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STEAM Educators Embracing the Arts to Develop Students' Capabilities for Resolving Global Sustainability Crises

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Abstract: We are currently experiencing an era – the Anthropocene – that is unprecedented in the history of our planet. Our addiction to fossil fuels and powerful technologies has dangerously altered the Earth's natural systems, giving rise to the well-documented global crises of climate change, plastic pollution of the oceans, and tragic loss of biocultural diversity. These crises have created a unique challenge for STEM educators, given that STEM disciplinary knowledge and skills are often viewed as the key to solving the world's economic and environmental problems. This popular view tends to focus narrowly, however, on students learning objectively about the world out there. Such a restrictive view largely ignores the crucial role education can and should (ethically) play in developing students' attitudes and values - their inner worlds - that fuel their moral agency for living and working in sustainable ways. Across the world transformative STEM educators are embracing Arts-based methods to prepare young people with special capabilities and values for actively contributing to the sustainable development of a world in crisis. Examples of these innovative approaches are featured in Transformative STEAM Education For Sustainable Development (Taylor & Taylor, 2022).

Keywords: STEAM education, sustainable development, Capabilities

Introduction

Two hundred years after the European industrial revolution the Earth's natural systems are under severe duress due to our modern technological footprint. We have not only developed the means for vastly improving the material quality of our lives, but also the means for our collective destruction. This new geological era - The Anthropocene - manifests in numerous ways; amongst the most visible are catastrophic climate change, dire plastic pollution of the world's acquatic ecosystems, and tragic loss of indigenous wisdom traditions that sustain biocultural diversity.

For over a decade the United Nations has advocated the urgency of education for sustainable development for reconciling the competing interests of our globalising

economies, biocultural diversity, and the natural environment. However, despite inter-governmental agreements, such as the Paris Agreement on climate change (UN 2015a) and the Glasgow Climate Pact (UN 2021), progress has been disappointingly slow. The recent report on global warming issued by the Intergovernmental Panel on Climate Change (IPCC, 2021) urgently warns that the world has only until 2030 to drastically reduce carbon emissions in order to limit the global temperature increase to +1.5C. Going beyond this modest target is predicted to result in an unmanageable climatic tipping point. The Bulletin of the Atomic Scientists' (2022) Doomsday Clock is now set at 100 seconds to midnight. The World Economic Forum (WEF, 2016) estimates that, at current rates of plastic leakage into the natural environment, by 2050 there will be more (toxic) plastics than fish (by weight) in the oceans. And the current OECD (2022) report confirms that, under the current 'business as usual' approach to waste management, by 2060 plastic leakage into aquatic environments will more than triple. Clearly, we are facing human-induced environmental crises on a global scale.

The recent UN Emissions Gap Report (2018) calls on all sectors, including education, to develop emissions mitigation strategies. From an eco-justice perspective, it is clear that professional educators, especially in the STEM field, have a moral imperative to engage students (from early childhood to graduate school, including teacher education) in education for sustainable development. Although the worldwide endeavor to create synergies between the related disciplines of Science, Technology, Engineering and Mathematics is promising, we are falling short of preparing young people with transdisciplinary capabilities necessary for engaging in sustainable development practices in their homes and local communities and, subsequently, their places of work. Many government-sponsored innovative STEM curricula and pedagogies are driven by the economic imperative of the Fourth Industrial (Digital) Revolution (WEF 2016). Although critical thinking, creativity, digital literacy, teamwork and communication skills are essential for employment in a globalizing digital economy, they are not sufficient for transforming unsustainable practices in the home, community and workplace.

Education for sustainable development needs to be guided by a philosophy of education based on a broader notion of the public good (Hazelkorn & Gibson 2017) that envisions young people as active citizens of democratic societies that value equally the competing interests of globalizing economies, diverse cultures, and the natural environment. Educating young people with transdisciplinary capabilities for reconciling these often conflicting interests involves immersing them in transformative learning experiences that enable them to reflect critically on their valued beliefs and habits of mind, engage empathically and collaboratively in real-world ethical decision-making scenarios, contemplate their spiritual connection with the natural world, and develop their moral agency for making the world a healthier and happier place in which future generations can thrive.

