interdisciplinary content knowledge and to capture (sub-)disciplinary distinctiveness. Implementing some aspects of the TLOs, particularly 'communication' and 'professional responsibility', was considered difficult in terms of both curriculum design and assessment.

Key points:

- Some TLOs are more difficult to implement than others.
- Interdisciplinary content creates a challenge for disciplinary TLOs.
- Assessment and curriculum design are challenging for 'soft' TLOs (communication and professional responsibility).
- Lack of alignment or inclusion of disciplinary distinctiveness led some interviewees to develop their own TLOs.
- Cross-linking, interrelatedness, and different tiers of concepts complicate the process of developing learning outcome statements.

Theme 2: Connecting with standards

Interviewees' reflections on the use of TLOs to drive or guide curriculum reform explored their value as externally recognised standards. Benchmarking as a mechanism of assessing the level to which TLO standards statements are achieved was not a strong sub-theme, although it was considered potentially useful. Likewise,

external engagement and accreditation were viewed as having the potential to be influenced by the TLOs.

> …every, I suppose, three years we have a course group review for one of our courses – that's to make sure that we are aligning with what's required from [an] accreditation perspective, from a marker perspective, from an industry perspective. (Interviewee 3)

2.1 Relationships between learning outcome statements

The conversations included consideration of *relationships between learning outcome statements*. Baseline alignment to national requirements was built into the TLO statements, such that the Science TLOs are designed to apply at AQF7, the national standard for a bachelor qualification. Interview participants focused on the relationships between the Science TLOs and locally relevant statements (e.g., institutional, professional, sub-disciplinary, and interdisciplinary). These relationships were expressed in terms of managing tensions, with the Science TLOs translating the generic AQF7 to the disciplinary context. In turn, the Science TLOs could be adapted to accommodate sub-disciplinary or multi-disciplinary learning outcome statements.

Key points:

- Sub-disciplinary TLOs align with the Science TLOs and AQF.
- Institutional statements (graduate attributes) are linked to design, but do not appear to lead design.
- Tensions between disciplinary values mean the original flavour of Science TLOs can be lost.
- Sub-disciplinary TLOs make overt the differences in how science is done.
- Learning-outcome comparisons create opportunities to subtly revise and adjust courses.
- Interdisciplinary courses require multiple mapping processes.

2.2 Structuring processes

Interviewees described various *processes* associated with implementing the Science TLOs that can be identified as effecting or *structuring* various practices. The TLOs were embedded in governance documents, requiring curriculum review and changes to a course or its units. Documentation and associated practices, activities related to course approval, unit outline presentation, and course guide information required

explicit explanation of alignment with the Science TLOs. Using the Science TLOs to drive curriculum reform was seen in both positive and negative terms. Projects to review and redesign curricula were viewed as an opportunity to drive reform, with the caveat that these could be perceived as an opportunity to drive compliance, with the risk that teachers would ignore them or would engage with them only at a surface level.

Key points:

- TLO use is both valuable and challenging in forcing engagement.
- Academic governance processes (approvals, course documentation) drive curriculum reform, but can be seen as compliance-driven, and thus can be ignored by staff or result in only surface engagement.
- TLOs can be used as a mechanism for control alongside other guiderails and, where embedded in assessment policy, can enforce linkage between assessment and unit learning outcomes and TLOs.
- Major projects, such as degree restructure and curriculum review and redesign, are key opportunities for achieving significant reform and adoption of TLO statements.
- Impact is affected by how projects are presented: an opportunity or a compliance issue.

2.3 Benchmarking

Interviewees were aware of the value of *benchmarking courses* and applying a formally endorsed external reference point. There were different visions of the timeframe for benchmarking (e.g., a seven- or three-year cycle) and different approaches (e.g., participation in a mandated scheme; internal roundtable discussion). The intention to benchmark was not always accompanied by action, but participants acknowledged that benchmarking is important to facilitate alignment of grading across institutions, achieve accreditation, and meet industry expectations.

Key points:

- Use of the TLOs for cross-institutional benchmarking is potentially useful.
- Benchmarking within the discipline can drive deeper engagement with alignment and design.

