Learning How Everything is Connected:
Research in Holistic and Cross-Cultural Indigenous Technacy Education

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Abstract
As regional populations close in on each other and cultures connect across continents, the demand for fresh ideas becomes critical to our common future. This paper presents a collection of key ideas from cross-cultural technacy research and advocates a new branch for technological thought development from Kindergarten to Adulthood based on the idea of learning how technological understanding is necessarily always an interconnected sociocultural, ecological and systemic form of knowing.

This paper also forms a part of the Symposium: ‘(Re)visioning Technological Learning and Thinking – the Clifftop Manifesto for Educational Change’ (Elshof, Keirl, McLaren, & Seemann, 2010). It supports the manifesto’s ethics of an education that is: informed by a different consciousness which accommodates complexity, holism and the interaction of systems; is guided by an ecological insight foundational to life; and draws particular attention to the call to celebrate the ingenuity of cultures and their diversity.

Key Words: Cross-cultural technology education, Indigenous technology education, Aboriginal, technacy, design and technology, sustainability, innovation, holism, networks, Clifftop Manifesto for Educational Change.

Introduction

“Technology is seen in limited terms: if it is not computers then it is vocational technical training, and rarely ever is the whole spectrum of technology that constitutes its existence between these bookends made apparent, explored or debated. In the curriculum of many nations technology is portrayed as a process or thing one simply is taught to use, rather than study. It is at best the metaphor for building the skills of a labour force to given standards, and at worst it is the school subject that offers students mental recess before carrying on into the more noble studies of subjects associated closely with literacy and numeracy such as language, mathematics or science. What is not understood is how technology presents and represents a mirror of our values, our means for building new knowledge (that is, its role in the knowledge creation process itself) and our relationship to our eco-environmental futures.” (Seemann, 2009, p. 117)

The Clifftop Manifesto for Educational Change (Elshof, et al., 2010) identifies a need for an education based on a new ethic of technology and design. The ethic has eight dimensions, three of which state that the ethic:

• is informed by a different consciousness which accommodates complexity, holism and the interaction of systems
• is guided by an ecological insight foundational to life; and
• celebrates the ingenuity of cultures and their diversity.

To reflect on the above three ethical dimensions, the ‘Clifftop Manifesto for Educational Change’ do not currently see enough investment in scholarship, pedagogy research and practice that deliberately accommodates complexity, holism and the interaction of systems nor do we see much technology and...
Similarly, our educated habits of mind in teacher education and curriculum about what Technology pathology of our technological routines is thus predisposed to work against easy transformation. Our current view of technology education is likely to be neither easy nor welcoming in all systems. The pathology of our technological routines is thus predisposed to work against easy transformation. Similarly, our educated habits of mind in teacher education and curriculum about what Technology

A different consciousness that accommodates complexity, holism and the interaction of systems

This dimension of the manifesto asserts that while the era of technological education that is based on the human scale of ‘object-making/product-designing’ activities ought continue, the extreme scale of technological development now far exceeds our traditional educational assumptions of what ought define relevant knowledge, principles and modes of educational practice in the study of our made-world. This is not merely a reference to scales of mass production, but rather to a demand for education to grasp completely new concepts about technological complexity in design, system behaviours, and development.

The vast majority of the ‘ecology’ most people now a days experience is not dominated by the rhythms of nature, but by the new rhythms emerging from the linked up, and inter-reactive behaviour of the made-world. This made-world is increasingly systemic with technologies that are too tiny or too expansive to touch, nor comprehend, with the ordinary cognitive scaffolds traditionally developed about ‘object-making’ concepts taught in schools. From the scale of nanotechnology to connected city networks, our scope is beyond breathtaking, and indeed is often ‘breath-taking’ in terms of its geo-ecological impact and speed of depleting the same. We have long entered the era where ‘who the client is’ or what the ‘need is’ is not entirely clear, or static anymore. It may no longer serve humanity well to resolve this dilemma with gross simplifications where techniques and habits-of-mind that we reinforce in human scale object-making, can be assumed to be appropriate for guiding technological practice associated with the study of extreme scales of nano- (very tiny) or geo- (very large or planetary) technological systems and their principles of ‘design’. There is room to consider a more organic construct to the study of our technologically complex world, simply because there is reason to assert that as the linked up density of our technological world increases, it paradoxically also seems to display more natural responsive systemic behaviours to our intervention efforts (Barabási, 2002, 2003; Doxiadis, 1968, 1970). This is very different from a mechanical lever view of technology. It is a view that subverts the somewhat biblical assumption that the maker designs and controls the made.

