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Enriching STEM with the Arts to Better Prepare 21st Century Citizens

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Why should we consider integrating the Arts with Science, Technology, Engineering and Mathematics? Is this just another curriculum fad? In this paper I argue that STEAM (STEM + Arts) Education is an important response to the pressing need to prepare young people with higher-order abilities to deal positively and productively with 21st Century global crises that are impacting the economy, the natural environment, and our diverse cultural heritage.

Australian Science Curriculum

The Australian Science Curriculum (ACARA, 2016) directs teachers to engage students in developing a range of important scientific concepts and inquiry skills (science understandings, science as inquiry). It also directs teachers to help students understand that science is a human activity that responds to and, in turn, is shaped by social, cultural and ethical issues (science as a human endeavour). This third strand is promising but is not strongly articulated, and can easily be overlooked in favor of the traditional approach of teaching scientific knowledge and laboratory skills.

However, it is the broader Australian Curriculum (www.australiancurriculum.edu.au) that fully opens the door to a radically expanded scope for science education to address pressing global issues. Two overarching dimensions - general capabilities and cross-curriculum priorities - direct teachers to develop students as global citizens capable of not only adapting to a rapidly changing world but also participating actively in shaping it for the better.

The general capabilities focus on developing a suite of higher-order abilities, including critical and creative thinking, personal and social capabilities, ethical understanding and intercultural understanding, aimed at preparing future citizens "to contribute to the creation of a more productive, sustainable and just society" (ACARA, 2016).

The cross-curriculum priorities - sustainability, Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement in Asia - provide compelling contexts for students to understand the worldviews of culturally different others and develop a moral conscience about the impact of their planetary footprint.

It is intended that teachers of all learning areas, including science, will build these two new curriculum dimensions into their teaching programs. However, the prospect of designing teaching and learning activities to develop students' higher-order abilities can be daunting for science teachers, especially when assessment systems privilege the science understandings strand of the curriculum. Nevertheless there are strong social drivers - economic and sustainability imperatives - that science teachers cannot afford to ignore as they prepare students for life and work in the 21st Century.

Driver 1: The IT Workforce of the Future

Given the rapid emergence of digital technologies, artificial intelligence, DNA mapping, robotics, nanotechnology, 3D printing, biotechnology and the ‘internet of things’, business
and industry leaders are calling for graduates with liquid skills that enable them to adapt to a fluid working landscape throughout their lives. To prepare for jobs that currently do not exist but that will be essential to the nation’s economic wellbeing.

Liquid skills include creative and critical thinking, the ability to work with others, verbal communication and active listening, and a disposition towards life-long learning. These capabilities are deemed to be more important than high academic achievement for IT workers in the ‘fourth industrial revolution’ (Infosys, 2016).

Recent national reports on future-proofing Australia’s high-tech, digital workforce call for STEM graduates with creative and innovative abilities (Australian Government, 2015; Pricewaterhouse-Coopers, 2015). Australia’s Chief Scientist has called for educational reforms to better engage students in STEM-related career pathways (Office of the Chief Scientist, 2013).

**Driver 2: Education for Sustainable Development**

We are now experiencing an unparalleled period in the history of the Earth, an epoch in which we have wrested control over Nature: the *Anthropocene* (Crutzen & Stoermer, 2000). This era has its genesis in the industrial revolution and is characterised by our use of fossil fuels and development of powerful technologies. Alarmingly, our technological superpowers are dangerously altering the natural systems of the planet, including the climate, oceans and soils, resulting in fundamental changes to biological and geological systems. The impact of the modern human footprint has become so profound that, for the first time in history, natural ecosystems are at the mercy of human systems.

In the public mind the clearest evidence of our detrimental impact on the planet is climate change (National Research Council, 2011; IPCC, 2014). Another major impact, one that is not so well embedded in public consciousness, is loss of linguistic, cultural and biological diversity, which together are framed as *biocultural diversity*. The importance of the intimate interrelationship between language, culture and the environment has been documented by UNESCO, The World Wide Fund for Nature and Terralingua (Skutnabb, Maffi, & Harmon, 2003):

> In the language of ecology, the strongest ecosystems are those that are the most diverse. That is, diversity is directly related to stability; variety is important for long-term survival. Our success on this planet has been due to an ability to adapt to different kinds of environment over thousands of years (atmospheric as well as cultural). Such ability is born out of diversity. Thus language and cultural diversity maximises chances of human success and adaptability. (p. 10)

Because we have failed to resolve human-induced global crises during the *United Nations Decade of Education for Sustainable Development 2005-2014*, the UN (2015) has established the *2030 Agenda for Sustainable Development*, with 17 Sustainable Development Goals. Goal 4 is Education, which needs to promote the well-being of self, family, community, nation, and humanity at large, as well as the planet’s living systems and other life forms. In setting out the following principles of education for sustainable development, UNESCO (2006) recognises that sustainable development is an ethical challenge as well as a scientific concept. Education for sustainable development:

- is based on the principles and values that underlie sustainable development
• deals with the well-being of all four dimensions of sustainability – environment, society, culture and economy
• uses a variety of pedagogical techniques that promote participatory learning and higher-order thinking skills
• promotes lifelong learning
• is locally relevant and culturally appropriate
• is based on local needs, perceptions and conditions, but acknowledges that fulfilling local needs often has international effects and consequences
• engages formal, non-formal and informal education
• accommodates the evolving nature of the concept of sustainability
• addresses content, taking into account context, global issues and local priorities
• builds civil capacity for community-based decision-making, social tolerance, environmental stewardship, an adaptable workforce, and a good quality of life
• is interdisciplinary. No single discipline can claim ESD for itself; all disciplines can contribute to ESD

In responding to these principles, a 21st century science education for sustainable development (of the economy, the environment, and the social-cultural world) would incorporate values education, citizenship education and global issues, and embrace interdisciplinarity. It is clear that, in addition to developing students' science knowledge and inquiry skills, a 'socially responsible science education' needs to contribute to preparing students as future citizens by developing their higher-order abilities, as required by the Australian Curriculum's general capabilities and cross-curriculum priorities.

**STEAM Curriculum Perspective**

STEM education has become a nation-wide focus of innovation and entrepreneurial funding, as witnessed by industry sponsored initiatives such as the 21st Century Minds (21CM) Accelerator Program, which aims to prepare children with '21st century skills' for the jobs of the future, including the ability "to think smart and creatively, solve problems, persist and take risks, have strong digital skills and know how to collaborate effectively" (Pricewaterhouse Coopers, 2016).

On the other hand, in many of the nation's schools, especially at the secondary level, the STEM learning areas are somewhat bereft of curriculum resources for teachers to foster students' innovative and creative abilities, despite the requirement to address the Australian Curriculum's general capabilities.

Deloitte's (2015) report on the IT worker of the future argues that creativity is a key priority and that STEM educators need to embrace the arts in order to foster students' creative design and performance, using various media:

> IT leaders should add an "A" for fine arts to the science, technology, engineering, and math charter-STEAM, not STEM. Designing engaging solutions requires creative talent; creativity is also critical in ideation-helping to create a vision of reimagined work, or to develop disruptive technologies deployed via storyboards, user journeys, wire frames, or persona maps. Some organisations have gone so far as to hire science fiction writers to help imagine and explain moonshot thinking (p. 126).
Eliot Eisner (2008) explains that the arts are concerned with expressiveness, evoking emotion, generating empathic understanding, stimulating imagination that disrupts habits of mind and creates open-mindedness, and eliciting emotional awareness. In sum, the arts enable us to discover our humanity. Such an altruistic goal sits well with education for sustainability.

A succinct account of what the arts have to offer was coined by arts educators, Bucheli, Goldberg and Philips (1991):

The arts can be, for both students and teachers, forms of expression, communication, creativity, imagination, observation, perception, and thought. They are integral to the development of cognitive skills such as listening, thinking, problem-solving, matching form to function, and decisionmaking. They inspire discipline and dedication. The arts can also open pathways toward understanding the richness of peoples and cultures that inhabit our world, particularly during this period of global change. The arts can nurture a sense of belonging, or community; they can foster a sense of being apart, or of being an individual. By acknowledging the role of the arts in our lives and in education, we acknowledge what makes individuals whole.

In the 1950s Snow (1998) argued for a rapprochement of the cultures of science and the arts. Today, there is a wellspring of opinion that combining science and the arts in the form of STEAM education is essential for producing a creative, scientifically literate, and ethically astute citizenry and workforce for the 21st century (Boy, 2013; Edwards, 2010; Feldman, 2015; Piro, 2010). Already, the USA and Korea have begun producing STEAM curricula for their respective nations (White, 2010). Recognising their limitations in developing students’ higher-order abilities, visionary science educators are teaming up with their colleagues in the arts learning areas to design innovative interdisciplinary STEAM curricula and teaching approaches. (Root-Bernstein, 2008; Sousa & Pilecki, 2013).

Early research studies on ground-breaking STEAM curricula in the USA have demonstrated that learning activities integrating science, technology and the arts successfully engage minority and disadvantaged students, resulting in improved literacy and numeracy competencies (Clark, 2014; Stoelinga, Silk, Reddy, & Rahman, 2015). In WA, a science/mathematics teacher in a Big Picture school integrated stories about everyday ethical dilemmas into her Earth Science lessons and demonstrated that at-risk students engaged in ethical decision-making while developing scientific knowledge and inquiry skills (Taylor, Taylor & Chow, 2013).

So, to sum up.

- STEAM education is not in opposition to STEM education; it enriches and expands the scope of STEM education.
- STEAM education is a curriculum philosophy that empowers science teachers to engage in school-based curriculum development
- STEAM education involves teachers in developing a humanistic vision of 21st century education and their role as professionals.
- STEAM education provides a creative design space for teachers in different learning areas to collaborate in developing integrated curricula.
• STEAM educators can draw inspiration from project-based learning programs (e.g., Holm, 2011).
• STEAM education engages students in *transformative learning*, which promotes five interconnected ways of knowing: cultural self-knowing, relational knowing, critical knowing, visionary and ethical knowing, and knowing in action (for details see Taylor, 2015).

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References