2.4 External engagement

The sub-theme *external engagement* was broadly conceived in the context of partnerships, with industry to deliver authentic assessment. Work-integrated learning programs provided specific examples of curricula developed with a strong focus on employability, ensuring that curriculum was aligned with accreditation requirements and addressed industry perspectives.

Key points:

- Engagement outside the institution fosters curriculum development and builds staff capability.
- TLOs are useful in the context of strong employer and work-integrated learning programs, facilitating industry engagement in curriculum design.

2.5 Accreditation

The sub-theme *accreditation* identified an asymmetry of influence between TLOs as standards statements and as accreditation statements for professional graduate outcomes. The Science TLOs were positioned as subordinate to the requirements of professional accreditation bodies. Some interviewees understood that development of the TLOs had included engagement with professional accreditation bodies and reported that the process had influenced changes to models for designing course curricula, significantly shifting from inputs (e.g., number of laboratory hours scheduled) to outputs (expected minimum learning outcomes).

Key points:

- Professional accreditation statements take precedence where it is important for graduate practice, but they can 'learn' from the discipline statements.
- TLOs have a positive impact on accreditation where a professional body engages with them.

Theme 3: People and culture

People and culture as a theme draws together an articulation of the role of leadership in implementing the TLOs and of the role of the TLOs in building staff capability. Students' engagement with the TLOs was reported as being limited to exposure

through unit outlines. Many comments touched on the cultural norms and practices of academics when engaged in teaching practice. This included how academics conceptualise and articulate their curriculum designs, with the TLOs functioning to prompt and guide necessary and productive conversations.

> We introduced them [TLOs] to our unit outlines. I think that's the first thing we did so that teachers or coordinators had to align their unit of study learning outcomes to the science TLOs. (Interviewee 1)

3.1 Roles in leading and using the learning outcomes

It was evident that the *roles* held by positional leaders influenced their capacity to engage academic teachers and expand their capacity to use the TLOs effectively. *Leadership* involved different levels of responsibility, accompanied by different levels of understanding of the use of the TLO statements and of connections between unit-level outcomes and the course learning outcomes. Course coordinators were identified as central to curriculum mapping and brokering conversations to develop shared understanding amongst staff and external partners. Action was also driven by publication of quality-assurance performance data; for example, the Australian Quality Indicators for Learning and Teaching (QILT) website (https://www.qilt.edu.au/).

Key points:

- Leaders in teaching and learning carry key responsibility for embedding learning outcomes, depending on how curriculum design/change processes are linked to roles.
- Course or discipline coordinators understand the Science TLOs through systematic course design and quality-assurance processes.
- Course coordinators are usually familiar with course-curriculum maps and are responsible for assuring course learning outcomes.
- QILT and other performance indicators are an external driver for course coordinators to engage with TLOs.
- A process or system (including mapping software) that has embedded the TLOs supports conversations and knowledge about the purpose and value of TLOs.
- Unit coordinators have variable understanding of the role and use of TLO statements in their unit, and variable knowledge of other units and the course learning outcomes.

3.2 Building capability

Building capability refers to commentary on the knowledge and skills of academic teaching staff, and how the TLOs could be used directly to increase staff members' engagement and ability to design curricula that met basic standards. Direct influence was primarily through the TLOs being embedded in governance instruments such as policies, procedures, and report templates. Participants also noted indirect influence, through the experience of discussing curriculum with reference to the TLOs.

Key points:

- Governance processes are an opportunity for reflection and building capability.
- Using the TLOs prompted deeper, and sometimes challenging, discussions about curriculum.

3.3 TLO visibility and value to students

The sub-theme relating to the *visibility and value* of the TLOs for students was not strong in comparison to the other sub-themes. Student awareness of the TLOs was considered low. Attempts to make them visible included embedding the TLOs in documents used by students (e.g., unit outlines, lectures, assessment tasks, lab manuals) or encouraging students to track their own progress against the TLOs.

Key points:

- Explicit student interaction with TLOs is low.
- Student engagement with TLOs can be driven through tailored activities and exposure by making them explicit in unit outlines.

