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Technacy Education: Towards Holistic Pedagogy and Epistemology in General and Indigenous/Cross-cultural Technology Education

Dr Kurt Seemann (SCU[1])

Technology Education Research Conference, Dec 2000

Abstract

This paper consolidates a brief history of Western, particularly NSW[2], technology education. The paper asserts the case for a creative leap from convention in technology education paradigms apparent in much of Australian schooling and tertiary teacher courses. Technical education transfer issues in the Indigenous Australian context are presented that highlight serious theoretical flaws to resolve before one can assert the inclusion of technology subjects as core to educational (as opposed to vocational) development. There is a need to develop not only the pedagogical but also the epistemological basis to technology studies in schooling. Without this depth of understanding the field of technology education has little hope of meeting its potential as an equal in its standing to that of the traditional subjects such as Mathematics, English or Science.

Preamble

The concept of technacy education and research are outlined which have been endorsed by the Australian Science, Technology and Engineering Council for setting Australia's educational priority for 2010 opportunities[3]. Technacy has also become the new generic and examinable core in the Southern Cross University Technology teacher's course. It has been accredited as core to a highly successful national curriculum and award in Indigenous education and training: success that has also established its value as an attractive export education for complex overseas development projects. The technacy education paradigm is based on a holistic approach to perceiving, teaching, practising and learning technology in any culture. Its origin has been based on extensive years of field research mostly in central Australia but also in theoretical analysis work to assure its structures.

Technacy is founded on a steadily maturing theoretical framework and body of knowledge. It includes implied method and conceptual schema. In this way technacy distinguishes itself from such lay expressions as 'technological literacy' which offers no suggested method or schema. 'Technological literacy' maintains its utility in popular culture discussion, a level quite different to educational discourse.

Technacy, listed in the full Macquarie Dictionary, is therefore based on a body of evolving theory, practice and understanding. It offers a framework to teach and evaluate technology education, technologies in societies and industry development. It

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[1] SCU: Southern Cross University, Coffs Harbour Campus, NSW.
[2] NSW: New South Wales, Australia.
[3] ASTEC Report on Technacy, 1997: Available:
http://www.isr.gov.au/science/astec/astec/future/final/futureb.html

is the term to use for educational discourse that asserts a central place for technology understanding and competence in general and developmental education. In the same way as literacy is core to language and comprehension in society, or numeracy to number and mathematics, so too is the discourse in technacy to technology in society. Technacy is therefore not driven by vocational themes or agendas. Instead, its themes are driven by developmental concerns that underpin all other discourse that may follow in related branches of study and vocations.

Technacy education seeks to highlight the universals that define holistic technology education and understanding. It provides a generic expression for focusing and raising the level of pedagogical and epistemological exchange in technology education. In terms of outcomes, technacy education programs seek to develop skilled, holistic thinkers and doers who can select, evaluate, transform and use appropriate technologies that are responsive to local contexts and human needs. In other words, the technacy educator seeks to foster technate individuals, just as other educationists are striving to foster people who are literate and numerate.

The Wild West in the Evolution of Technology Education

In Western industrialised societies many scholars and teachers have devoted much of their time to analysing and debating the purpose of schooling. This of course was not always the case. The provision of education was traditionally the responsibility of parents and families and later, for some, the church. The context of human settlements generally dictated the things one had to know and to become skilled in, in order to simply live. What was taught by parents and their parents before them was sufficient. There was no pressing need to challenge conventional practices and thought. The economy, the social structures and the technologies of human settlements changed little.

During the nineteenth century, with the advent of the industrial revolution, western societies began to change their human, technical and environmental dynamics, although some scholars have argued that the changes began much earlier when Benedictine monks introduced systematic work routines to mass produce the Scriptures (Mumford, 1934). The rhythm of production, it was said, was already in place and set human activity towards a greater degree of mechanization. The invention of the clock only helped to speed this process up. Time became a measurable commodity, divorced from the natural cyclical seasons and the sometimes chaotic patterns of nature. A growing proportion of people found themselves looking towards a clock to regulate their activities and their production, rather than towards the patterns provided by nature.

The model of a linear sequential time interval soon became the backbone of Western education. To prepare citizens for industrial life, they had to become productive as a measure against labour time. People were led to believe that to have self worth they had to regulate their working day to achieve maximum productivity. People thus became organised as cogs and functionaries for industries (Mumford, 1934; Seemann, 1987; Toffler, 1970; Wartofsky, 1979). The industrial, regimented work ethic became a measure of self worth and soon found its way into education. Schooling began to emulate the factory. The school day was regulated by the bell. It could be said that these underlying patterns still prevail today in most schools, the only changes being in lesson styles and educational technologies. In many countries vocationalism has re-

emerged, placing renewed expectations on schooling and technical education to produce economically productive functionaries.

