The Dance of Science and Mathematics in Higher Education: the Quantitative Skills (QS) in Science Project

By Kelly E Matthews

Every discipline has a shared history, usually stories of influential people or defining pieces of work. In the Life Sciences, Darwin would be one of the key shapers of the discipline with *The Origin of Species* being an example that shifted the field from infancy into childhood. Perhaps we could think of his work as a necessary step in science, just as crawling precedes walking. Despite the profound impact of his work, Darwin considered himself deficient in mathematics and felt this affected his practice as a scientist. In his day, mathematics was well established as a distinct discipline dating back to the Greeks, with Euclid in particular documenting and naming the discipline. While science was learning to crawl, mathematics was already running and dancing. In the past two decades science has been learning to run, catalysed by advancements in technology, which have resulted in our ability to collect data in ways not imaginable to Darwin. In today's world, science and mathematics are obviously interconnected with science finally learning to dance with mathematics as its partner.

Gone are the days of Darwin. The big questions facing society (climate change, genomics, poverty, human health), the avalanche of data available and the wealth of scientific knowledge, represent profound shifts leading to new ways of doing science. For example in conservation biology, the impact of over-fishing has been enhanced immeasurably by the ability to model populations using mathematics. Much of this work has gone in to the formulation of marine protected areas on the Great Barrier Reef. As we look to the future, science will increasingly rely on mathematics. The implications for how we teach science are equally as profound. The science Higher Education community is only recently coming to grips with the rapidly changing nature of modern science and need to become leaders in how these changes in science are translated into how we teach the future generation of scientists. There is little doubt that science students will need greater levels of quantitative skills (QS), that is, the ability to apply mathematical and statistical thinking and reasoning in science.

In a recent workshop of 20 scientists from diverse fields teaching in the undergraduate science program, we focused on a single question: what quantitative skills are we teaching our students? What we learned is that many felt as Darwin did, deficient in mathematics, while recognising its essential nature for being a modern scientist. The consensus that came from deliberations was that students today require ever more sophisticated levels of QS to be competent in the world of modern science. It was also apparent that we need to continue working on how QS are articulated to students and staff, and work together to create better links across the units in first year and across year levels such that QS are systematically built across the majors in the program.

The *Quantitative Skills (QS) in Science* project seeks to address the challenge of embedding QS in undergraduate science programs, and brings together an impressive team representing core stakeholder groups including STA (previously FASTS), ICMI, MERGA, HERDSA and ACDS. Acronyms aside, the message is that key academic and professional organisations acknowledge the importance of QS in science, recognising the issue represents a national and international challenge facing undergraduate science programs. Our project team argues that the movement to transform science education, to reflect the interdisciplinary and quantitative nature of modern science, requires a "whole of program" approach with QS as an essential component of any undergraduate science curriculum. However, institutions continue to struggle to integrate QS across undergraduate science programs. Workshops, like the one described above, fit into a range of strategies we have undertaken in the past year to contribute to our ultimate goal of enhancing student learning outcomes in the sciences.

Our website at www.qsinscience.com.au offers a concise overview of our project aims, outcomes and activities. Our focus is at the program-level, exploring and sharing information on how science undergraduate curricula are designed to include QS. We started by identifying Australian institutions at which QS had been identified as an outcome of the science degree program. Next, we contacted Associate Deans (Teaching and Learning) or equivalent in science and requested their agreement for us to visit them, to discuss QS with them and academic staff teaching into the science program. We received 100% agreement, indicating yet again the importance of this topic!

In presenting the project outcomes to date, we have adopted a case study approach, based on a model for educational change from the work of Michael Fullan (2007). The project has been underway for one year, and there are approximately 11 case studies on our website highlighting how Australian science curricula have been designed to build QS. In addition, we have selected two international universities as international comparative case studies.

Our findings thus far are exciting and promising. Of course, we are still creating case studies and analysing a wealth of interview data so conclusions will be teased out more thoughtfully as the project continues. However, some key emerging findings can be organised around two themes.

1. There is a growing movement around QS in science. The Australian science Higher Education community has QS on its radar and there is a range of activity occurring within individual institutions and at a national level. QS have been acknowledged broadly as an area requiring action. Nationally, the recently articulated *Threshold Learning Outcomes* for Science, endorsed by the Australian Council of Deans of Science, highlights the underpinning role of QS for science graduates. Many universities are articulating learning outcomes in science to drive curriculum development that implicitly and explicitly mention QS. A quick glance of our online case studies will highlight the diversity of curricular structures and approaches being implemented to build QS.

2. Evidencing QS in Science needs urgent attention. Our initial analysis from Australian case studies has identified a substantial gap in thinking about undergraduate science curricula. In the institutions participating in our study, only 10% of the focus on building QS in science was directed towards assessing or evaluating student learning of QS, either at a unit level or a program level. The implications are huge, given the recent creation of the Tertiary Education Quality and Standards Agency (TEQSA) with a keen focus on learning outcomes and how these are evidenced. In the coming year our project will present a case study with a robust QS in science assessment and evaluation strategy that includes data on both performance and student perception. Evidencing QS learning outcomes, given the vast array of curricular approaches we have documented in Australia, is an exciting opportunity to gather evidence on varying approaches and how they influence student learning. We hope to act as a catalyst for future projects, in the area of evidencing QS learning outcomes, as the work to build QS in science will extend far beyond our 2012 project completion date.

Moving into Year Two of the *QS in Science* project, we hope to further engage the Higher Education community to make a meaningful contribution to how science is considered and taught at the undergraduate level. Our team has planned several dissemination activities; here we would like to highlight two. The first centres around face to face events: our *QS in Science* symposium which will be held under the auspices of the Australian Council of Deans of Science in July 2012 and planned workshops at the Australian Conference of Science and Mathematics Education in September. For the second dissemination activity, we will seek academic articles for inclusion in a special edition of a journal on the topic of QS in science.

For science, as a discipline, to advance, practitioners will require increased mathematical competence. Our belief is that to prepare science graduates in the undergraduate learning environment, science and mathematics need reacquainting. Our project proposes QS as a core skill set that future scientist will require, which should then be explicitly threaded throughout the curriculum and evidenced to inform on-going curricular reforms. Our findings to date highlight the fact that universities in Australia are adapting a myriad of approaches and we must capitalise on the opportunity to gather evidence to inform the sector.

Visit our website, www.qsinscience.com.au, for more information. If you would like to keep up with the project activities and findings, email v.simbag@uq.edu.au to be added to our email list for our monthly *QS in Science* Update.

Reference

Fullan, M. (2007). The new meaning of educational change (4 ed.). New York: Teachers College Press.

The QS Project team: Kelly Matthews, Peter Adams, and Vilma Simbag – The University of Queensland;

Shaun Belward – James Cook University;

Carmel Coady and Leanne Rylands – University of Western Sydney;

Kaci Thompson – University of Maryland; Nancy Pelaez – Purdue University;

Mark Parry is a communications consultant with Parryville.com

Contact: k.matthews1@uq.edu.au