3.4 Academic practices and language

The sub-theme *academic practices and language* is an important context in which use of the TLOs flourishes or fails. Two strands of thought were articulated: 1) the value of collegial discussion about course curriculum, including the role of the TLOs in providing language and concepts to prompt discussion; and 2) challenges created by academic independence, enabling low or no engagement, along with a compliance mentality toward demonstrating course quality. For some staff, there is a gap between understanding the concept of learning outcomes and the ability to design assessment to measure the extent to which students achieve them.

Key points:

- TLOs provide language that enables thinking about assessment and curriculum.
- Collegial discussions and peer critique of assessments are valuable.
- Gaps in knowledge of constructive alignment are a prompt for professional development.
- Unless mandated, significant numbers of academics can refuse to engage with TLOs with little or no consequence.
- Compliance behaviours occur if the use of TLOs is presented using a compliance lens but can also be a prompt for conversations about quality.

Citation analysis

Google Scholar™ listed 51 citations of the Learning and Teaching Standards Statement (Jones, Yates & Kelder, 2011), although three were for different sections of the same online resource. ResearchGate™ yielded 48 citing references, 35 of which were not also listed in Google Scholar™. Interleaving of these two sources yielded a total of 84 relevant publications as at 25 February 2020, grouped in four thematic categories: *development of sub-disciplinary TLOs (8/84); graduate outcomes for bachelor-level science graduates (21/84); individual academics' explorations of strategies to improve student learning and teaching, including assessment and curriculum-level initiatives (49/84);* and *national directions in university science education* (6/84).

Discussion

The Science TLOs were established by a process of national consensus and were explicitly designed to align with both the AQF, which regulates nationally recognised education awards in Australia, and a range of international standards statements, including the European Tuning Process (González & Wagenaar, 2003). Endorsement of the Science TLOs by the ACDS underpinned the status of the *Science Standards Statement* (Jones et al., 2011) as a national standard of achievement with associated implications for course design.

Our research sought to understand the extent to which the Science TLOs are currently applied in quality assurance at Australian universities, assess the impact of the

Science TLOs on curriculum design to date, and identify the challenges to their implementation in curriculum design. While Hay (2012) and Brawley et al. (2013) have examined the immediate uptake of equivalent standards from the LTAS Project for quality-assurance purposes in the disciplines of geography and history, respectively, our study goes further, exploring the application of disciplinary standards in curriculum design and revision.

Four areas of impact emerged from our multi-layered investigation: constructing course learning outcomes, valuing quality assurance, framing curriculum renewal, and developing capability in teaching teams.

Construction of course learning outcomes

The Science TLOs have had a direct and ongoing impact on the construction of course learning outcomes, as demonstrated by the BSc learning outcomes published by Australian universities. Faculty leaders valued the Science TLOs as a starting point for the construction of course learning outcomes in discipline-relevant language, an agreed reference list of outcomes, and shared standards across institutions and disciplinary communities. This supports international views of the value of disciplinary learning outcome statements (Sweetman, 2019; Ure, 2018).

Quality assurance

The Science TLOs are widely perceived as providing a trusted external reference point aligned with national legislative requirements. Academics value the notion of contributing to the national impetus towards a shared understanding of what a science education is intended to achieve. As an external benchmark, the Science TLOs offer transparency and comparability. They are seen as less useful for professional accreditation, probably reflecting the perceived primacy of accreditation requirements. However, the Royal Australian Chemistry Institute's recent revision of accreditation standards to align with the Science TLOs provides an example of bringing together disciplinary thinking, accreditation, and professional requirements to create a shared understanding of desired graduate learning outcomes (Schultz, Southam, & O'Brien, 2020).

The influence of the Science TLOs has not yet extended to quality assurance for assessment and measurable outcomes of learning. This probably reflects both a lag in

cycles of curriculum development and well-recognised barriers to pedagogical change, such as the need to improve teacher capability and the need for resources and leadership to support and sustain change (Brownell & Tanner, 2012; Henderson & Dancy, 2007).

Framing curriculum renewal

Curriculum renewal and how it is initiated and progressed are affected by academic culture and practices. The principle of academic independence is embedded in academic culture: leaders need to manage people's expectations in the context of curriculum change and use the Science TLOs as the starting point for discussing curriculum and learning designs.