The school systems of the industrial era presented the world as generally ordered into independent subjects. This pattern so characteristic of western education sounded warning bells for some educationists. Dewey, for example, rejected the divisions of the curriculum, arguing that disintegrated school curriculums produced disintegrated minds (Dewey & Archambault, 1974). The divided presentation of knowledge deskilled the mind and reduced its capacity to make integrated judgements. The powers and structures of industrial economies were inappropriate to foster the development of integrated schema of social, cognitive and material experience. It could be said that people were expected to become efficient only in the short sighted particulars. What was not fostered was the long sighted integration of knowledge that is needed for the implementation of sustainable development strategies.

Western education thus has become a commodity of modularised, disintegrated learning. With the aid of science and technology, it has become more important to collect data and file it in databases than to make practical, integrated sense of it all. The current explosion of the information age into global networking will no doubt produce fundamental effects, leaving others wanting. One effect may be an increase in the demand for "anywhere/anytime" database and communication software and pocket-sized hardware. We can expect an increase in the tendency to extract convenient data from the huge pile of changing information in order to advance private or secular gains: a kind of self-satisfying pseudo-science. An area left wanting may continue to be the development of expertise capable of understanding the whole, extracting the essentials, and implementing new processes that are relevant, humane and sustainable in their outcomes.

With industrialisation, education became instrumental in creating new social hierarchies. Managers of industry achieved higher status while workers on the factory floor assumed subservient roles, even if highly skilled. In the school too, when manual training in woodwork and metalwork was offered, it was quickly relegated to a lowly position and so became the preserve of the slower learners. The academically oriented subjects became more highly valued. Literacy and numeracy thus became the cornerstones of western education, while technacy was marginalised. In effect, the human hand was perceived and represented in the curriculum as divorced from mind and therefore less prestigious.

The separation in the curriculum of mind from matter was the antithesis of village education in pre-industrial Europe. For many villages, the most highly prized individual was the chief artisan such as the blacksmith, the carpenter, or the stone mason. Not only were they skilled in their craft but they also relied on them for practical community guidance in the social sense. The prowess of the artisan was deeply embedded in a social context that directly related to the natural environment from which his/her raw materials were derived. The artisan's prowess was necessarily defined by the interdependent relationships found in the social, technical and environmental context of the craft.

Emerging from the Foliage

While there has been a socio-political policy push in recent years, to re-assert vocationalism, there is also a clear undercurrent in the labour market to shift away from that policy paradigm: students in the United States are voting with the new tide of opportunities. A recent report published its findings that in United States high schools, in the last ten years, a dramatic decline has occurred in students electing Trade and Industrial Vocational courses while at the same time a surge has emerged in the election of service and academic based courses. This trend has been explained as matching the move in the US and global labour market towards the new ideas or innovation economy now driving new industries (National Centre for Education Statistics, 2000). Given that much of Australian trends in education and economies follow those in the US a few years later, it is no wonder that the recent Australian Innovation Summit has pledged such enormous support to raise the standard of technology teachers in readiness for the new wave of the innovation or ideas economy (Innovation Summit Implementation Group, 2000). Could it be that, essentially, we are hearing the cry "the era of manufacturing trades and associated vocational courses is setting. Long live the rising ideas and service economies"? The bigger question for our profession is, how do we break this news to fellow technology teachers in NSW schools? And, who are going to resist and who are going to get excited about this cry?

The Transfer Of Technical Education To Other Cultures

When western colonisation and invasion occurred, the education system introduced was predominantly literacy and numeracy based. Ghandi once criticised the imposition of British education in India as a major contributor to the demise of rural India as a dynamic region of small cottage industries. Local innovation and small-scale rural productivity not only declined, but became less valued socially. Indigenous rural production was both economically viable, and was undertaken in a local social context that contributed to cultural maintenance. Technical activity and innovation defined Indian culture in many ways. The introduction of non-technical activity redefined the identity and aspirations of many Indian people. When British colonisation began about 200 years ago in the continent of Australia, one of the first effects for the indigenous peoples was the displacement of materials for hunting, tool reproduction and shelter. Prior to the British invasion, indigenous Australian tools and trading lines across the continent were in a balanced technacy dynamic, which in turn maintained long standing social structures.

