Response to the Australian Government's Consultation Paper: *Vision for a Science Nation. Responding to Science, Technology, Engineering and Mathematics: Australia's Future*

Australia's Chief Scientist, Professor Ian Chubb, presented a major address at the 2014 Australian College of Educators annual conference, detailing the critical importance of STEM for Australia's future. The Australian College of Educators (ACE) acknowledges the importance of the Australian Government's consultation paper *Vision for a Science Nation,* and welcomes the opportunity to respond.

This response focuses on three of the Chief Scientist's recommendations related to the training of in-service and pre-service teachers and the nature of this training, with particular emphasis on mathematics and science.

STEM in school education in Australia

Quality learning experiences for Australian students in mathematics and science, as the pillars of STEM, will increase self-efficacy, confidence and participation in these subjects at school and post school levels, with increased career opportunities in STEM-reliant industries.

A sustained STEM focus in Australia, over the long term, requires more than "simply igniting a passion for STEM in our classrooms" (Ministers' foreword, *Vision for a Science Nation*). What is required are positive learning experiences in mathematics and science, provided by capable teachers. This will only be realised by raising the quality of teachers' professional capability in mathematics and science teaching "from primary to tertiary level" (*Vision*, p.7).

Training for in-service generalist primary teachers in mathematics and science

Many practicing primary teachers continue to struggle with the content and pedagogy of primary mathematics and science, resulting in compromised (low quality) learning opportunities for students. The solution to this challenge is not to import secondary teachers with expertise in mathematics and science, but to include a systematic focus on building capability and efficacy in primary mathematics and science for practising primary teachers. A coherent proposal for the training of in-service primary teachers in mathematics and science is absent in *Vision for a Science Nation.*

Part of a systematic approach to resolving this issue should include the mapping of national professional learning initiatives for in-service teachers in primary mathematics and primary science, with research proven outcomes in teacher efficacy in these initiatives. ACE is aware of a number of initiatives that have included a strong focus on teacher learning and build students' self-confidence in mathematical thinking. For example: *Extending Mathematical Understanding–EMU* (Gervasoni, 2010).

In relation to science, *Primary Connections* provides a valuable initial resource for primary teachers who may not have strong science backgrounds. However, teachers with greater confidence in science, or those wishing to use more open ended, non-prescriptive learning opportunities which foster creative thinking, will be looking beyond *Primary Connections*. The kind of training likely to have the most impact for in-service primary teachers is becoming clearer in science, with the following example of an effective model.

In the *MyScience* Educational Model, mentors with practical science knowledge and expertise work alongside students and the class teacher in a *community of science practice* (Forbes and Skamp, 2014). *MyScience* affords the kind of science learning that allows scope for creativity and inquiry-based learning—more like science is practised. (*For a brief summary of the findings related to primary teachers, see the references section at the end of this paper.)*

An additional pathway would be for universities to offer postgraduate specialised qualifications for practising (qualified) primary teachers, such as a Graduate Certificate of Education in Primary Science education or in Primary Mathematics Education, which could articulate into a Masters degree. This would provide pathways to raise the quality of primary teachers' professional capability in mathematics and science teaching, resulting in a recognised tertiary qualification.

Pre-service training for generalist primary teachers in mathematics and science

Given the importance of teacher capability in primary mathematics and in primary science, a long-term goal should be that every Australian primary school has at least one teacher with a mathematics specialisation *and* one teacher with a science specialization—so that "their expertise will be available in the school to assist other teachers with the knowledge and expertise to teach the subject effectively" (*Action Now: Classroom Ready Teachers*, 2015, p. 8).

To enable this, pre-service primary teachers should be provided with specialisation pathways in *both* mathematics *and* science, among other options, within a Primary Education degree: a position recommended by the Teacher Education Ministerial Advisory Group (*Action Now: Classroom Ready Teachers*, 2015, p. 8).

The nature of this training should equip pre-service primary teachers specialising in mathematics and/or science with both discipline knowledge and contemporary pedagogy.

The inclusion of mathematics and science as specialisation areas within Primary Education degrees—or as a post graduate degree—is likely to require adjustments to the offerings available within current programs. A scan of the websites of 32 Australian universities providing Primary Education indicated that only a minority made explicit mention of

specialisation options in STEM subjects, other than technology and numeracy as part of core learning. Of the 14 that did mention STEM, only a small number mentioned science, one mentioned primary science as a specialisation, one environmental education and one science education for sustainability.

Explicit inclusion and promotion of mathematics and science as part of the range of specialisation areas offered within Primary Education pre-service experiences would provide an appropriate and important response by providers to *Vision for a Science Nation*. For example, students could exit with a 'major' or 'Honours' in named discipline areas: science and /or mathematics.