We face a crisis of choices. Do we take the business as usual path, or do we transform how we view and educate people in new principles that attempt to better reflect the ‘pseudo-organic’ nature of the emerging made-world? Increasingly, it is harder to defend the view that successful technological solutions come about via some one-way master controller process of its design and implementation. Success is increasingly a result of iterative two ways exchanges between designed solutions and the applied context. Once initially implemented, one is more likely to see the context of application respond with unpredictable effects, causing further design iterations, until some mutually acceptable fit is established socially, ecologically and technically, if not also economically if the latter were a success parameter. This technological world sits and functions within us: such as the rise of medical devices. It expresses its own systemic demands upon us for its own continuance: such as its entanglement with our income and lifestyle expectations, and maintenance needs. Moreover, it is around us as part of our made-ecology: such as our built structures, clothing, and systems. To choose to change the direction of such systems may also demand a corresponding change to some of our routines of wealth production, resource flows, or alters some of the comforts we have become accustomed to, or aspire to, in our lifestyle. Transforming our current view of technology education is likely to be neither easy nor welcomed in all systems. The pathology of our technological routines is thus predisposed to work against easy transformation. Similarly, our educated habits of mind in teacher education and curriculum about what Technology
Education ought mean would rather avoid the symptoms of withdrawal that accompany lasting transformation. However, transform we must. The social, ecological if not long term economic consequences of not transforming concepts of technology education however, may be far worse, and increase in the stakes at play the longer we ignore the call.

We are in an era where we are seeking to design and develop technological understandings about dynamic ever-responsive connected systems. New ideas are needed to scaffold technological constructs in children that engage them beyond ‘object making’ and in some case even beyond ‘designerly thinking’ when teaching methods assume design cannot happen without a client, a need and an object-making task. It is not clear how such forms of thinking equip people for the complexity of our new technological ecology. Such a world produces emergent behaviours, and demands new language to cope, such as managing ‘strange attractors’ and responding to ‘scale free preferential network typologies’. The scale of our task as technology and design educators needs desperately the courage to undergo a world wide overhaul, not only in matters of curriculum content, but essentially also in matters of value and how we conceptually transform our emergent made-world before us. This is not easy, and ought not assume a science based dogma as its foundation. These systems of linked-up-other-systems are no longer purely structured on simple logic nodes nor technical device performances. They form emergent behaviour compliant with Technacy Genre Theory principles (Seemann, 2009), where human agency, ecological interaction and device responses, combine to assert simulated coherence in applied contexts of application, given purpose drives that are pushing and pulling such systems about. That is, no technology system can be legitimately understood without necessary reference to agency choices, envelopes of influence, the effect of both regular and stochastic events, and the ecological levellers that underwrite the lot where life is valued. These ideas are fundamental to understanding technology holistically, and so form axioms of technacy theory (Fleer & Jane, 2004; Ramsey, 2003; Seemann, 2003, 2009; Seemann, Parnell, McFallan, & Tucker, 2008; Walker & Seemann, 1990).