> **A Case in Point: The Steel Axe.**
> Most remote indigenous communities today use the short-handled steel axe for hunting and gathering, and for crafting goods for the tourism market. However when missionaries first handed out the axes to encourage church patronage, a ripple effect disrupted long standing social structures (Sharp, 1952). The axe was traditionally a men's tool. The prized smooth stones of traditional axes were tradable items linking local groups with trade lines across the country. For groups in the far north the hardwood axe handle had to be traded from desert groups to the south as local woods were less suitable. Some men held particular status because of acquired skills as trade negotiators, and because they had established friendships across vast lines of trade. Skills of diplomacy in trade gave rights to men to regulate the axe. Women were not denied the axe, it was simply a very important survival tool, the men having primary responsibility for its care. Women had similar tools that defined their own roles. To gain a traditional education in the production of axes was to develop social trading skills, technical knowledge, and techniques in assembly and selective extraction of local natural resources. One could imagine that the traditional knowledge that assured

> sustainable axe supplies for community survival was something akin to having passed through an education in technacy. The present day antithesis would be for a school to teach a module that leads to the fabrication of a traditional stone axe without genuinely developing skills in trade negotiation, and in the selective extraction of raw timber from the environment in a socially acceptable way.
>
> When steel axes were handed out to uninitiated men, and to women and children, in the above example, the trading skills and social status of men changed. In time a new balance was achieved where all used the steel axe. But now, rather than having artisans to sustain local subsistence economies, indigenous Australians are dependent on receiving a cash income in order to buy, repair and sharpen their axes. In effect, from a sustainability perspective, they have taken a backward step. They have had to move from being technate to being technical. The steel axe without question is technically superior to the stone version, but there were no options open for people to incorporate the steel axe into their cultural context. While the axe is a relatively insignificant example, the principles of its introduction and effects could be replicated many times over in relation to other new technologies introduced to indigenous communities since western colonization (Seemann, 1997).

Western technical education introduced to indigenous communities was no different in its negative effects. Modularised, and taught as if technical skills were defined independently of the social and environmental contexts, western technical education has had minimal desirable impact in remote indigenous communities. In particular it has failed to provide them with local maintenance personnel who are able to service and repair equipment and machinery. In effect, the social lore of technology was not relevant to indigenous people living in small, remote communities. The community context was much different not only to the woodwork and metalwork rooms, and to the tools and organisational dynamics, of the technical training programs introduced to indigenous Australian communities, but importantly it was different in the value and paradigm from those of indigenous students.

Transfer Data

Of the many significant changes that have impacted on the lifestyle of Aboriginal people the most pervasive has been the role played by new technologies. Many recent strategies (health, housing, employment, community development) rely on technology to underpin their success. The facilitative role of technology makes it a means to an end therefore it often receives less attention than the desired ends.

A 1987 survey of 34 remote Indigenous communities throughout remote Australia. We identified those pieces of technology and technical hardware that were available to people in the communities (Seemann, 1997).

Table 1. Commonly found tools and technologies. [4]

[4] Centre for Appropriate Technology, The Aboriginal Technical Worker Feasibility Study Report, May 1990, p22 (Project Officer: K Seemann)

Technologies most used by individuals		Technologies most used by the council workshop	
1	Axe or tomahawk	1	Shifting spanner
2	Spear	2	Screwdriver
3	Broom	3	Hacksaw
4	Garbage Drum	4	Socket Set
5	Digging Sticks	5	Tyre repair tools
6	Television	6	Oxy Cutting set
7	Gun or rifle	7	Hammer
8	Fishing equipment	8	Pliers
9	Utility knife	9	Shovel
10	44 Gallon Drums	10	Crow bar
11	Electrical extension lead	11	Spanner set
12	Shovel	12	Measuring tape
13	Hammer	13	Tyre bead breaker
14	Screwdriver	14	Arc welding set
15	Shifting spanner	15	Vice grips or clamps
16	Video recorder	16	Stilson pipe wrench
17	Wood rasp	17	Woodsaw
18	Pliers	18	Cold chisel
19	Boat	19	Fixing devices (glue, bolts,etc)
20	Metal file	20	Electical extension leads

It was observed that people responded to these technologies and many accommodated new technologies - cassette recorders, cars, TV's. They identified a range of short cut methods of coping with these technologies - matches as electrical connectors, spent bullet cartridges as car fuses etc. Clearly a technology training program in this situation had to cope with few resources, differing concepts and broad multi skilling and low levels of specialisation.

The response was to identify core competencies that would allow people to sustain and develop their life in these communities.

It was noted that many of these people were neither literate in a western sense nor numerate beyond simple counting - yet they were able to modify existing traditional and new introduced technologies to provide benefits, although the benefits were not always those imagined by the designers. This response has sometimes been referred to as 'bush mechanics'.

