Assessing the Assessments: Evidencing and Benchmarking Student Learning Outcomes in Chemistry

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Outline

- Australian Higher Education Teaching & Learning Landscape
- Threshold Learning Outcomes (TLOs)
- Assessing the Assessments Project
- Calibration
- Conclusions and Future Work

The landscape

What are (collectively) the graduate outcomes that we want?

- These wear a variety of labels such as ‘Graduate Attributes’, ‘Graduate Learning Outcomes’, ‘Graduate Capabilities’ etc.
- In principle, they describe what a graduate “**knows, understands and can do**”.

How will we (collectively) know that students have met these outcomes?

The L&T 'environment'…

1. 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/or international comparators.
2. The specified learning outcomes for each course of study encompass discipline-related and generic outcomes, including:
   a) **specific knowledge and skills and their application** that characterise the field(s) of education or disciplines involved
   b) **generic skills and their application** in the context of the field(s) of education or disciplines involved
   c) **knowledge and skills required for employment and further study** related to the course of study, including those required for registration to practise if applicable, and
   d) **skills in independent and critical thinking** suitable for life-long learning.

The L&T 'environment'…

3. **Methods of assessment** are consistent with the learning outcomes being assessed, **are capable of confirming that all specified learning outcomes are achieved** and grades awarded reflect the level of student attainment.
4. On completion of a course of study, **students have demonstrated the learning outcomes specified for the course of study**, whether assessed at unit level, course level, or in combination.

Higher Education Standards Framework, 2015

Learning Outcomes and Assessment (Part A; Standard 1.4)

Made under subsection 58(1) of the **Tertiary Education Quality and Standards Agency Act 2011** (TEQSA Act 2011).

Developing ‘standards’…

- The Learning & Teaching Academic Standards (LTAS) project was established in 2009 by the Australian Learning and Teaching Council (ALTC) to facilitate and coordinate the definition and implementation of **academic standards** by academic communities.
- In the Science LTAS Project, development of overarching Threshold Learning Outcomes (TLOs) for bachelor degree graduates was the target.

The Science TLOs

Learning and Teaching Academic Standards Statement (2011).

	Upon completion of a bachelor degree in science, graduates will:
Understanding science	1. Demonstrate a coherent understanding of science by: 1.1 articulating the methods of science and explaining why current scientific knowledge is both contestable and testable by further inquiry 1.2 explaining the role and relevance of science in society.
Scientific knowledge	2. Exhibit depth and breadth of scientific knowledge by: 2.1 demonstrating well-developed knowledge in at least one disciplinary area 2.2 demonstrating knowledge in at least one other disciplinary area.
Inquiry and problem solving	3. Critically analyse and solve scientific problems by: 3.1 gathering, synthesising and critically evaluating information from a range of source 3.2 designing and planning an investigation 3.3 selecting and applying practical and/or theoretical techniques or tools in order to conduct an investigation 3.4 collecting, accurately recording, interpreting and drawing conclusions from scientific data.
Communication	4. Be effective communicators of science by: 4.1 communicating scientific results, information, or arguments, to a range of audiences, for a range of purposes, and using a variety of modes.
Personal and professional responsibility	5. Be accountable for their own learning and scientific work by: 5.1 being independent and self-directed learners 5.2 working effectively, responsibly and safely in an individual or team context 5.3 demonstrating knowledge of the regulatory frameworks relevant to their disciplinary area and personally practising ethical conduct.

Chemistry TLOs

Upon completion of a bachelor degree with a major in chemistry, graduates will be able to:

Understanding the culture of chemistry	1. *Understand ways of scientific thinking by:* 1. recognising the creative endeavour involved in acquiring knowledge, and the testable and contestable nature of the principles of chemistry 2. recognising that chemistry plays an essential role in society and underpins many industrial, technological and medical advances 3. understanding and being able to articulate aspects of the place and importance of chemistry in the local and global community
Scientific knowledge	2. *Exhibit depth and breadth of chemistry knowledge by:* 1. demonstrating a knowledge of, and applying the principles and concepts of chemistry 2. recognising that chemistry is a broad discipline that impacts on, and is influenced by, other scientific fields
Inquiry, problem solving and critical thinking	3. *Investigate and solve qualitative and quantitative problems in the chemical sciences by:* 1. synthesising and evaluating information from a range of sources, including traditional and emerging information technologies and methods 2. formulating hypotheses, proposals and predictions and designing and undertaking experiments 3. applying recognised methods and appropriate practical techniques and tools, and being able to adapt these techniques when necessary 4. collecting, recording and interpreting data and incorporating qualitative and quantitative evidence into scientifically defensible arguments 5. demonstrating the cooperativity and effectiveness of working in a team environment
Communication	4. *Communicate chemical knowledge by:* 1. presenting information, articulating arguments and conclusions, in a variety of modes, to diverse audiences, and for a range of purposes 2. appropriately documenting the essential details of procedures undertaken, key observations, results and conclusions
Personal and social responsibility	5. *Take personal, professional and social responsibility by:* 1. demonstrating a capacity for self-directed learning 2. demonstrating a capacity for working responsibly and safely 3. recognising the relevant and required ethical conduct and behaviour within which chemistry is practised

TLO 2: Exhibit depth and breadth of chemistry knowledge by:

2.1 demonstrating a knowledge of, and applying the principles and concepts of chemistry

- 2.1.1 Stoichiometry, structure and characteristic properties of chemical substances
- 2.1.2 Methods of structure determination
- 2.1.3 Properties of matter in relation to structure
- 2.1.4 Chemical thermodynamics, equilibrium and kinetics
- 2.1.5 Reaction processes and syntheses which can transform substances into very different products
- 2.1.6 Reactions of metal and non-metal compounds including carbon compounds
- 2.1.7 Quantifying concentrations of elements and compounds in simple and complex mixtures

TLO 2: Exhibit depth and breadth of chemistry knowledge by:

2.1.4 Chemical thermodynamics, equilibrium and kinetics

i. Different chemical species have different energies. Most chemical changes are accompanied by a net change of energy of the system.
ii. Energy is conserved in chemical changes: breaking chemical bonds requires energy; formation of chemical bonds releases energy.
iii. Spontaneity of a chemical change is determined by a balance between energy change, available energy and entropy change.
iv. Starting and finishing states are independent of path, and may be predicted.
v. All chemical changes are, in principle, reversible; chemical processes often reach a state of dynamic equilibrium.
vi. Thermodynamics provides a detailed capacity to understand energy change at the macroscopic level and to understand equilibrium systems quantitatively.
vii. Chemical change occurs as a function of time over a wide range of time scales.
viii. Most chemical reactions take place by a series of more elementary reactions, called the reaction mechanism.
ix. The products obtained from a chemical reaction can be influenced by controlling whether reaction rate or reaction energy plays the key role in the mechanism.

Assessing the Assessments

- OLT Grant (ID14-3652)
  - Assessing the assessments: Evidencing and benchmarking student learning outcomes in chemistry
- Develop catalogue of exemplary assessment items
- Develop self-assessment tool for academics at Australian universities

Australian Government | Office for Learning & Teaching

The ‘Calibration’ Process

- The aim of this process is two-fold:
  1. To evaluate whether the assessment task allows students to demonstrate engagement with the indicated TLO(s)
     This is carried out individually then collaboratively
  2. To evaluate to what extend ‘pass grade’ student work demonstrates that the required standard has been met
     This is carried out individually then collaboratively

- It is very important that the evaluations are carried out individually before collaborative discussion (the idea is to build a mutual understanding of the standards)

Using the Knowledge/Process matrix

For each of the assessment item components, identify the 'scope & complexity' of the task by identifying the appropriate Knowledge & Cognitive Process aspects of the task. If possible, also map the intended TLO(s) for assessment item components.

	COGNITIVE PROCESS DIMENSION					
KNOWLEDGE DIMENSION	**1. Remember**	**2. Understand**	**3. Apply**	**4. Analyse**	**5. Evaluate**	**6. Create**
A. Factual						
B. Conceptual						
C. Procedural						
D. Metacognitive						

'A Taxonomy for Learning, Teaching and Assessing' (LW Anderson & DR Krathwohl Eds.; 2001, Longman)

Task Evaluation

Goal:

Evaluate the assessment task in terms of its ability to allow students to independently and rigorously demonstrate achievement of the indicated TLOs.

To achieve this we use a two step process:

1. **Engagement**

   To what extent does the task design allow students to engage with the TLO?