**An education in technology and design guided by an ecological insight foundational to life**

This dimension of the Manifesto demands inclusion of substantial detail in knowledge, and in the level of sophistication of guiding principles to assure technological practice clearly accepts it is immediately accountable for ecological consumption by definition of its form. Our made-world plays an active part in transforming and contextualising our consciousness, and thus where it has become so highly complex with emergent behaviour to manage, humanity needs to draw on more than individual “object-designing-and-making-skill” arguments to build its educational case in the humane and sustainable development of humanity. This complex-systemic context of technology is now akin to a cultural, not just a skills or design process based, form of education. Part of this paper explores how cultural constructs around the world can help western societies deal with its new technologically dense ecology. A creative source to look to for principles includes understanding what the very old and continuous living cultures on earth have come to learn in their efforts to manage systemic complexity. Our interest here is to explore how Indigenous settled cultures have managed the challenge to educate their group in the emergent behaviour of their own systems-rich ecology. Their world may have been technically simpler, we agree on that part, but their principles nevertheless offer some transferrable ideas and unsustainable concepts to avoid.

Cross-cultural research in technology education undertaken in Central Australia identifies the need to link all human activity and identity ultimately to land (Altman, 1987; P Memmott, 2003; Paul Memmott & I.B. Fell Research Centre., 1991; P Memmott & Moran, 2001; O'Rourke, Memmott, & Cooperative Research Centre for Sustainable Tourism., 2005; Seemann, 1997; Stafford-Smith, Moran, & Seemann, 2008). There is the simple principle, a truth to not trivialise that all forms of technological practice ultimately consume and alter resources drawn from our ecology including digital resources. The simple techno-cultural message is to not transform our ecology or take from it beyond its own ability to regenerate. That is, live off the interest, not the principle, and pay rent to our ecological landlord. This
It is hard to imagine digital hardware and software functioning if it were not for our ability to mine energy, silicone, and gold (among other resources computers and networks use up) from our eco-material (or ingredient) environment. The tendency for much of the teaching and learning of technology studies over decades to under-represent this thesis, is a major concern that we have only now as a species begun to regret. If we have not woken to revelations about how our technological choices and designs have contributed to climate change, then we must at least come to accept that our growing ecological consumption and production of unnaturally concentrated waste material, is occurring at rates faster than nature’s systemic capacity to replenish itself, or break down and disperse our waste.

Further, and this learning well underpinned the basis to success or failure of cross-cultural technology transfer projects, all technological forms of practice, are always reliant on agency for the designed solution to achieve effectiveness and efficiency in the intended context of application. This is no trivial claim. Domesticated technologies, technologies and modes of technological practice that maybe regarded as indigenous to a group, are very well reliant on the invisible hand of that group’s values and social agency (Wheatley, 2006). Where housing or health hardware (such as sanitation systems and maintenance routines), have been issued by one mainstream cultural context into the fringe of, in this example, the Aboriginal contexts, we can readily assess the assumption errors of values driving inappropriate and unsustainable outcomes (P Memmott, 2003; Seemann, 1997; Seemann, 2009; Seemann, et al., 2008; Seemann, Walker, & Centre for Appropriate Technology (Alice Springs N.T.), 1991; Stafford-Smith, et al., 2008; Walker & Seemann, 1990).

Such a densely linked up view of technology, with extremes of design and development systems at play, strangely also simulate the overall complexity of human, technology and ecology interaction behaviours that old continuous cultures have long come to accommodate and learn principles about to enable rich and sustainable lives. By this claim, we refer to the way dense connected interactions of socio-technical systems, reliant on their ecological source, begin to display natural preferential and emergent behaviours not unlike natural ecological systems (Barabási, 2002, 2003; Doxiades, 1968; Wheatley, 2006).

This paper contends that at least in the example of Australian Aboriginal cultures, the 40,000 year or more laboratory of continuous cultural learning has developed insightful ideas that are relatively new to Western civilisations and that the mainstream could learn a thing or two from. One example of this is the notion of greater definition of terms to describe ecological patterns such as types of water in the outback to help both sustain life but also to plan travel through seasonal ecology. Another is planning for several generational needs ahead, or for minimising the ecological footprint to assure resources recover season to season. The way a young boy learns to throw a spear in some desert cultures for examples, is often by social dance and song (Palmer, 1996). The singing of spear throwing and its acting out from boyhood to adulthood is key to many ideas designed to facilitate responsible safe management of that technology as a socialisation process. All culturally domesticated technologies, that is, technologies that have become indigenous to a group’s way of life, are and ought be, well embedded in relevant values essential to its coherent management of use. To this end, the ethic of the manifesto that seeks to develop a different consciousness accommodating complexity, holism and the interaction of systems, must include acceptance that hitherto rare exchanges between cultures will increasingly become a normal part of the global trade of ideas. We simply need to welcome this exchange both ways, and this is partly induced by the nature of the technological world now transcending beyond our ability to truly touch, nor ever absolutely comprehend it at any one moment. An idea that would have been thought ridiculous while we were mostly concerned with mastering take home, product assembly projects!