People were able to take needs, and match them with materials and resources etc and apply skill and knowledge to achieve an outcome. Not always efficient but an outcome all the same.

It was concluded that in times of rapid technological change there is little time to go through a linear process of literacy followed by numeracy. These people had started with what we called technacy - an ability to manipulate form in space. A three dimensional expression or response to need. In doing so they had taken account of resource availability, cultural and social issues and a range of time and money issues.

In many respects a holistic problem solving approach not bound by various disciplines, work classifications (trade demarcation) etc.

The above analysis emphasised the need to develop a totally new framework for technical education for indigenous people. Traditional knowledge had sustained the existence of Indigenous culture for 40,000 years. Technology and technical activity were inseparable from social and environmental knowledge. There was no basis to a technical knowledge framework that excluded social and environmental knowledge. To produce an artefact, a tool or a shelter was to integrate all three forms of knowledge.[5]

Technacy provides a framework for considering science and technology within a socio-environmental context. Technacy is a way of defining the meaning of technological literacy that goes beyond competency in using technology. Technacy is the technological equivalent of literacy and numeracy, and relates to a holistic view of problem solving, communication and practice that includes consideration of social technical and environmental resources and constraints.[6]

It is a view that recognises the values underlying the design and application of technology. The concept of technacy is particularly applicable to cross cultural technology delivery situations, but it has broad applicability in technology education and practice. Some have argued that it might be regarded as a third basic competence alongside literacy and numeracy. It is this technacy which should be taught in primary school not a history of science and technology or manual crafts or computing.

Rethinking Technology Education

The above analysis emphasizes the need to develop a totally new framework for technical education not only for indigenous peoples but for all peoples. There ought be at least two outcomes to such a reform: it must be useful to the individual and it must be useful to the society.

> **Another case in point: Pandanus Baskets.**
> Traditional knowledge has sustained the existence of indigenous Australian cultures for over 60,000 years. Technology and technical activity were inseparable from social and environmental knowledge. There was no framework for practising technical knowledge apart from social and environmental knowledge. To produce an artefact, a tool or a shelter was to integrate all three forms of knowledge. To illustrate this point consider how women in small island communities in northern Australia integrate skills to produce pandanus baskets (or carry bags) for themselves. They organise a work group, with each woman having particular tasks, including food preparation and child care. They arrange transportation to a site in the natural bush to harvest the best pandanus trees. Each tree requires a keen, informed eye to pluck the better leaves for weaving. Roots also are collected for dye. While this is going on, children are encouraged to watch carefully as a learning exercise, not only in pandanus harvesting but equally in the social protocols and organisation of the whole day. Some of the tools for manufacture of the baskets are fashioned by the women themselves while others are purchased (Walker & Seemann, 1990).

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[5] Seemann,K and Talbot,R. Technacy: Towards a holistic understanding of technology teaching and learning among Aboriginal Australians, *Prospects, vol XXV, no4*, December 1995. p765
[6] Seemann,K and Talbot,R. Technacy: Towards a holistic understanding of technology teaching and learning among Aboriginal Australians, *Prospects, vol XXV, no4*, December 1995

The above story is very important. The technology of pandanus basket construction could not be conveyed adequately through a compilation of segregated competency modules. Yet much of technical education being imposed on indigenous peoples is still based on an industrial world view that emphasizes the compartmentalisation of knowledge through modularised learning. For women in island communities, learning the technical skills of basket construction is necessarily a social event deeply embedded in sustainable human and environmental relationships. The whole exercise necessarily integrates social, technical and environmental knowledge and skills. To represent the pandanus "curriculum" in a series of parts would be to misrepresent the quality of the integrated knowledge these women have developed. A disintegrated curriculum simply produces disintegrated judgements and hence inadequate solutions to the project or problem at hand.

Stepping away from the Foliage into new rules and uncharted territory

In developing a new framework for the technical education curriculum, then, it is important to recognise the capacity of this area of knowledge to teach students how to think and act holistically. Their accumulated knowledge and skills from other subjects, and their personal life experiences, now can be given meaning in the one integrating medium of the design and technology curriculum. This assumes that the new framework is socially innovative, and that design and technology education maintains a link between learning and its application in the community. Given an adequate model, there is the potential for design and technology education to be an enabling and empowering medium for students to integrate their cognitive, psychomotor and affective capacities, thereby enhancing their ability to make holistic judgements that lead to holistic practice.