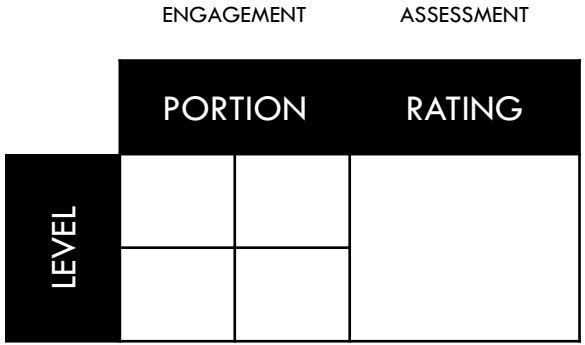
2. **Assessment (of the assessment)**

   To what extent is the relevant part of the TLO assessed?

Task Evaluation

- The evaluation for each TLO is split into two components
  1. an “engagement” classification; and
  2. an “assessment” rating.

The grid to the left is shaded to appropriately reflect the extent to which the task allows **engagement** with the TLO



The box to the right is used to report an **assessment** rating of 1, 2 or 3 as appropriate

Task Evaluation: Engagement

The engagement 'decision matrix':

		PORTION	
		partial	whole
LEVEL	graduate		
	developing		

Possible decisions:

All of the TLO to graduate level

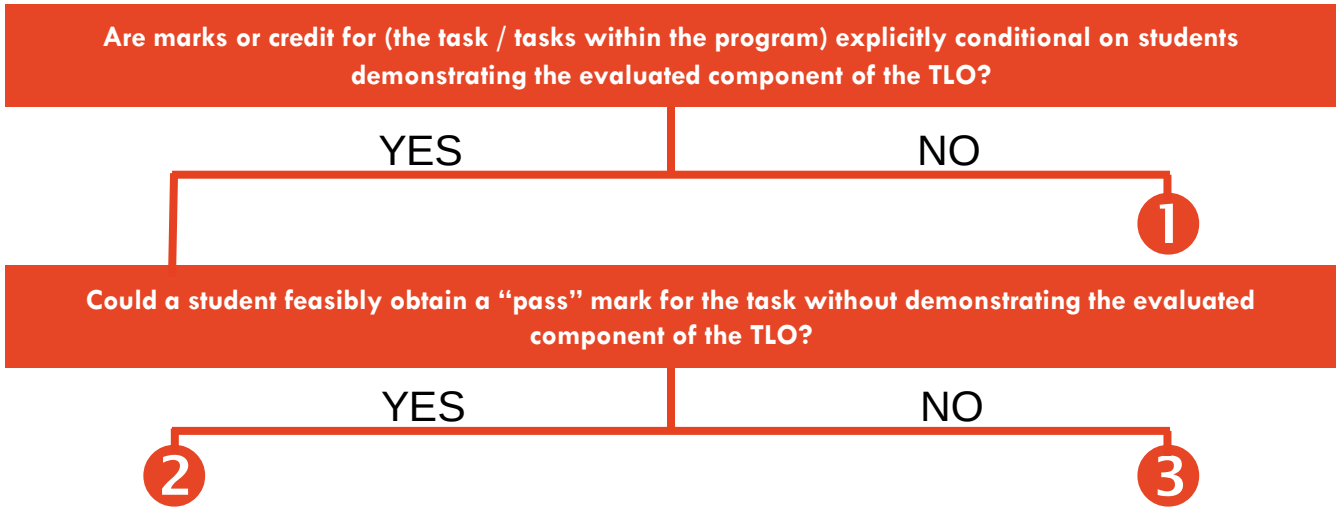
Part of the TLO to graduate level

All of the TLO but not to graduate level

Part of the TLO but not to graduate level

None of the TLO

Task Evaluation: Assessment



ASSESSMENT RATING	
1	The task allows some engagement with the TLO, but the TLO is not assessed
2	The relevant portion of the TLO is assessed within the task, but not sufficiently
3	The TLO has been sufficiently assessed

Future Work & Conclusions

- Not all TLOs assessed equally!
- How many TLOs can reasonably be met in one assessment task?
- How do we know when a student has ‘achieved’ a TLO?
- How many times does a TLO need to be ‘achieved’ so that we have confidence in the student’s capabilities?

OLT Project Team

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