The End of an ALTC-OLT Project: Findings Point Toward New Projects

By The QS in Science Team

Mathematics underpins science. Increasingly, students struggle with weak mathematical knowledge and the ability to apply such knowledge in scientific contexts (AAAS - American Association for the Advancement of Science, 2011; Brown, 2009; Koenig, 2011; National Research Council, 2003). While the majority are in agreement that these quantitative skills (QS) are essential in science, academics are struggling to coordinate efforts to build such skills (Brakke, 2011; Koenig, 2011; Rylands, Simbag, Matthews, Coady, & Belward, accepted). Responding to this issue, the *QS in Science* project set out to explore current QS curricular pathways to further ongoing efforts to better infuse the science curricula with QS. From 2011–12 with funding from the Australian Learning and Teaching Council, the project was able to develop 13 case studies that outlined the critical pathways for developing QS across 12 institutions. These are accessible on the project website, www.qsinscience.com.au.

Now that the final report has been submitted, we ask ourselves, where to now? You can read an early version presented to the Australian Council of Deans of Science (Matthews, Belward, Coady, Rylands, & Simbag, 2012). Is the discussion over or it is really just beginning as Australian institutions become critically aware of the QS shortcomings of their science students? The *QS in Science* team believe that there is still a lot of work to be done, so we offer possible projects, which are designed to overcome many of the difficulties identified in the study. What did we find?

Findings confirmed and categorised the challenges facing the higher education sector in coordinating curricular efforts to develop science students' QS, efforts that cross traditional disciplinary and departmental boundaries. Our key findings are:

1. **Lack of shared meaning (common understanding) for QS**. Academics agreed that QS are an essential learning outcome for science graduates; however, evidence showed that academics possessed differing and often vague notions of what specific QS were needed. While many are working feverishly to "fix the QS" problem, our understanding of QS is not clear, nor is it shared among academic staff. The inherent interdisciplinary nature of QS, building on mathematical and statistical knowledge that is then applied in varying scientific contexts, further complicates arriving at a shared meaning of QS.
2. **Lack of communication about curricular issues across disciplines**. Organisational structures and processes for science and mathematics academics to discuss QS were not evident. Backed by the literature, our study affirms the structural, cultural and disciplinary divides that exist within universities, and that the "silo" mentality is common.
3. **Lack of connection between attributes, outcomes and standards**. Despite having national standards, institutional attributes and program-level graduate outcomes, the influence on curricular design to build QS was not evident beyond generic statements.
4. **Lack of curricular leadership for graduate learning outcomes**. Despite agreement that QS are an essential learning outcome, limited evidence was found of those in leadership roles taking responsibility for the achievement of QS as a learning outcome across degree programs. Further, there was no substantial evidence of existing, deliberate curricular design approaches in place at the 13 universities that we studied to build QS.
5. **Lack of evaluation and evidencing of QS curricular learning outcomes**. In Australia there was no evidence of science-specific, program-level evaluation activity for QS and with only one university (in the USA) among the 13 case studies having a well-developed evaluation program.
6. **Lack of QS reform efforts when organisational restructuring is occurring**. Where institutional restructures and redundancies ran in parallel with curricular review processes, academics were less inclined to address the QS issue.
7. **Lack of knowledge and adaption of QS educational resources**. Academics tended to develop their own QS resources, largely reacting to basic deficiencies in numeracy skills and duplicating existing resources unknowingly.
8. **Lack of clear QS curricular pathways due to diversity in student cohorts**. Catering for the mathematical diversity in student cohorts impacted on the design of science curricula with different institutions trying various methods to deal with a wide range of mathematical ability.

These findings are deliberately expressed in deficit terminology, as they are disconcerting findings that we should not deny. However, they also hold the clues for improving the QS of science students, when considered as gaps to be addressed. Thus the recommendations, listed below, specifically respond to the key findings by suggesting ways of moving forward.

1. **Formulation of a shared meaning for QS in science**. To facilitate this, effective fora to allow open discussion between mathematicians and statisticians, and discipline scientists must be provided.
2. **Development and maintenance of effective communication channels across and within disciplines**. An effectual mechanism for communication must be established and maintained so that discussion can continue as the need for QS in science evolves.
3. **Fostering of curricular leadership in QS**. This leadership needs to be at the forefront of the development of

whole-of-program approaches to QS in science.