In my experiences with indigenous Australian technical education, some theoretical and practical problems have had to be overcome. The first was the conservatism of Australian industry and State Education systems. Industrial unions were initially concerned for the protection of their particular trades. In many ways the TAFE sector has maintained this legacy due essentially to both the source of their compliment and their complex funding policies and constraints. It is for example, not surprising that through the 1990s enterprises have pushed hard to gain the right to be their own Registered Training Organisation so that they many credential their staff, their way for their company needs rather than to the tune of others. Although this concern has changed a little during the past few years (for the better), it is still a battle in the political arena to promote successful new models in technical education, particularly amongst our own fraternity of technical educators and mainstream educational funding bodies. Why may we ask has it taken until 2000 for Australia to have a Technology Education Research Unit? Perhaps this unit's biggest challenge is to engender genuine research into a new bread of technology teachers here after and to support the many thousand highly dedicated practicing teachers with useful research findings.

The second constraint has been the language embedded in the mainstream technical education curriculum. In Australia, the English lexicon is reasonably well equipped to name most finite bits and pieces of the world. We seem very capable of finding names to describe parts. However we do encounter problems in assigning names to integrated concepts and modes of practice. In technology education, for example, we

find people talking of technological literacy, which seems a very obscure expression. When indigenous Australians attempted to relate their concerns to the broader Australian community, many of them found that non-indigenous Australians either did not understand their message, or reacted to their requests with too much emphasis on the details. The spirit of the proposed programs was lost once it was processed through centralised legal and accounting procedures.

A third problem has been the lack of a simple, understandable model to help teachers and students to integrate holistically in design or problem solving processes utilising tools, material forms and spaces, and techniques. Another problem has been the major constraint of simulation where the teacher, or a computer, would attempt to replicate a problem or task in a classroom, which all along was happening naturally outside the school. Learning to respond to the rich unpredictabilities of real life events provides a good environment for developing holistic skills.

Technacy Development Issues

Out of the above issues developed the core educational model that is now becoming known as technacy education. Technacy is a simple but powerful holistic model developed to accompany design processes in technical and general education. It is a model that, in effect, advocates that all technology practice is grounded necessarily in the dynamic interaction of its social, technical and environmental states. These three elements of technacy become both the resources and the constraints of all technical activity, and thus together their dynamic defines much of human knowledge and existence. The idea is to move the student on from developing his/her technical skills, to becoming technate. Developing ones technacy skills is as much an art as a science. We can parallel this argument in literacy and numeracy education. Just as there are levels of competence in literacy from writing one's name to writing profound poetry, and in numeracy from adding a few numbers together to compiling a fundamental formula in physics, so too there is a range in technacy from being skilled in joining materials together or repairing equipment to being innovative in the design and development of appropriate technologies and systems. From an educational basis, our research in technacy education is designed about the following framework.

- *Technacy Pedagogy*
  (Removing the traditional vocational case, what is the educational case for technology studies in k-12 schooling? How and what ought we be teaching today for the future at different ages?)
- *Technacy Epistemology*
  (What do we understand of the phenomenology of technological activity, designing and technical experience in the development of knowledge, values, and in various settings such as in cross-cultural technology transfer settings and future studies settings?)
- *Developmental Technacy*
  (What may be the development psychology and sociology aspects of technacy education? Can we develop a technacy age index as we have for diagnosing development in reading and number? Can we develop a taxonomy or benchmark of understanding against levels of educational development for aspects of technacy education?)

Put simply, technacy is holistic technology problem solving, communication and practice. It is a view that perceives technology practice as value laden. The utility and appropriateness of technologies are defined by the end-user in the local context. Technacy can be argued to be the main art, skill and knowledge of appropriate technologists.

First Principles Of Technacy: A Theoretical Proposition

The theoretical model underpinning technacy has one side of its "ancestry" linked back to Hegel, Feuerbach, Marx, Dewey, Wortofsky, Schumacher, Papanak and Ihde in western societies (Seemann, 1987). On another side its "ancestry" is linked back through the social learning styles and knowledge frameworks of indigenous Australians, and probably of many other indigenous peoples (Walker & Seemann, 1990).

Technacy is based on a three way "dialectic" of necessarily interdependent parts. These are the human, technological and environmental ingredients of any technical undertaking. Each part both defines and therefore requires the other two parts. No pair can be adequately defined without inclusion of the third part.

The notion of human consciousness and social organisation, and indeed of human existence, proves to be an inadequate proposition as a self defined thesis. Human existence finds its definition in the manifestation of human technology knowledge and social material practice.

However the human technology dialectic also proves inadequate as both are partly defined by their natural environment. Humans cannot exist without drawing energy from and manipulating their natural environment. Technology software (knowledge of such fields as economics, science, computer programs, social science) and hardware (forms and spaces including equipment, tools, houses, farms and settlement infrastructure) cannot exist without the same.

