Report on a Mapping Exercise of Chemistry at Australian Universities

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The mapping exercise aimed to profile the current teaching of undergraduate chemistry around Australia, as a snapshot of 2011. We were interested in the content taught as well as delivery and assessment methods.

This report is based on responses from twelve universities:

- Charles Sturt University
- Curtin University
- LaTrobe University
- Melbourne University
- Monash University
- Queensland University of Technology
- University of New England
- University of Queensland
- University of Sydney
- University of Tasmania
- University of Western Australia
- University of Wollongong

The information gathered for each unit, including service teaching of chemistry, covered the following parameters:

- Title, brief content description, assigned textbooks, prerequisite requirements;
- Breakdown: percentage of content in the categories of organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry, biochemistry and general chemistry;
- Delivery: lecture, tutorial, field trip and practical contact hours; internal or external students;
- Assessment: percentage of assessment allocated to examinations, practical reports, assignments and presentations; form of practical report; percentage of total assessment conducted in groups, by multiple choice examinations and on-line;

- The approximate number of students.

The data has been collected into spreadsheets for analysis. Some of the results of the mapping exercise appear in this report. Further analyses can be conducted if you have a specific query, or if you would like your institution included in the next exercise (likely 2014). Please contact us on madeleine.schultz@qut.edu.au

Results

1. Content

In first year chemistry units that are part of the chemistry major at each institution, the breakdown of the subdisciplines is as follows:

	% Organic	% Inorganic	% Physical	% Analytical	% Biochem	general chemistry
mean	27	13	36	5	1	19
range	8-35	0-29	25-50	0-25	0-7.5	0-42

These units are typically very large (from 200 - 1300 students) and include service teaching into other degrees. Note that in many cases, the responses indicated that it was difficult to perform this breakdown into the traditional five subdisciplines, so the heading "general chemistry" was included. Different respondents have likely interpreted "general chemistry" differently, leading to the large variation.

In the second year of the degree, the breakdown is more even, as follows; note that only one institution has biochemistry at all in the major.

	% Organic	% Inorganic	% Physical	% Analytical	% Biochem
mean	26	18	25	27	1.5
range	20-37	13-25	0-38	7-44	0-15

In the third year of the degree, students often have a greater choice over the breakdown of subdisciplines that they study, with some universities offering only a selection of elective units at third year. Of the universities that do include core units in the third year of a chemistry major, the breakdown is as follows:

	% Organic	% Inorganic	% Physical	% Analytical	% Biochem
mean	34	25	23	18	0
range	25-70	20-33	0-33	0-25	0

Across the three years, it can be seen that Australian chemistry degrees are weighted to organic chemistry, with physical chemistry second most heavily weighted. Analytical and inorganic chemistry are given less emphasis.

Biochemistry is not included in a typical Australian chemistry major. It is taught at 60% of institutions to third level as a minor or elective.

Environmental chemistry is taught at 75% of institutions (in combination with atmospheric, aquatic and/or analytical chemistry), but only 25% teach sustainable chemistry or green chemistry specifically. These units are not in the major but are elective, third year units.

Minors and elective units vary according to the subdiscipline emphasis of the institution, and include nanotechnology or nanoscience, forensic science, industrial chemistry, bioinformatics, medicinal chemistry, materials chemistry and food chemistry.

2. Delivery

Contact hours vary significantly between institutions. In first year chemistry units that are part of the chemistry major at each institution, the breakdown of contact hours is as follows:

	total lecture hours	total tutorial/workshop/ PASS hours	total practical hours	total contact hours
mean	76	25	44	145
range	72-91	0-52	30-54	112-178

We asked respondents to include only hours with a paid instructor (staff or student) in tutorial and workshop hours.