4. **Development of an evaluation framework for QS**. This is essential so that individual institutions can determine how their curricula should change to meet the needs of the science community and the government's reporting requirements.
5. **Making QS a graduate outcome for any science degree program**. It is universally agreed that QS is an essential part of a science program. For students to graduate with QS in science, QS must be visible and assessed throughout every year of the degree program.
6. **Searching for strategies to deal with diverse student backgrounds, particularly those with poor QS.** Current strategies to address this issue include diagnostic testing and voluntary drop-in centres, but more effective solutions to this major challenge for academics must be found.
7. **Communicating in every way possible that science is quantitative.** All possible means must be used to inform students of the importance of QS in science and to make them understand, accept and appreciate QS by emphasising its relevance to science and their everyday lives.

In an effort to keep the momentum going, the *QS in Science* team has developed potential future projects, which we offer as guidance to the sector as others endeavour to build on the *QS in Science* project recommendations. We invite anyone concerned with the current state of QS or the achievement of learning outcomes in science more broadly to lead a future project. The *QS in Science* project team members offer our support, encouragement, knowledge, advice and even partnership. Follow-on QS project ideas include:

1. **Acquiring a shared meaning of QS**

   Project name: Translating what quantitative skills are needed for science graduates

   Project aim: This project aims to engage mathematicians, statisticians and life scientists in conversations and activities to articulate, define and converge on a shared understanding of what QS actually are, the relationship between QS as perceived by mathematicians and statisticians, and QS as perceived by life scientists.

2. **Identifying and bridging the QS gap from secondary school mathematics to university**

   Project name: Transition: QS from secondary school to first year university

   Project aim: This project aims to address issues concerning QS in secondary school and how well this prepares students for first year university science. Answers to questions such as: "What QS were acquired in secondary school?", "Are these QS enough to cope with what is required in first year?", and "How do universities build on these acquired QS?" will be documented.

3. **Evaluating assessment activities across the year levels**

   Project name: Assessment of QS learning in science

   Project aim: This project aims to focus on evaluation of assessment activities designed to measure students' QS in a science program, as well as how QS are built across the year levels.

4. **Evaluating QS as a program-level learning outcome in science**

   Project name: QS assessment in science: Engaging academics in developing, assessing and interpreting data on program-level learning outcomes

   Project aim: This project aims to bring together academics to develop a program-level assessment framework for QS in the sciences, to pilot the evaluation framework and to interpret results though benchmarking. Further, the project aims to engage academics in the collection of data that are reliable and useable as a means to influence curriculum development and teaching practices.

5. **Applying the *QS in Science* approach to exploring other program-level learning outcomes**

   Project name: Writing Skills in Science: Curriculum models for the future

   Project aim: Writing Skills (WS) have been identified as essential for science graduates; however, the teaching and assessing of writing within the undergraduate science curricula are presenting numerous challenges. Adopting the successful *QS in Science* project methodology, this project seeks to engage academics in a process of identifying curricular "critical pathways" that build the WS of science students, which can then be shared across the sector.

Are ALTC-OLT projects ever really done? The issues we are addressing are complex and ongoing with few simply, off the shelf solutions available. They require engagement, effort, time and coordinated efforts from numerous stakeholders. Our project attempted to actively engage academics and to disseminate our findings in a timely manner using face-to-face interviews, presentations, online media including our website at www.qsinscience.com.au, short videos, regular email newsletters, and published reports and articles (several forth-coming). Importantly, so that others could easily build on the knowledge and resources we gained, we endeavoured to make all our findings publically accessible via case studies, reports and publications (again, on our website). In 2013, a special edition dedicated to QS will be published in the highly rated *International Journal of Mathematical Education in Science and Technology.*

In conclusion, the *QS in Science* team have set the scene and continued the momentum of the 2006 joint associate fellowship of Adams and Poronnik, *Embedding quantitative principles in life science education*. QS are on the minds of many academics teaching science students. Despite this, it is clear there is still much work to do. Our team members continue to be active in several related projects collaborating with colleagues in Australia and overseas to build on what has been started. We look forward to expanded collaborations and making inroads into the challenges QS in science present.

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