Technological practice thus far has concerned itself with its necessary and foundational, rather than optional, link to the social and cultural dimensions of its form. However, we are now much more aware of how all technological practice must necessarily acknowledge its reliance on its ecological foundations,
or broadly, resource environment. Both the means of production and the source of energy for the agent transforming the resource, are themselves systems that rely on fundamental resources from our ecology. In addition, we note that all ecological transformations have a tendency to yield waste and by-products that deserves quantification as a way to monitor our impact on the ecology we ultimately rely upon to live materially, economically and for many also emotionally. Sometimes calculated under the Pressure-State model of open systemic behaviour (Newman, et al., 1996), the ecological impact of our technological consumption (including multiplier effects of all school projects made annually world wide) is as essential to reduce as is the output of waste relative to the output of any desired amenity.

Technologists however, are now learning to see ecology as both a library of design manuals and technical solutions, as well as a million year old well tested design-research laboratory. The diverse forms of life and the eco-systems that life relies upon, are only now re-emerging as key instructions towards our lives supporting a lighter foot print. While the medical sciences have long identified the rich knowledge to be discovered in the medicinal properties of our plants and creatures, we are now also discovering the innovation, engineering structures and systems that nature can teach us to do many things more effectively (Forbes, 2005).

An education in Technology and Design that celebrates the ingenuity of cultures and their diversity

This dimension of the Manifesto explores an opportunity for synergy of the other two dimensions noted above. A great deal of traditional Aboriginal knowledge of the land involves intimate detailed knowledge of both the complex systemic patterns (as well as stochastic events) of nature, as well as the engineering and technological properties of it. Importantly, cultural principles have evolved that have held well to sustain the technological solutions of groups for tens of thousands of years: to compare Western civilisation is barely a few thousand years old. The methods and necessary social organisational knowledge about tools are ingenious. This ingenuity includes the use and sustainable management of kangaroo sinew, spinifex glue (a very high strength thermoplastic fibre resin); the selection of specific flora for spear construction; and, the technique to use fire to straighten and hardened spears - are examples of many years of design research laboratory work undertaken with their local ecology. Valuing, caring and learning from ecology has long become a core basis for Aboriginal ways of knowing in what is a complex contextual basis to sustain and enrich lives. Despite this learning, much of non-Aboriginal population across the globe has recklessly stomped over and permanently extinguished whole sections of the eco-library and so its design-laboratory notes. Tragically, we may now never know about the many innovations that were waiting to be discovered that might have been essential to our collective or regional futures. Thus, learning knowledge principles of complexity and ecology are now far more import to a new ethic in design and technology education than we have given it credit for to date. To effectively take advantage of the bio-mimicry potential of technology education demands new language, new higher order teacher training content, and new values to learn how to accommodate its diverse potential responsibly. This is knowledge that cannot be genuinely learned with a few staff development workshops or textbooks to foster and assess genuine capability and accountability among students. New school devices, tools, and resources reinforced with proper undergraduate or graduate education are required.