The technology-environment dialectic is an inadequate proposition as neither technology nor the environment gain their definition entirely from each other. They both interact with humans. While the environment could be argued to exist without human involvement, at issue is the definition of human knowledge and technical practice. It is thus academic to debate the independence of the environment from human existence or human technology when our concern is to understand and define the universal concept of human technical activity. Put crudely, the concern for human technology practice, and so for education, is only relevant where humans exist, intend to exist or can apply their technology.

The technacy model contrasts, or complements, one particular idiom of western logic: Venn's logic of intersecting sets. If we represent the three context factors of the technacy model as Human Context Factors, Technological Context Factors and Environmental Context Factors they would look like Diagram 1A and 1B below.

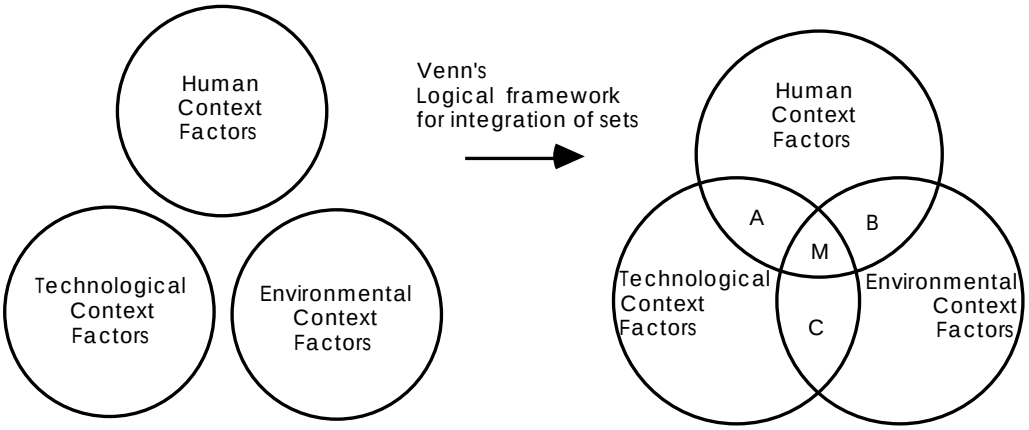

Diagram 1A

Model of world where parts are intially perceived as independent sets.

Diagram 1B

Model of the integration of independent sets showing integration pairs A, B, C and full integration at M.
(M=region of Mutual integration)

Diagram 1A is a representation of a view where the sets intending to be integrated are in the first instance perceived as disintegrated, or as independent and self-defined. This is consistent with much western logic where we tend initially to approach a problem or task as being made up of independent sets or parts. In effect we disintegrate a problem when we analyse it as our initial course of action. At this point, many of us can get lost in the detail and fail to see the overall outcome or solution to the problem we are addressing. We often lose our focus. We then attempt to put together a solution and specify a response. But in Diagram 1B, the integrated solution, 'M' is not consciously or necessarily the outcome. It is possible to ignore one of the sets and produce a solution only integrating in A, B or C. Thus 'eco-tech' solutions (green technologies) could focus on 'C' outcomes ignoring or making gross assumptions about the human social or political consequences or benefits of their actions. Socially sensitive technologies at point 'A' risk ignoring or making gross assumptions about the environmental consequences or benefits of their actions. And socially sensitive natural environment projects at point 'B' risk ignoring or making gross assumptions about the technological consequences or benefits of their actions. Judgements in the past made in the areas of A, B or C exclusively have quite possibly been mis-judgements.

The technacy model outlined previously argued that the triad is essentially interdependent. If this proposition is true and relevant for human technical practice, how can it be possible to produce solutions in A, B or C exclusively? Indeed, how can it be possible to represent the three interdependent "sets" within the predominantly western logic of Venn's diagram from 1A to 1B in the first instance? The proposed solution is to develop a new model to represent the holistic integration of interdependent "sets", as shown in Diagrams 2A and 2B. The old Venn framework is plainly limited, not irrelevant, just limited.

The technacy model in Diagrams 2A and 2B below is only a model, but we think it a very useful one. Its purpose is simply to guide conceptual development and holistic technical education practice. However, it does show how western Venn logic has limitations in its capacity for guiding true integrated technology practice: i.e., for the attainment of "M" solutions.

Diagram 2A shows that no one aspect of human technology practice can be defined and analysed without necessarily including the other aspects. Holistic technology practice exists at ‘M’. Holistic technology education therefore must foster the capacity to function creatively in ‘M’. Thus technology practice and technology education have their performance regulated by how well they have been tailored to the human, environmental and technological contexts of the end-users of technologies and technical training programs.

