Initial report on the TLO Mapping Exercise of Chemistry at Australian Universities

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In 2010 the ALTC (now the Office for Learning and Teaching) launched the Learning and Teaching Academic Standards (LTAS) project, to identify and document a set of threshold (minimum) learning outcome (TLO) statements for undergraduate science degrees. The LTAS project is led by two University of Tasmania academics, zoologist Professor Sue Jones and chemist Professor Brian Yates.

In early 2011, the LTAS Chemistry Working Group agreed a set of chemistry-specific TLOs. When the Chemistry Discipline Network (ChemNet) was established by the ALTC toward the end of that year, it was set the task of working toward the implementation of these standards in university chemistry departments nationwide.

A ChemNet TLO working group, chaired by Professor Brian Yates, was formed in order to address this task. The group was initially charged with assessing how effectively current university chemistry degrees meet the TLO standards, and collecting examplars showing how each TLO could be taught and assessed.

As a first step, the first year chemistry units at six universities were assessed in order to examine how well they currently meet the TLO standards:

- Macquarie University
- Monash University
- Queensland University of Technology
- University of Tasmania
- University of Western Australia
- University of Wollongong

Each first year unit contributing to the chemistry major was mapped against the TLOs.

Results and discussion

1. Core chemistry units

In order to assess how well the TLOs were being met, the content outline for each unit was collected, along with other teaching and assessment materials such as lab manuals and sample exam questions.

The table below lists the chemistry TLOs, and is colour-coded to show the TLOs being met at all (green), some (orange) and none (red) of the first year chemistry units mapped as part of the initial pilot project:

TLO 1. Understanding the culture of chemistry	***Understand ways of scientific thinking by:***	1.1 demonstrating a knowledge of, and applying the principles and concepts of, chemistry
		1.2 recognising that chemistry is a broad discipline that impacts on, and is influenced by, other scientific fields
		1.3 recognising that chemistry plays an essential role in society and underpins many industrial, technological and medical advances
		1.4 recognising the creative endeavour involved in acquiring knowledge, and the testable and contestable nature of the principles of chemistry
TLO 2. Inquiry, problem solving and critical thinking	***Investigate and solve qualitative and quantitative problems in the chemical sciences, both individually and in teams, by:***	2.1 formulating hypotheses, proposals and predictions; designing and undertaking experiments in a safe and responsible manner
		2.2 applying recognised methods and appropriate practical techniques and tools, and being able to adapt these techniques when necessary
		2.3 collecting, recording and interpreting data and incorporating qualitative and quantitative evidence into scientifically defensible arguments
		2.4 synthesising and evaluating information from a range of sources, including traditional and emerging information technologies and methods
TLO 3. Communication	***Communicate chemical knowledge by:***	3.1 appropriately documenting the essential details of procedures taken, key observations, results and conclusions
		3.2 presenting information, articulating arguments and conclusions, in a variety of

		modes, to diverse audiences, and for a range of purposes
TLO 4. Personal and social responsibility	***Take personal, professional and social responsibility by:***	4.1 recognising the relevant and required ethical conduct and behaviour within which chemistry is practised
		4.2 demonstrating a capacity for self-directed learning
		4.3 demonstrating a capacity for working responsibly and safely
		4.4 understanding and being able to articulate aspects of the place and importance of chemistry in the local and global community

Broadly speaking, there was a striking similarity between all units mapped in terms of the TLOs being taught and assessed in the first year of a chemistry major.

As would be expected for first year units, the TLOs being taught and assessed were all judged to be being met at introductory or intermediate level, rather than at graduate level.

The greatest variation was seen for TLO 1.2 and 1.3. Certain universities included topics such the chemistry of DNA and other biomolecules, and the chemistry of industrially significant chemical reactions such as the Haber process. Inclusion of such topics was interpreted as meeting TLO 1.2 and 1.3, although it is perhaps arguable whether or not students absorb the underlying message that chemistry impacts on, and is influenced by, other scientific fields and plays an essential role in society.

For the TLOs judged not to be being taught or assessed at first year, some would be expected to be incorporated in later years of a degree, such as TLO 4.2. Others, such as TLO 1.4 and 4.4, might not be addressed at all in current degree programmes at many institutions.

2. Breadth units

In addition to the core chemistry units, four of the six universities involved in the mapping study require their first year chemistry students to take non-chemistry 'breadth' units. These units range from short, non-credit online training modules on risk management, to full credit units covering maths for scientists or the philosophy of science.

When mapped against the chemistry TLOs, these units broadened the number of TLOs being met at first year at three of the four universities at which they are taught. In particular, TLO 1.4 and TLO 4.2 can be added to the list TLOs being taught and assessed at first year, changing the table as follows:

TLO 1. Understanding the culture of chemistry	***Understand ways of scientific thinking by:***	1.1 demonstrating a knowledge of, and applying the principles and concepts of, chemistry
		1.2 recognising that chemistry is a broad discipline that impacts on, and is influenced by, other scientific fields
		1.3 recognising that chemistry plays an essential role in society and underpins many industrial, technological and medical advances
		1.4 recognising the creative endeavour involved in acquiring knowledge, and the testable and contestable nature of the principles of chemistry
TLO 2. Inquiry, problem solving and critical thinking	***Investigate and solve qualitative and quantitative problems in the chemical sciences, both individually and in teams, by:***	2.1 formulating hypotheses, proposals and predictions; designing and undertaking experiments in a safe and responsible manner
		2.2 applying recognised methods and appropriate practical techniques and tools, and being able to adapt these techniques when necessary
		2.3 collecting, recording and interpreting data and incorporating qualitative and quantitative evidence into scientifically defensible arguments
		2.4 synthesising and evaluating information from a range of sources, including traditional and emerging information technologies and methods
TLO 3. Communication	***Communicate chemical knowledge by:***	3.1 appropriately documenting the essential details of procedures taken, key observations, results and conclusions
		3.2 presenting information, articulating arguments and conclusions, in a variety of modes, to diverse audiences, and for a range of purposes
TLO 4. Personal and social responsibility	***Take personal, professional and social responsibility by:***	4.1 recognising the relevant and required ethical conduct and behaviour within which chemistry is practised
		4.2 demonstrating a capacity for self-directed learning
		4.3 demonstrating a capacity for working responsibly and safely

		4.4 understanding and being able to articulate aspects of the place and importance of chemistry in the local and global community

These results confirm that it will be important to include breadth units when considering whether a chemistry degree fulfils all TLOs over the course of the three year program.

Next steps

Having successfully completed the initial pilot phase of the mapping project, the TLO working group is currently expanding the mapping process to include the second and third year chemistry units taught at participating universities. This process should reveal whether TLOs are generally being met to graduate level over the course of a chemistry degree.

Ultimately, the entire chemistry major at one university will be assessed to examine whether all TLOs are being met, or whether some TLOs are currently being missed.

At the same time, alongside the mapping process, exemplars illustrating how each TLO can be taught and assessed are being collected, in order to form a resource to which chemistry departments around the country might refer.

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