Here we draw on our new book (Taylor & Taylor, 2022) to explain briefly (i) how a philosophy of transformative learning can operationalise education for sustainable development, and (ii) how integrating Arts and STEM education can create powerful interdisciplinary curriculum spaces for teachers to design learning experiences that enable students to develop not only STEM disciplinary knowledge and skills but also transdisciplinary capabilities for ensuring their ongoing engagement in sustainable development practices. We conclude by outlining an example of a successful transformative STEAM strategy – ethical dilemma story pedagogy – that is being embraced by teachers and researchers in Australian, Thai and Indonesian schools and universities.

Education for Sustainable Development

We are experiencing an unparalleled period in the geological history of the Earth, an epoch in which, it is argued, we are injudiciously interfering with the planet's natural systems: The Anthropocene (Crutzen & Stoermer 2000). This era has its genesis in the European industrial revolution, and is characterised by our use of fossil fuels and powerful technologies to exploit the world's natural resources. Alarmingly, our use of these technologies is dangerously altering the natural systems of the planet, including the atmosphere, riverine and marine environments, the cryosphere and the soils, resulting in fundamental changes to biological and geological systems. The impact of our 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 the climate change emergency (National Research Council 2011). 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 (WWFN) and TerraLingua (Skutnabb et al. 2003, p. 10):

> 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.

Because we have failed to resolve human-induced global crises the United Nations established the 2030 Agenda for Sustainable Development (UN 2015b). Goal 4 is Education, which states that our education systems need 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:

- 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,
- 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, and
- is interdisciplinary.

By embracing these principles, a socially responsible STEM education incorporates values education and citizenship education by addressing global issues of sustainable development. It is clear that, in addition to developing students' disciplinary knowledge and skills, a socially responsible STEM education needs to contribute to preparing students as future citizens by developing their transdisciplinary capabilities, as mandated by the Australian Curriculum.

Socially Responsible STEM Education

The Australian Science Curriculum provides a futures perspective on preparing young people with not just disciplinary knowledge and skills but also essential transdisciplinary capabilities for working and living in a rapidly globalising world in which we are

experiencing unprecedented development and disruption, especially in regard to the natural environment.

The Australian Science Curriculum is impressively multi-dimensional, comprising three distinct strands. The Science Understandings strand directs teachers to engage students in understanding the evolutionary dynamics of scientific knowledge, concepts, principles, theories, models, etc. The Science Inquiry Skills strand focuses on developing skills of inquiry and evaluation of scientific explanations. The innovative third strand of Science as a Human Endeavour opens the door to understanding the nature and limitations of science and to considering the cost to the planet and humanity of its unintended side-effects. This strand "acknowledges that in making decisions about science and its practices, moral, ethical and social implications must be taken into account." (Australian Curriculum Assessment and Reporting Authority 2010).

Although the third strand is a significant advance towards building a socially responsible science education, two overarching dimensions of the broader Australian Curriculum fully open the door to a radically expanded scope for science education to address pressing global issues. The general capabilities and cross-curriculum priorities invite teachers to develop their students as global citizens capable of not only adapting to a rapidly changing world but also participating actively in shaping it for the better. Importantly, this includes consideration of the many competing (values laden) perspectives on what 'better' might mean.

The general capabilities focus on developing a suite of transdisciplinary abilities - 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" (Australian Curriculum Assessment and Reporting Authority 2016). The three cross-curriculum priorities - Sustainability, Aboriginal and Torres Strait Islander Histories and Cultures, and Asia and Australia's Engagement in Asia - provide compelling learning contexts for students to understand the worldviews of culturally different others and to develop a moral conscience about the impact of their planetary footprint. It is intended that teachers of all learning areas, including STEM, will build these new curriculum dimensions into their teaching programs.

However, the prospect of designing teaching and learning activities to develop students' transdisciplinary capabilities can be daunting for STEM teachers whose experience has been largely restricted to teaching disciplinary knowledge and skills. A solution to this issue lies in making permeable the walls of traditional disciplinary silos, thereby fostering interdisciplinary collaboration between STEM and the Arts.