In second year, there is even more variation, with over 100% difference between the longest and shortest institution in total contact hours:

	total lecture hours	total tutorial/workshop/ PASS hours	total practical hours	total contact hours
mean	99	27	116	242
range	78-143	0-49	63-192	154-336

In third year, the variation is similar to second year. Note that this arises in part due to the number of elective units that can be taken during final year, depending on the degree structure.

	total lecture hours	total tutorial/workshop/ PASS hours	total practical hours	total contact hours
mean	100	21	145	267
range	36-144	0-57	72-276	122-360

In the context of practical hours, it should be noted that the previous RACI accreditation process required a minimum of 50 practical hours at first year, 100 at second year and 200 at third year. Less than half of the institutions satsify this

with units in the chemistry major only. The RACI is moving to an outcomes-based accreditation process, so the numerical values will no longer be as important from 2013.

Unlike the structure in the United States, Australian institutions include both theory and practical in every unit, with the exception of research projects and distance education (where lectures are replaced with recordings, and practicals are conducted as a residential block).

Field trips are offered by 25% of institutions at some point in the degree programme, but always as part of an elective unit rather than a core component of the major. This seems a low proportion, given the importance of the chemical industries in Australia.

The structure of first year chemistry varies somewhat – 58% institutions offer only one main chemistry subject per semester to all incoming students who require chemistry, including chemistry majors. 42% of institutions have a separate chemistry for health sciences or engineers, taught as a service only unit. Only 8% institutions have a separate chemistry for chemistry majors in addition to the other separate units. In addition, 75% of institutions have a foundations of chemistry unit for students who have not completed chemistry at high school, which is required before the students can enrol in the main unit, but 25% include these students in the main unit.

Student numbers drop significantly at every institution from first year (including service teaching) to second year, by around 80%; this is not surprising and reflects the number of chemistry majors. More surprisingly, the number of students in third year chemistry drops again from second year, on average by another 50%.

Of the institutions in the snapshot, four had clickers available for in-class polling. At two those institutions, all staff involved used them for teaching first year chemistry, at the other two, less than a quarter of staff use them. They are not used beyond first year at any institution.

3. Assessment

In chemistry units that are part of the chemistry major at each institution, the breakdown of assessment is as follows:

	practical %	assignment/ workshop /tutorial %	mid semester exam(s)	presentations (poster/oral/ vlog)	final exam
mean	28.2	15.6	4.3	1.8	50.3
range	20.6-34.3	2.3-40.8	0-25	0-5.4	32.7-70.2

In the first year, assessment by multiple choice is 35% (mean); the range is 15-49%. In second year and third year, only four institutions use any MC assessment for any units, with 15% as the maximum in second year and 7% in third year.

On-line assessment is now used by around half of the institutions in the first year, for up to 50% of the total assessment. It is used by 25% of institutions in later years of the degree. This total is likely to grow, particularly for large, first year classes.

Presentations are only used by one institution as part of the assessment in the chemistry major. However, another four do assess a presentation in a minor unit.

Team or group work is used as part of the assessment in four institutions within the chemistry major, and at another two institutions in elective chemistry units. In the institutions that use it, it constitutes up to 45% of the assessment of some units.

Discussion

Given the current focus on threshold learning outcomes and graduate attributes, it is disturbing that such a high percentage of assessment is still through examinations, and such a low percentage involves oral and group work presentations (none at most institutions in this study). It cannot be assumed that the learning outcomes will be covered in elective or minor units; these skills must be included in the major if all chemistry graduates are to have them.

The importance of practicals in the teaching of chemistry cannot be underestimated and it is heartening to see that most institutions still have significant practical hours and assessment. In the first year, the number of hours spent in the laboratory, and the proportion of assessment for practicals as a proportion of total assessment are much lower (presumably due to the costs of running these classes for service units).

In interpreting these results, it must be kept in mind that this report is based on a snapshot of 2011 teaching. Several of the institutions involved were in the midst of curriculum review, so the results are likely already somewhat out of date. A repeat snapshot is planned for 2014.

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