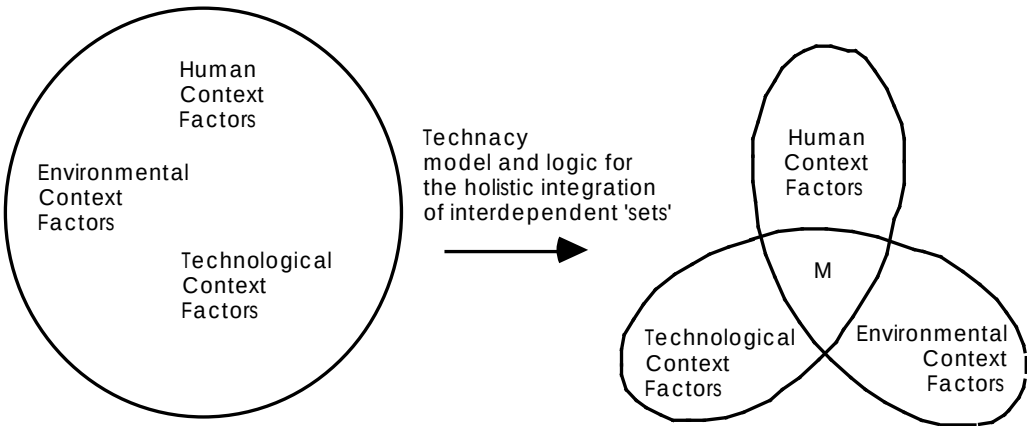

Diagram 2A

Model of world where parts are intially perceived as members of a whole

Diagram 2B

Model of the holistic integration of interdependent sets showing integration at M.

No two sets can be integrated without necessary inclusion of the third set.

The technacy model for guiding curriculum and educational practice is static on its own. There have been four major developments in technacy education, all resulting from the input of indigenous Australians. The first development was to embed the technacy model in all stages of designing and problem-solving education. The design process has been analysed in many texts for its educational value, but generally missing was a framework to guide students and teachers in their efforts to design and produce holistically integrated solutions: hence the technacy model. Diagram 3A provides a model of the stages one progresses through in the course of designing. In real life designing is much more of a chaotic exercise with designers naturally jumping backwards and forwards in the design process, for designing incorporates individual creative thinking patterns. Nevertheless, the model of the design process adequately represents the overall logical sequence of the art and science of designing. Diagram 3B shows how technacy underpins all stages of the design process. This ensures that technacy education is focused on the development of holistic technology practice.

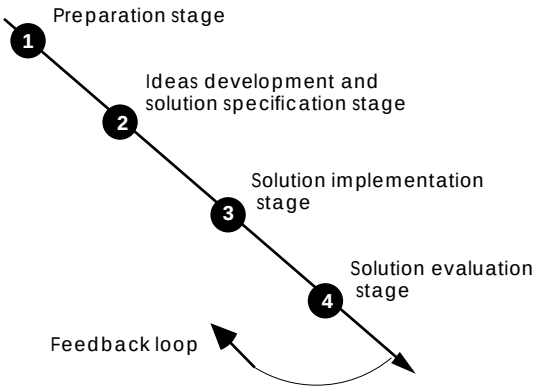

Diagram 3A
Basic problem solving and design process

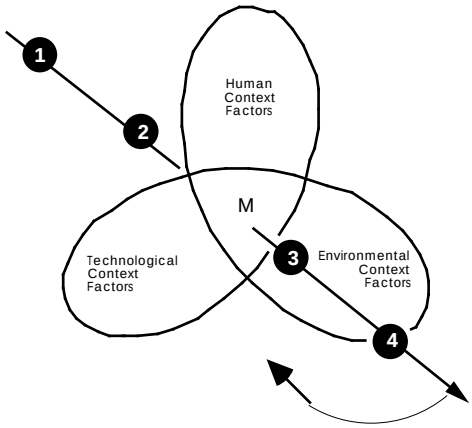

Diagram 3B
The technacy model is written into every stage of the design/problem solving process to foster holistic technology problem solving skills

The second development was to organise the application of technacy education around the functions in remote settlements that determine their viability and utility. A study of several remote indigenous communities across central and northern Australia showed that most of the technical breakdowns in communities that are often linked to poor health environments occur in five key settlement functions: water, waste and sanitation, shelter and space usage, transportation and communication. Each involves a particular social and technical dynamic for its maintenance and development. These five settlement functions were consistent across all communities. They became the five strands of the technacy course that feature in the new curriculum. All students have to practice their design and problem solving technacy skills with projects in all of the strands. In this way they will gain broad experience of how their community functions from a technacy perspective. Energy, like economics, was seen to transcend all these functions and so was classified as part of the hardware and software of the technacy model. Learning about energy only has value when it is applied to something meaningful such as transport, shelter or communication technologies.