Training for in-service and pre-service secondary teachers in mathematics and science

Earlier comments related to deepening mathematical and scientific understandings for primary teachers also apply to in-service and pre-service secondary mathematics and science teachers. They must possess deep discipline knowledge combined with contemporary pedagogical approaches.

In science, inquiry-based pedagogical approaches such as problem-based learning are emerging to challenge traditional teaching norms in the secondary science setting. The 'resilience' of traditional science teaching suggests that in-service and pre-service training for secondary science teachers must address the development of science discipline knowledge *in parallel with* contemporary pedagogy, with a focus on creativity and inquiry-based learning—more like science is practised (Recommendation 7, *Vision for a Science Nation, p. 7*). The mismatch between how science is taught and how science exists in the real world has been clearly identified by Tytler (2007), who describes ways to 're-imagine' science education to engage students in science for Australia's future. (*For a brief summary of Tytler's paper, see the references section at the end of this paper)*.

Out of field secondary teachers in mathematics and science

In-service training in contemporary pedagogy, in parallel with discipline knowledge, is particularly relevant for out of field teachers in STEM subjects. In *Vision for a Science Nation*, the Government's response notes that "currently some teachers without a background in STEM are teaching these subjects" (p. 10). Out of field teaching in secondary mathematics and science is not uncommon, and as with generalist primary teachers, will impact on teachers' confidence and capacity to fully "engage students and encourage curiosity and reflection and link classroom topics to the real world" (Vision, p.10).

Out of field teaching in some secondary mathematics courses and senior secondary subjects such as Physics and Chemistry is a significant issue for many schools in Australia, particularly in remote communities. A national STEM strategy should include comprehensive mapping of where such practices are occurring together with proposals developed in collaboration with school communities to provide support.

University mathematics, science, and educational faculties, and professional associations in mathematics and science are well placed to collaboratively provide both discipline and pedagogical knowledge for out of field secondary teachers. Proposals that streamline and coordinate training options for out of field secondary teachers would be welcomed by the profession.

References

Australian Government (2015). *Vision for a science nation, responding to science, technology, engineering and mathematics: Australia's future,* Consultation paper. Canberra, ACT: Commonwealth of Australia.
http://science.gov.au/scienceGov/news/Pages/HaveYourSayOnTheFutureOfScienceInAustralia.aspx

Australian Government Department of Education and Training (2015). Students *First*. *Action Now: Classroom Ready Teachers.* Teacher Education Ministerial Advisory Group, Australian Government Response.

Forbes, A., & Skamp, K. (2014). Because we weren't actually teaching them, we thought they weren't learning: primary teacher perspectives from the MyScience initiative. Research in Science Education, 44(1), 1–25. doi:10.1007/s11165-013-9367-9.

Forbes' and Skamp's paper details how primary teachers' views of science education were transformed by their involvement in a science education initiative called *MyScience.* Interactions between teachers, students and mentors resulted in communities of science practice (CoP) developing in classrooms, where participants learned from each other. Most participating teachers' significantly changed their perceptions about what it means to 'do' science in primary classrooms. Learning to do science as a member of a CoP widened teachers' perceptions of their role as a facilitator and how students learn in and about science. This came about through teachers stepping away from their traditional role, which then afforded students with alternative learning opportunities. These circumstances were so different to those traditionally experienced by teachers that their initial reaction was that students weren't learning anything because they weren't 'being taught'! The pedagogical implications for primary science are that teachers who engage with *MyScience* never teach science in the same way again– they adopt a more student-centered approach, which leads to deep student engagement and learning in science.

Gervasoni, A. (2010). Extending Mathematical Understanding: Intervention program specialist teacher manual (2nd Edition). Ballarat: Ballarat Heritage Services.

Tytler, R. (2007). Re-imagining science education: engaging students in science for Australia's future. Camberwell, VIC: Australian Council for Educational Research. Retrieved June, 2015 from www.acer.edu.au/documents/AER51_ReimaginingSciEdu.pdf.

Tytler's paper details how to 're-imagine' science education to engage students in science for Australia's future. He argues that traditional science education (the acquisition of knowledge, facts, and preparation for tertiary science), supported by resources (textbooks), institutional traditions (timetabling, assessment and reporting) and teaching practices (teacher as director, learning of de-contextualised conceptual knowledge, practical exercises to demonstrate known phenomena) has resulted in students' lack of interest and engagement in science. Tytler maintains that a way forward is for school science education to focus on developing students' understandings of the 'nature of science': how science is used to solve problems and make claims using evidence from carefully collected data about real-world issues.