Partly in response to the impacts of academic independence on the ability to drive change, leaders have noted the importance of using processes that have the authority to compel action. However, effective leadership to engender whole-of-course curriculum changes includes thoughtful framing (see Sweetman, 2019), such that conversations about including the TLOs in curriculum renewal focus on quality (an opportunity for improvement) rather than compliance with standards. A quality focus enhances opportunities for positive engagement and reduces the likelihood of a compliance mindset with minimal, token engagement.

The Science TLOs can function as a boundary object (Kelder & Jones, 2015b) for curriculum renewal. They provide a common framework to guide local discussions and collaborative work on curriculum design and renewal, enabling curricula to align with national standards and be benchmarked against other discipline-aligned curricula. Discipline-specific learning outcome statements create a shared language and move abstracted notions of learning outcomes into the familiar territory of a recognisable disciplinary context.

Developing teaching capability

Building capability is a complex challenge (Henderson & Dancy, 2011) influenced by personal, institutional, and external factors (Austin, 2011). Interviewees and survey respondents described two forms of interaction that prompted informal professional development through discussion and reflection: internal course-level discussions and sector-wide discipline projects. Curriculum alignment and mapping prompted reflection

on course goals and broadened thinking about learning amongst course teaching teams. Across institutions, sub-discipline communities within science, notably chemistry (Schultz et al., 2020) and agricultural science (Acuna et al., 2016), have fostered peer learning in curriculum design through collaborative projects.

The influence of the Science TLOs on shaping curriculum is also evidenced in academic publications, as demonstrated by the citation analysis and by comments from faculty leaders. Through scholarly publications, leaders of TLO implementation are contributing to curriculum development, improvements in personal practice, and national directions in science education.

Challenges for disciplinary learning outcome statements

Sustained curriculum change is difficult, as indicated by repeated calls for action to implement decades of educational research in university science courses (Anderson et al., 2011; Bradforth et al., 2015). Henderson, Beach, and Finkelstein (2011) analysed STEM curriculum reform reported in scholarly literature and found that common strategies such as creation and dissemination of 'best practice' materials or top-down policy-making were not effective in embedding evidence-based practice. The authors concluded:

> Effective change strategies are: aligned with or seek to change the beliefs of the individuals involved; involve long-term interventions, lasting at least one semester; require understanding a college or university as a complex system and designing a strategy that is compatible with this system (p. 952).

Science academics are influenced by individual circumstances (experience, career, discipline, appointment, motivation) and their teaching context (department, institution, and external environment) (Austin, 2011). Successive layers of influence act on teachers, with the most immediate effect from the local departmental environment, followed by the institutional environment and then external factors including government, employers, accrediting agencies, and scholarly associations. Austin proposed four 'levers' that either promote or impede evidence-based practice: reward systems, work allocation, professional development, and leadership (Austin, 2011).

The perceived barriers to implementation of the Science TLOs reported here echo Austin's (2011) findings. Curriculum review and reform requires active engagement, which is discouraged by adverse workload models, personal career aspirations, and a perception that teaching is less valued than research (Brownell & Tanner, 2012). Faculty leaders participating in this study reported that some staff saw review as a bureaucratic exercise that simply had to be endured. Similarly, Cooper (2017) points to tensions between the new curriculum and the 'tacit' curriculum embedded in university processes, supporting Austin's systems approach calling for alignment between disparate influences on teachers (Austin, 2011).

Conclusions

Publication of the Science TLOs was a watershed for university science teaching in Australia. This study reveals what has been achieved through application of the TLOs as consensus-based curriculum tools. It also demonstrates the complexity of implementation for a generalist degree that draws together diverse sub-disciplines, curriculum leaders, and teachers. It highlights the gap between intent and practice, but also demonstrates the opportunities presented through brokering curriculum conversations with stakeholders. Our study shows that the Science TLOs are widely accepted as reference points for quality assurance of bachelor-level science degrees and have catalysed widespread curriculum change across the Australian higher-education sector. However, a longer-term study is needed to demonstrate whether this collegially accepted approach to quality assurance and curriculum design has translated into improved student learning outcomes.

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