The third development was to make the curriculum *project* based rather than *tool-specific* based for learning outcomes. The latter skills were included throughout the course but only on an "as needed" basis determined by the students, in collaboration with their educators and occasionally with their communities. The process of undertaking applied technacy design projects in water, for example, required students to identify a project that was meaningful to them and where possible to their home community.

One student identified his grandfather's traditional land in the arid zone of central Australia as needing a more sustainable way to store rainwater. The student was aware that he could have gone to a retailer of fibre-plastic rainwater tanks, but decided against it. Considering the technacy model, he argued that *technologically* such a tank would be difficult to repair out in the bush should it be damaged, and that fibre-plastic technology was much too expensive for the scale of the local economy at his grandfather's camp. *Human* issues included a desire to keep skills in the camp and not have outsiders coming and going all the time to install and repair the tank, leaving no reusable skills behind. *Environmental* issues included the fact that the land

at his grandfather's camp was sparse, with little timber, but had plenty of desert sand. He grappled with several ideas and finally decided he wanted to try and construct a ferro-concrete water tank using "bush sand" from the camp site. He had no skills in cement mixing and as a result the educator included in his learning experience a short module dedicated to cement mixing techniques. The end result was a very functional and locally repairable water tank for his grandfather. The student had commenced his journey of empowerment in holistic technology practice through the production of technologies appropriate to his grandfather's particular context. It should be noted that the student not only gained skills in specific technical processes, but also in the overall organisational skills required for getting the job done in a culturally, technically and environmentally appropriate way.

The fourth and most recent development has been to structure the technacy and applied design course in an overall career path that maximises local knowledge yet links to other courses. The technacy course was earlier given the name of the Aboriginal Technical Worker program. This has since been abbreviated as the ATWORK program. It has many parallels to community health worker programs, but essentially provides primary technical care of the physical aspects of communities. Graduates are known as ATWORKERs and now have a four level training and career path to progress through if they so choose. The highest level is technology management oriented, with the option to specialise as a community educator in technacy. The certificates are nationally recognised across Australia and lead to a qualification in 'Applied Design and Technology'. The basic focus is on applied holistic problem solving in technacy, and on the development of appropriate technological solutions to community problems. The ATWORK course differs from the conventional output of technical training in many ways, an important one being its emphasis on appropriate solutions as an outcome, rather than a technical skill as an input.

Conclusion: A Creative Leap From Convention

This paper has argued that the evolution of western education generally, and technical education specifically, has not moved beyond the compartmentalised and mechanistic delivery of skills. Indeed, in recent years, with short term vocational pressures, ever more finite divisions have been introduced to the curriculum and how such Vocational Education and Training is funded. This disintegrated model has been transferred to other cultures during colonisation. Most of these transfers have yielded little benefit to the recipients, complex tricks for VET providers to assure some continuity of funding delivery and very often, such training has only destroyed indigenous and mainstream stock of innovative non-standard, but usually most sustainable techniques, knowledge and wisdom in local technical activity.

Far from the claim that technology education and teacher course may be too theoretical, it is the assertion of the author that technology education lack credible research depth. Within this dearth is also the lack of a generic theoretical framework. The first principles of technacy education has made a significant contribution to addressing what that framework may look like and offers a vast range of pedagogical epistemological and development research possibilities for advancing technology education.

There is a missing element in basic education. For many years literacy and numeracy have been the cornerstones of western industrialised education. Many people have questioned the adequacy of this cornerstone for the new technological age. In addition to literacy and numeracy there are basic skills in technology and problem solving which are required to support a technological lifestyle. The need to reform the understanding and practice of technology education is just as urgent in western industrialised societies as it is in developing countries and indigenous communities. Wherever an educational program exists, there too an education in technacy should exist. Where technacy does not exist, or where conventional technical education or design process education is active, there should be an overhaul of the quality of the judgements derived from such programs.

The most developed literacy and numeracy programs will provide neither the skills nor the rounded judgements necessary for an integrated approach to technology. Nor will the most effective technical training program or design program alone yield people capable of producing appropriate and locally sustainable innovations. Somewhere these programs need to reset themselves towards an education in technacy. Technacy education is in its infancy. It works well, but there is a long way for it to go before educators find a consistent method to teach others how to integrate holistically, and how to gain competence in holistic technology practice through technacy. There is a need to generate a new universal curriculum. There is a need for a creative leap from convention in technology education.

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