There is much to do in the field of cross-cultural technology education. For the most part, indigenous and cross-cultural technology education is not oriented to what it may appear to claim in many institutionalised education systems where such systems are typically oriented to serve predominantly urban economies and perceptions. In such institutions indigenous education in technology barely gets a mention¹, and when it does, its orientation is not uncommonly aimed at how to educate the fringe cultures

¹ In the southern hemisphere, a notable exception to this pattern is the New Zealand curriculum in technology education.
(e.g., how to act around or improve the educational scores) of indigenous learners to socialise them in dominant culture constructs of knowledge. While not necessarily a concern when taken in isolation, it does present a challenge when multiplied across regions and years, where such a view reveals limitations underpinning the education system for how it values new ideas to help address world issues. Few national or state curriculums list core Aboriginal ways of knowing and doing for its Aboriginal students, although the link to Maoris ways of knowing in New Zealand seems to be one of the exceptions. While some institutions of technology teacher education study Aboriginal technologies albeit fleetingly, most rarely explore and seek to embrace such modes of insight as core learning curriculum content to guide modern judgement, let alone tool or design choice considerations in activities and learning programs. It is rare for mainstream Education Boards to accredit Aboriginal and regionally significant hybrids of technological knowledge. This attitude must stop, if for no other reason than to assure mainstream education systems have a chance to be refreshed with essential new ideas and values in technology studies for our common sustainable interests.

The need to explore and exchange knowledge and ideas with other cultures is increasingly essential for very practical reasons. With more accessible international travel, web and media, all cultures are now closing and bumping in on each other like never before. Moreover, with no plan nor time for cordial introductions to appreciate the utility and complexity of each others knowledge systems, it would be prudent to at least assert a world wide ethic through Technology Education policy and practice to share and learn key principles cultures may offer each other. The conceptual frame driving our actions are no longer a local concern, but a consequential planetary one.

**Regrouping the core ideas: the use of technacy theory**

Most indigenous cultures have developed long tested principles to guide judgement and tool management based on how multiple variables influence each other. In the West we often class this kind of thinking as holistic. In fact, it is more than this for many long lived active cultures. It is holism with detail and utility in mind and accommodates probabilities of success in how tasks are viewed and undertaken. The long term (inter-generational) interest features often in Indigenous judgement, and this typically necessitates how material action, action that always consumes the ecology, equally draws upon socio-cultural values. Indigenous technological knowledge offers the wider “newer cultures” of the modern economies, a score of elegant principles to learn in technology. Such learning from other cultures may assist curriculum design and teacher education in the mainstream if done right.

One example of such synergy of thinking born from traditional Aboriginal Australia is technacy theory. Technacy is a relatively new branch of study. It aims at learning how we understand technological ways of knowing that is systemic and holistic so solutions are more likely to fit intended contexts of use and application. It draws on indigenous cross-cultural technology research and concludes with a new, more integrated scholarly framework for use in the mainstream. The theory is finding a wide range of application, maturing quickly as it gets tested in new contexts of use (Seemann, et al., 2008). The work "Clarifying Sustainable Food Technology Futures through Technacy Genre Theory", offers insight to the empirical potential of technacy theory in addition to its conceptual and qualitative value (Turner & Seemann, 2010).

The holistic framework of technacy education is a new educational model for thinking through technical learning. Technacy theory has since been captured in the Australian dictionary as its use widens across reports, peer reviewed publications and teacher courses. Technacy is the view that all technical actions are necessarily interdependent systems that combine human agency including values and organization, tools and eco-resources together towards an initial purpose in mind. And importantly, it is a view that holds that all technical challenges find their sustainable solutions based in understanding the envelope of key
contextual factors that need to be satisfied for the innovation to be functionally, ecologically and socio-technically sustainable.

As a result of the emerging value of technacy theory, a cross-cultural mainstream schools research project was funded by the Federal Australian government during 2007-2008, and managed through its national Curriculum Corporation. Working with 10 schools in the middle school age range (10 to 15 year olds), 27 Aboriginal, and non-Aboriginal teachers participated which involved up to 300 students. The goal was to enhance technological ways of knowing through developmentally appropriate experience indicators in technacy and innovation education.