Arts Education

The Arts focus uniquely on developing our creative abilities (ingenuity, imagination), our aesthetic appreciation (beauty, sentiment, awe), our ethical values (virtues, human rights, social justice), and our rhetorical skills (expression, persuasion). As Eliot Eisner (2008), a leading arts educator, explains: 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 perceive the heights of our humanity, of what it means to be more fully human. And Arts education can enable us to ascend these heights, to enrich our lives with transdisciplinary capabilities that we can apply in different ways for different purposes. These capabilities are especially empowering for concerned citizens endeavoring not only to make sense of a complex, chaotic and contested (post-truth, fake news) world, but also to exercise their democratic agency by intervening constructively in private, public and professional discourses aimed at deciding the (ethical/morally) right

way to resolve global crises such as climate change and the scourge of feral plastics destroying our marine environments.

Such debates are hotly contested by competing interests arising from different (perhaps invisible) value systems that underpin strongly held convictions that often are immune to the objective facts and rhetoric of scientists. For example, the starkly contrasting responses of world leaders to IPCC scientific reports on the urgent need to mitigate climate change evidences a split between climate change deniers and acceptors, with the former refusing to accept that climate change is due in large part to (irresponsible) human actions, as concluded to an overwhelming degree (98% probability) by climate scientists.

This political stalemate makes it abundantly clear that a socially responsible STEM education must focus on developing not only young people's disciplinary knowledge and skills but also their transdisciplinary capabilities for engaging constructively in sustainable development debates, decision-making and practices.

The good news is that there is a wellspring of opinion worldwide that combining STEM education and Arts education is a curriculum imperative for a creative, scientifically literate, and ethically astute citizenry and workforce for the 21st Century (Boy 2013, Piro 2010, Root-Bernstein 2008). Recognising the urgency of developing students' transdisciplinary capabilities, visionary STEM educators are teaming up with colleagues in Language Arts (drama, poetry, prose), Performing Arts (dance, music, theatre) and Visual Arts (drawing, painting, sculpture, design, film making) to design interdisciplinary STEAM curricula and teaching approaches (Sousa & Pilecki 2013; Taylor & Taylor, 2022). In the Asia-Pacific region STEAM curricula are being developed, trialled and evaluated; and international conferences are bringing STEAM educators together around the theme of education for sustainable development (e.g., Ocean Park 2019; TERSD, 2022).

Transformative Learning

However, missing from the 'Arts+STEM=STEAM' equation is a compelling philosophy of learning that can guide the design of STEAM teaching and learning approaches aimed at developing students' transdisciplinary capabilities for engaging as future citizens in sustainable development debates, decision-making and practices. To address this need we turn to a philosophy of transformative learning that has been articulated in various ways for much of the 20th century by educational scholars such as Jack Mezirow, John Dewey, Parker Palmer, Carol Gilligan and Abraham Maslow, who call for our subjectivities and lived experiences to be addressed in the curriculum of formal education. This inner education perspective resonates with the Ancient Greek maxim of know thyself.

Transformative learning involves engaging students in reflecting critically on the presuppositions underpinning their (largely invisible) values and beliefs. Using cognitive, emotional, social and spiritual development methods, students learn to reconceptualise and reshape the relationship between their outer and inner worlds. It is useful to articulate transformative learning as five interconnected ways of coming to know (Taylor 2015).

a. Cultural-self knowing (or self-realisation) involves coming to understand our culturally situated selves, in particular how the (mostly invisible) premises underpinning our worldviews – our shared values, beliefs, ideals, emotionalities, spiritualities – give rise to our cultural identities and govern our habituated ways of being in, making sense of, and relating to our social and natural worlds.
b. Relational knowing (or embracing difference) involves learning to connect empathically and compassionately with our true (nonegoic) selves, our local community, the culturally different other, and, most importantly, the natural world. As TerraLingua (2022) argues, "indigenous principles of reverence, respect and

reciprocity are central to building a just, equitable sustainable world in which biocultural diversity can thrive".

c. Critical knowing (or political astuteness) involves coming to understand how and why (political, institutional, economic) power has structured historically our socio-cultural realities by creating seemingly natural categories of class, race, gender, vocation, intelligence, etc., and how this mostly invisible power governs (especially distorts) our lifeworlds, our relationships with others, and our relationship with the natural world.
d. Visionary and ethical knowing (or blue sky thinking) involves creative, inspirational and discursive processes of idealising, imagining, poeticising, romanticising, meditating on and negotiating a collective vision of what a better world could be like and, importantly, what a better world should be like.
e. Knowing in action (or making a difference) involves consciously developing our capacity and willingness to help make the world a better place, committing to making a difference, and taking action locally while thinking globally.

