Think Piece: Preparing today's children for the workplaces of tomorrow: The critical role of STEM education

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Three reports released in the last few months have highlighted the rapid transformation of the workplace that will impact on the students currently within our schools (CEDA, 2015; Delotte Access Economics, 2015; PwC, 2015). Many of the jobs these students will undertake when they graduate from schools, vocational and higher education do not exist yet. These reports make for arresting reading, and require educators to reflect deeply on the competencies that will be required of our students if they are to successfully navigate the changing employment landscape and a society increasingly reliant on science and technology.

Western society is being transformed by globalisation and digital technologies at an unprecedented rate. Globalisation has resulted in workforces that are increasingly mobile (physically and virtually) both within and between countries. For example, changing employment laws and new categories of visas within Australia have seen areas of skill shortage being rapidly filled by skilled migrants. During 2013-14 there were 19 000 net arrivals of Information and Communication Technology (ICT) workers to fill key technical capabilities in fields such as software development and programming (Deloitte Access Economics, 2015).

New digital technologies are enabling automation of increasing dexterity to accomplish many routine and repetitive roles in production; some have coined this phenomenon as 'digital disruption'. Modelling the impacts of digital disruption in the workplace indicates that in Australia "almost five million jobs face a high probability of being replaced in the next decade or two while a further 18.4% of the workforce has a medium probability of having their roles eliminated" (CEDA, 2015, p. 9). Analysis by PriceWaterhouseCooper shows that 44% of current Australian jobs are at high risk of being affected by digital technologies over the next 20 years (PwC, 2015). The jobs most likely to be affected are those that involve "low levels of creativity, or low levels of mobility and dexterity" (CEDA, 2015, p. 9) and "where computer learning systems or robotics are able to perform simple and routine tasks faster and more accurately than humans" (PwC, 2015, p. 10). Examples of low-skilled jobs likely to be replaced by digital technologies include "data entry, operating a checkout, book-keeping, doing simple office administration and operating machinery"

(PWC, 2015, p. 10). By comparison, the jobs most likely to endure over the next couple of decades are those that require high levels of social skills, technical ability and creative intelligence such as health care workers, teachers, engineers, ICT professionals and managers (PwC, 2015, p. 12). For example, Australia is predicted to require an additional 100 000 ICT workers over the next six years (Deloitte Access Economics, 2015).

PwC (2015) argue that 75% of the fastest growing occupations will require STEM skills, and that Australian employers identify STEM employees as being among the most innovative. PwC modeling suggests that shifting one per cent of the Australian workforce into STEM roles would add $57.4 billion to the GDP over 20 years. It is the overarching STEM skills that are required: "Critical thinking and problem solving, analytic capabilities, curiosity and imagination have all been identified as critical 'survival skills' in the workplace of the future" (PWC, 2015, p. 14). Australia's Chief Scientist, Professor Ian Chubb, has argued that "Curricula and assessment criteria should prioritise curiosity-driven and problem-based learning of STEM—STEM as it is practised—alongside the subject specific knowledge that STEM requires" and that "We need a reliable pipeline of specialist STEM skills; but we also need informed workers, users and consumers who have the curiosity and imagination to be part of the broader STEM economy" (Office of the Chief Scientist, 2014, p. 21).

Given the importance of attracting and retaining more students in the STEM education pathway and to raise achievement standards, considerable attention has been given to pedagogical and curriculum formulations that will engage students in STEM learning and enhance learning outcomes. There is a long-standing international consensus that science should be taught by inquiry-based methods (Goodrum, Hackling, & Rennie, 2001), and this approach is well-suited to STEM education. A working group established by the worldwide network of academies of science argued that inquiry-based science education is characterised by students:

> … developing concepts that enable them to understand the scientific aspects of the world around them through their own thinking using critical and logical reasoning about evidence that they have gathered. This may involve them in first hand manipulation of objects and materials and observation of events; it may also involve them in using evidence gained from a range of information sources including books, the Internet, teachers and scientists (Inter-Academies Panel, 2010, p. 4).

The active engagement of students in scientific inquiry provides rich opportunities for developing higher order thinking, problem solving skills and scientific reasoning which are important components of scientific literacy. However, student inquiry needs to be set in authentic contexts to maximise students' interest and engagement in learning science. Schools need to collaborate closely with industry, commerce and the professions, as it is the employers who can provide the real-world contexts and authentic learning tasks that are based on real-life scenarios. Such authentic tasks will often require trans-disciplinary approaches to inquiry, providing opportunities for integration across STEM disciplines. Tytler's (2007) seminal paper on reimagining the science curriculum argued strongly for a curriculum which sets science learning in authentic contexts, involves community partnerships, utilises inquiry-based pedagogies in which students have some

agency in their learning, and that the forms of assessment better reflect the higher order learning outcomes that we aspire to.
Assuring the right fit of the curricular and pedagogical settings of the intended curriculum is essential; however, the fidelity of curriculum implementation depends very much on the pedagogical content knowledge (PCK) of the teacher. The lack of specialists teaching science in primary schools and out-of-field teaching in the secondary years results in science being taught by teachers with limited science PCK, repertoire of inquiry pedagogies and capability for recognising and responding to students' learning needs (Hackling, 2014).

Mathematics education also faces the challenge of high rates of out-of-field teaching with one-in-four Australian secondary schools reporting difficulty in recruiting qualified mathematics teachers; only 75% of those teaching Year 11 and 12 mathematics having a university mathematics major; and 23% of lower secondary mathematics teachers having completed no more than first year studies in mathematics and one-third have not completed studies of mathematics teaching methods (Harris & Jensz, 2006). McConney and Price (2009) indicate that: "there is a much higher incidence of teaching out-of-field in poor communities, rural and remote schools and metropolitan schools considered 'hard to staff'" (p. 89) and this is a major contributor to the relative under-achievement of students in these schools.

In recent years, the goals of mathematics education in most countries have placed an increased emphasis on problem-solving, investigation, mathematical modelling and the communication of mathematical ideas (Barnes, Clarke, & Stephens, 2000) and "allowing students to experience the actual processes through which mathematics develops (e.g., conjecture, generalisation, proof, and refutation)" (Goos, 2004, p. 258). In both science and mathematics education, reform agendas highlight the need for students to engage in disciplinary processes so that they might gain a richer understanding of how the disciplines work and to develop competencies required to investigate and solve authentic problems. The three key questions needed to guide the reform of STEM education are therefore: (1) What are the STEM competencies that will be of most value to enable our students to navigate the new employment landscape? (2) What practices of the STEM disciplines do students need to participate in to develop those competencies? and (3) What types of tasks and pedagogies do teachers need to implement to ensure students engage with these practices of the STEM disciplines in meaningful and authentic contexts?

It is the higher order STEM cognitive skills that can empower and emancipate young people giving them more control over their own lives and enhancing their opportunities for accessing the new employment opportunities emerging in a globalised and digitally disrupted society. Reform of STEM education will have significant wider impacts strengthening the economy through increases in innovation and productivity; decreasing youth employment and reliance on skilled migration; and, building capacity to address the global challenges of climate change and human population growth.

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