The signature pedagogy in chemistry education (Note †)

Laboratories are the signature pedagogy in chemistry education. The chemical sciences are based in investigations that are reproducible, and objectively testable. Some investigations might involve testing a hypothesis – does a carbonate produce carbon dioxide gas when reacted with acid? Other activities may not have an obvious hypothesis[2] – how much salt is in this detergent package? Nevertheless, laboratory work is a distinctive part of science generally, and of chemistry in particular.[3-7]

Computer simulations, dry labs, and workshops are some alternatives to learning in the laboratory, but these other activities cannot replicate the full experience of laboratory work. For example, they cannot replicate the development of manipulative skills required to use glassware, like the fine motor skills needed to adjust a burette tap to a very slow drip, or lifting just one minute crystal on the tip of a spatula, or folding a fluted filter paper for filtration. Although we try to have reproducible results, this is not always the case in school or undergraduate laboratory work: stock bottles get contaminated; the incorrect amount of reagent is used; an essential step is omitted; the temperature is too low because the students keep opening the oven door; unexpected things happen. Computer simulations and textbook pictures are exemplars of what should happen and how things should look; they give little indication of the variability of observations, or the sometimes-subtle differences between a positive and negative outcome. Computer simulations and textbook pictures do not teach what reality can look like.

Hands-on investigations enable students to learn by doing. When my son was 3 years old, Jonathan declared that he could drive the car – after all, from the safety of his child seat, he could see the driver's hand and foot movements! But practice is more then just watching, or listening, or reading. If learning was as that simple, then we would all be trapeze artists, Masterchefs and expert house renovators, just by watching reality-TV!

Laboratory work is a significant part of working in the chemistry profession. The *Australian Curriculum: Science*[8] has Science as a Human Endeavour (SHE) as one of its three strands. Some of SHE looks at the day-to-day work of scientists, including chemists. Not just the revolutionary discoveries that go in the history books, but the human aspect of just going to the workplace as a scientist – our everyday activities, including laboratory work. The best way for students to learn what scientists do, is to do what scientists do.

Science Inquiry Skills (SIS) is another of the three strands in the *Australian Curriculum: Science*.[8] SIS includes non-laboratory skills like research, communication, analysis and interpretation of data. However, a significant part of SIS is designing and conducting laboratory investigations, including: the procedure to be followed; the materials required; using equipment and techniques safely, competently and methodically; risk assessments; and considering research ethics. The only way to conduct a laboratory investigation is to get into a laboratory and to do it!

In summary, laboratory work may not the only part of our discipline practice, but it is definitely a distinctive and significant part of chemistry.[3-7] In these days of cost-cutting and virtual reality, we must profess again[9] that learning and doing chemistry in a laboratory is an important and irreplaceable part of a chemistry education.

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1 K. F. Lim, “Threshold learning outcomes”, *Chem. Aust.,* 2013, **2013 (March)**, 35.
2 S. Jones, B. Yates and J.-A. Kelder, *Science: Learning and Teaching Academic Standards Statement*, Australian Learning and Teaching Council, Strawberry Hills (NSW), 2011 <http://www.altc.edu.au/standards/disciplines/science%3E.
3 M. Schultz and J. M. Crow, “Networks: Networking for the next generation”, *Chem. Aust.,* 2012, **2012 (February)**, 38.
4 M. A. Buntine, “From the President”, *Chem. Aust.*, 2013, **2013 (March)**, 28.

1 K. F. Lim, “Threshold learning outcomes”, *Chem. Aust.,* 2013, **2013 (March)**, 35.
2 K. F. Lim, “Teaching the scientific method in the curriculum”, *Chem. Aust.,* 2012, **2012 (April)**, 39.
3 M. R. Abraham, "What can be learned from laboratory activities? Revisiting 32 years of research", *J. Chem. Educ.,* 2011, **88**, 1020–1025 <http://pubs.acs.org/doi/abs/10.1021/ed100774d%3E.
4 L. B. Bruck, M. Towns and S. L. Bretz, "Faculty perspectives of undergraduate chemistry laboratory: Goals and obstacles to success", *J. Chem. Educ.,* 2010, **87**, 1416–1424 <http://pubs.acs.org/doi/abs/10.1021/ed900002d%3E.
5 A. H. Johnstone and A. Al-Shuaili, "Learning in the laboratory: some thoughts from the literature", *Univ. Chem. Educ.,* 2001, **5**, 42-51 <http://www.rsc.org/pdf/uchemed/papers/2001/p8_johnstone.pdf%3E.
6 C. Hart, P. Mulhall, A. Berry, J. Loughran and R. Gunstone, "What is the purpose of this experiment? Or can students learn something from doing experiments?", *J. Res. Sci. Teach.,* 2000, **37**, 655-675.
7 R. T. White, "The link between the laboratory and learning", *Int. J. Sci. Educ.,* 1996, **18**, 761-774.
8 ACARA, Australian Curriculum, Assessment and Reporting Authority (ACARA), *Australian Curriculum: Science (F-10),* <http://www.australiancurriculum.edu.au/Science/Curriculum/F-10%3E, 2011 (accessed April 2011).
9 H. A. Rowland, "The Physical Laboratory in Modern Education", *Science,* 1886, **7**, 573-575.

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