These five dimensions comprise a 21st century philosophy of transformative learning that supports the moral imperative for STEM educators to draw on Arts education methods to develop students' transdisciplinary abilities for participating as key stakeholders in sustainable development decision-making and actions. We conclude by outlining a successful STEAM teaching and learning strategy – ethical dilemma story pedagogy – currently being implemented in schools and universities in Australia, Thailand, and Indonesia.

Ethical Dilemma Story Pedagogy

To summarise, we have argued that STEM educators have a moral imperative to design curricula that develop students' transdisciplinary capabilities for participating as socially responsible citizens in helping to resolve global crises such as climate change, plastic waste pollution and loss of biocultural diversity. We have argued that the Arts can provide STEM educators with much-needed methods for achieving this pressing goal. And we have outlined a transformative philosophy of learning to help drive transformative development of innovative STEAM approaches to teaching and learning.

Our experience shows, however, that many STEM teachers feel unprepared to develop their students' transdisciplinary capabilities. At the heart of the issue is an epistemological conflict: STEM education has traditionally focused on objective knowledge, whereas transdisciplinary capabilities are inherently inter/subjective. By and large, STEM specialist teachers lack the professional skills and experience to embrace Arts education methods.

However, there are ways of overcoming this roadblock, one of which is for a STEM teacher to team up with a colleague in an Arts learning area and co-design transformative STEAM lesson plans, perhaps around project-based learning (PBL) (eg., Manea & Williams 2022). However, this might be a curriculum bridge too far for many STEM teachers who wish to confine their socially responsible teaching innovation to a small-scale strategy within the curriculum borders of their own classrooms. The good news is that this goal is being well served by ethical dilemma story pedagogy, a transformative STEAM approach that we introduced into Australian schools a decade ago (e.g., Taylor, Taylor & Chow, 2013).

In brief, we have guided numerous STEM teachers to embrace Arts-based methods of dramatic storytelling, narrative reflective writing, and dialectical reasoning. We have helped them to write short stories in which the central character (a young person) experiences ethical decision-making scenarios in resolving real-life sustainable development dilemmas. The stories focus on ethical dilemmas such as:

- using convenient plastic shopping bags versus environmentally harmful waste disposal methods
- land clearance for housing development versus conservation of native bushland
- genetically modified food versus organic farming
- traditional organic fertilisers versus modern inorganic fertilisers to improve crop yield
- intervening to save stranded whales versus not interfering with natural processes

These (and many other) ethical dilemma stories have been incorporated into lesson plans aimed at developing students' disciplinary knowledge/skills and transdisciplinary capabilities (e.g., Maneelam & Yuenyong 2022). Details of ethical dilemma story pedagogy and research can be found in our new book (Taylor & Taylor 2022), and ethical dilemma stories and lesson plans can be found on our website: http://sociallyresponsiblescience.com.au .

References

Australian Curriculum Assessment and Reporting Authority. 2010. *The shape of the Australian curriculum: Version 2.0*. http://docs.acara.edu.au/resources/Shape_of_the_Australian_Curriculum.pdf

Australian Curriculum, Assessment and Reporting Authority (ACARA). (n.d.). *General capabilities.* https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/

Boy, G. A. 2013. *From STEM to STEAM: Toward a human-centred education.* Paper presented at the European Conference on Cognitive Ergonomics, 26-28 August 2013, Toulouse, France.

Bucheli, M. R. J., Goldberg, M. R., & Philips, A. 1991. Symposium: Arts as education. *Harvard Educational Review* 61(3): 25-26. http://hepg.org/her-home/issues/harvard-educational-review-volume-83-number-1/herarticle/expanding-our-vision-for-the-arts-in-education_121

Bulletin of Atomic Scientists. 2022. *Doomsday clock*. https://thebulletin.org/doomsday-clock/

Crutzen, P. J. & Stoermer, E. 2000. The Anthropocene. *Global Change Newsletter,* 41: 17-18.