As a result of this research, a new online technacy and innovation chart, or 'guide', has commenced development. Video, still images and dot point vignettes form an evolving collection of indicators as project skill complexity increases and demands on sociocultural, cognitive and applied contextual dilemmas unfold in technacy learning and innovation tasks. The technacy and Innovation chart however, demands open wiki style contributions for it to reach its potential. Accordingly, this presentation will invite world participation in the ongoing evolution of the development of the online recourse. While there is not the space in this paper to detail the emerging educational online resource (see under construction <http://dev.technacy.com/>, the response from the participating teachers and Chair of Teaching Australia Dr Ramsey has been overwhelmingly positive. They were so affected by the experience they formed in June 2008, in central Australia, an extraordinary collegial pledge, that resulted in what has become known as the Alice Springs Declaration: We educators and learners hereby declare that:

"We will foster and advocate technacy and innovation capability across curriculum and in teaching practice, in the interest of our common sustainable future." And, "We also acknowledge inspiration from desert people's ingenuity and the relationship between people, technologies and our environments that as a system offers both ideas as well as challenges for assuring intergenerational fairness." (Seemann, 2010)

Conclusions and recommendations for further research

The Clifftop Manifesto for Educational Change (Elshof, et al., 2010) raises the debate on eight dimensions of transformation in the field of technology and design education. Three of the dimensions addressed systemic complexity and holism, respect for ecology and the innovative contributions of cultures as core ideas to enriching the future of technology education. Increasingly, learning from and with other cultures may not only be unavoidable but essential. When we look at our planet from space at night we see immediately where the developed world consumes most of its generated power. These are the areas ‘lit up’ on our continents. They are the areas most urbanised, dense with sophisticated technological systems and where most of the wealth is consumed. In such an emerging technologically dense, connected world, new ideas are required. What is worth noting, however, is not the wide coverage of this lit up area, but where and how much land mass is left in the darkness. It is in these dark areas where we find both our key challenges as well as fresh ideas for how to redress global sustainability through a holistic basis to technology education. These ‘dark’ areas not only provide the energy resource to light up and feed the urban economy, but also offer a rich and diverse source of new ideas from indigenous peoples, whose knowledge can help the world innovate towards sustainable technological development and education.

Most of the world’s resource industries mine in these ‘unlit’ areas of our continents. They are typically sparsely populated with many small scale communities in rural and remote regions and in many cases, arid or extreme weather climates. Further, they are often refuge for the world’s remaining Indigenous and
developing cultures. As the world debates its sustainable future, all the while continuing to grow in its urban consumption for food and fossil fuel intensive technological systems, the ecological and social pressure will continue to bear upon the ‘unlit’ land mass for physical and, it is asserted, also conceptual solutions.

The scenario where the source for supplying much of urban fuel and food is from sparsely populated remote areas occupied in many countries by traditional and Indigenous peoples, indicates that the developed world must inevitably address the way it engages with those areas and cultures. Significantly, we also find that these areas not only are sources for fuel, but also for ideas. It was thus asserted in this paper that exchanging knowledge across cultures on how to understand technology reveals characteristics of technological actions that offer new systemic frameworks for innovation towards sustainable technological development.

To conclude, the paper presented a case where a new ethic is required globally to study the emergent properties and behaviour of complex and linked up technical, social and ecological systems. It argued that as the world increase its linked up patterns of development, it also confronts the cultural exchange problematic: how do we manage this exchange, and what can we learn from others. Increasingly, the developed cultures located in the ‘lit up’ areas of the world at night are becoming dependent on the ‘unlit’ areas of it for their existence and lifestyle. This scenario presents a key requirement to not only manage those vast and sparsely populated land masses and waters, but also work with the often indigenous cultures that live amongst those ‘unlit’ areas to help formulate new ways of thinking that can benefit the world. Finally, it is presented that the core ethics expressed in the *Cliff Top Manifesto* (Elshof, et al., 2010) are well placed to help respond to such areas of crisis as educating people who recognise that:

- Sustainable actions increasingly require innovation and working with linked up behaviours of systems.
- Innovation is not easy, and demands perception change and frontier attributes
- Globally, innovations in sustainability will increasingly need to work with and invest in indigenous ideas, many derived from remote areas. The West is in need of new paradigms.
- Holistic Technacy education came from such remote cultures and offers new ways to think technologically.

**Bibliography**