Eisner, E. 2008. Art and knowledge. In J. G. Knowles & A. L. Cole (eds.), *Handbook of the arts in qualitative research*: 3-12. Sage.

Hazelkorn, E. & Gibson, A. 2017. *Public goods and public policy: What is the public good, and who and what decides.* Centre for Global Higher Education, UCL Institute of Education, London.

Intergovernmental Panel on Climate Change (IPCC). 2021. *Climate change 2021: The physical science basis.* https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf

Manea, T., & Williams, R. 2022. What's a methematics teacher doing in an English classroom? A window on the environment. In E. (L.) Taylor & P. C. Taylor (eds.). *Transformative STEAM education for sustainable development*. Brill. https://brill.com/view/title/63388

Maneelam, P, & Yuenyong, C. 2022. Humanising educare for 21st century Thai students: Ethical dilemmas of plastics. In E. (L.) Taylor & P. C. Taylor (eds.). *Transformative STEAM education for sustainable development*. Brill. https://brill.com/view/title/63388

National Research Council. 2011. *America's climate choices*. National Academies Press. https://nap.nationalacademies.org/catalog/12781/americas-climate-choices

Ocean Park. 2019. *The first international STEAM education conference 2019*. https://oceanparkhongkong.ievent.hk/event/p/37814

OECD. 2022. *Global plastics outlook: Policy scenarios to 2060.* http://oecd.org/environment/plastics

Piro, J. 2010. Going from STEM to STEAM: The Arts have a role in America's future too. *Education Week, 29*(24): 28-29.

Root-Bernstein, R. 2008. Arts foster scientific success: Avocations of Nobel, National Academy, Royal Society, and Sigma XI members. *Journal of Psychology of Science and Technology*, 1(2): 51-63.

Skutnabb-Kanga, T., Maffi, L. & Harmon, D. (2003). *Sharing a world of difference: The Earth's linguistic, cultural and biological diversity*. UNESCO. http://terralingua.org

Sousa, D. A. & Pilecki, T. 2013. *From STEM to STEAM: Using brain-compatible strategies to integrate the arts.* Corwin/Sage.

Taylor, E., 2022. Ethical dilemma story pedagogy: Values learning and ethical understanding for a sustainable world. In E. (L.) Taylor & P. C. Taylor (eds.), *Transformative STEAM education for sustainable development*: 20-33. Brill. https://brill.com/view/title/63388

Taylor, P. C. 2015. Transformative science education. In R. Gunstone (ed.), *Encyclopedia of science education:*1079-1082. Springer. https://doi.org/10.1007/978-94-007-2150-0_212

Taylor, E. (L.) & Taylor, P. C. (eds.). 2022. *Transformative STEAM education for sustainable development*. Brill. https://brill.com/view/title/63388

Taylor, E., Taylor, P.C., & Chow M.L. 2013. Diverse, disengaged and reactive: A teacher's adaptation of ethical dilemma story pedagogy as a strategy to re-engage learners in education for sustainability. In N. Mansour & R. Wegerif (eds)., *Science education for diversity: Theory and practice* (pp. 97-117). Springer.

TerraLingua. 2022. Reverence, respect, and reciprocity: Cornerstones of biocultural diversity. *LangscapeMagazine, 11*. https://terralingua.org/read-langscape/

TERSD. 2022. *The third international conference on transformative education research and sustainable development*. https://tersd2022.kusoed.edu.np/

United Nations. 2018. Emissions gap report 2018. http://wedocs.unep.org/bitstream/handle/20.500.11822/26895/EGR2018_FullReport_EN.pdf?isAllowed=y&sequence=1

United Nations. 2021. *The Glasgow climate pact*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact-key-outcomes-from-cop26

United Nations. 2015a. *The Paris agreement*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations. 2015b. *Transforming our world: The 2030 agenda for sustainable development.* https://sustainabledevelopment.un.org/post2015/transformingourworld

UNESCO. n.d. *Education for sustainable development.* https://www.unesco.org/en/education/sustainable-development

World Economic Forum. 2016. *The new plastics economy: Rethinking the future of plastics*. http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf