Technology Education: perpetrator of past problems or gadfly for favoured futures?

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Abstract
Past constructions of technology education have, in general, been narrow, instrumental and, in terms of the crowded curriculum, marginalised. The recent ‘jollification’ and preoccupation surrounding the current dominant technology (information and communications technology) has raised a mixture of challenge and misunderstanding for the field responsible for ‘education’ in, through and about technology.

This paper takes both historical and futures perspectives in seeking to position or ‘get a fix’ on technology education today. There are ways that past, limiting, curriculum constructions are being perpetuated and that knowledge gained from experience is not being used in the case of emergent technologies. The paper uses the ‘skills-design interface debate’ in the contexts of past, current and emergent technologies to show how there is dissonance between curriculum development, pedagogical practice and general (public) technological awareness.

The paper presents some of the shaping and limiting influences on Technology Education curriculum design and draws on recent (Design and) Technology curriculum developments to illustrate potential for a critical education that embraces holism to assure ethical design practice for preferred futures.

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Introduction
The title of this paper has deferred to the more common descriptor of this field of education in Australia, namely, ‘Technology Education’ as it was constructed as a ‘learning area’ with its own Statement and Profile (AEC, 1994a&b). This curriculum construction has served, in its broadest usage, as a basis for the field in all states and territories. However, recent years have seen the emergence of localised revisions and refinements and this paper’s concern, advocacy and curriculum location is better described by ‘Design and Technology’ (D&T) – nomenclature gaining increasing usage both within and beyond the country.

Such naming, using a compound noun, is a result both of three decades of curriculum innovation and evolution as well as, for example in South Australia (DETE, 2001), considered and contested debate in recent times. Its use in New South Wales was formalised in the early 1990’s (Board of Studies, 1991). The history of the developments, and the politics of the debate are beyond the scope of this paper but are signified as being ever-present. As will be shown, the word ‘technology’ is prone to multiple understandings and uses both within and beyond education.
The paper is written with focal two circumstances in mind. The first is that ‘technology’ and ‘design’ have both had long histories and, it will be argued, futures, central to the development of our species. Secondly, it remains the case that both have had a reciprocal marginalisation so far as education is concerned.

**Historical perspectives of the state, technology and education**

Three historical snapshots of relationships between the state, technology and education are offered. They are set at, roughly, 100-year intervals and are presented to show that, at any time in a society’s lifespan, a relationship exists between people, social and political systems, and technologies and, as a result of this relationship, there are significant educational implications.

The 18\textsuperscript{th} Century period of the Enlightenment offers much by way of comparison with present times and Postman (2000) has made this the focus of his recent text. However a particular study of Thomas Jefferson is illuminating. He was barrister, Governor of Virginia, drafter of the Declaration of Independence, and third President of the United States. Such is the cultural valuation of the significance of technologies and those who develop them that one must search further to establish Jefferson’s roles in architecture, invention, agriculture, patenting and the establishment of decimal currency. However, it was the aggregation of all these capacities that allowed Jefferson to articulate his concerns for the *kind of society* he was willing to advocate and defend in the light of the alternatives he perceived in France and Britain at the time. (Hofstadter, 1958; Meier, 1981; Postman 2000)

Jefferson saw clearly the relationships between the technologies of the day and the forms of labour and economic organization that were possible. His analysis of agricultural and industrial practices at home and abroad led him to comment on the kinds of social and educational organization that could be engendered for a better world for American people. He recognised and articulated the significance of ‘know-how’ – procedural knowledge – against the (still today) educationally dominant propositional knowledge - ‘know-what’; of the dangers of private ownership of knowledge through patenting; of the excesses of capitalist industrialism in Britain’s mines, factories and mills; and, of the value of scepticism in political, religious and practical life. As Meier puts it, he was ‘…America’s earliest distinguished spokesman for a democratic technology.’ (Meier, 1981:17).

His self-professed “zeal to promote the general good of mankind by an interchange of useful things” resulted in a stream of ideas, books, commodities, and inventions likely to improve American technological know-how.

(Meier, 1981:22)

So far as patentable knowledge was concerned, Jefferson had a clear democratic vision (though it must be said that he wasn’t able to hold this position without moderating it in time). He thought that ideas for inventions were universal and should serve to improve the human condition. He argued that invention was ‘…an accumulative process rather than the single fruit of genius’ (Meier, 1981:28) with one idea leading to another and another thus having a public and social function. He likened technological knowledge to the flame of a candle:
“…He (sic) who receives an idea from me receives instruction himself without lessening mine, as he who lights his taper at mine receives light without darkening me.” Consequently, Jefferson conceived government’s role to be that of disseminating information useful to the citizens rather than insuring material profit for innovators. (Meier, 1981:28)

(How things have changed with the US government recently granting itself exclusive rights over a foreign citizen’s cell line (Penenberg, 1996)). As would be fitting of such a citizen and thinker, Jefferson articulated his vision into his educational designs.

Jefferson planned to introduce branches of technologically oriented education into the curriculum of his proposed University of Virginia, observing that “I have taken some pains to ascertain those branches which men (sic) of sense, as well as of science, deem worthy of cultivation.” (Meier, 1981:21-22)

Penfold (1988) provides useful analysis of the technical education scene in European countries in the late 19th Century. At the Great Exhibition of 1851, the first ever international exhibition, ‘…Britain’s manifest industrial supremacy’ was on show with manufacturers receiving ‘….a bevy of international accolades awarded by the exhibition jury.’ (Penfold, 1988:1) Just 16 years later Britain fared nowhere near so well at the International Paris Exhibition and:

Sir Lyon Playfair…a jurist on the international panels of both 1851 and 1867, believed he had identified the cause of Britain’s decline: it was lack of technical education. …(H)e compared the inadequate British provision with that available in the educatio n systems of…industrial competitors… (singling out) France, Prussia, Austria, Belgium and Switzerland… (Penfold, 1988:1)

1881 saw the establishment of the Royal Commission on Technical Instruction which was, inter alia, to ‘…inquire into the Instruction of the Industrial Classes of certain Foreign Countries…’ (Penfold, 1988:7). The momentum continued in many quarters of professional gatherings, parliament and the press. In 1886, one Professor Ripper argued that:

…the existing curriculum should be pruned to make room for industrial instruction …(and said) “We are entitled to expect from the schools substantial help towards the future industrial, as well as social, progress of the country…We believe that the early training of the children will have much to do with our future national progress…” (Penfold, 1988:11)

There is much to deconstruct from these extracts and Penfold documents a detailed picture of the times. The education under discussion was, of course, particularly for a working class – that necessary component of industrial capitalism – and its discriminatory jargon lingers today through terms such as ‘non-academic’, ‘good with one’s hands’, ‘skills-based’ and ‘job preparation’. Of major political and social impact, it was ‘for boys’ and thus, with the parallel
‘domestic training’ for girls, established the foundation of what remains today the most overtly gendered branch of curriculum activity.

Thus we can witness the establishment, on the basis of class, gender and race (imperialism supported by notions of technical and industrial superiority), of an area of education which carries and promulgates all these traits in ‘Western democracies’ today. Of course this, again, is not merely an educational phenomenon. It is intimately bound up in the cultural, the social and the political too.

Central to Penfold’s writing and analysis is his identification (as well as the irony) of the efforts of the British government to address the same perceived problems using the same (1880’s) arguments in the 1980’s. At the end of the 20th century another President of the United States saw technology and education as being significant issues too:

Today, technological literacy - computer skills and the ability to use computers and other technology to improve learning, productivity and performance - is a new basic that our students must master. Preparing our children for a lifetime of computer use is now just as essential as teaching them to read and write and do math. Every major U.S. industry has begun to rely heavily on computers and telecommunications to do its work.

(Clinton, 1998)

Such a position exemplifies that of any similar economy. The catchcry of ‘technological literacy’; the equating, by and large, of technology with computers alone; the juxta-positioning of learning, productivity and performance; the sense of ‘preparation’ as socialisation or conditioning; the given of a lifetime of computer use as an ‘essential’; the implied and continued valorisation of the three ‘R’s’; and the benchmark of industry, all combine to affirm just what is expected of education in general and of (one kind of) technology education in particular.

In bearing in mind the cultural, social, economic and political relationships with technology one can obtain richer and more accurate perspectives on the power and significance of technologies at any point or place in time (at least, time past and time present). One aspect of the current situation is exemplified by Luke although there are other issues, technologies and futures to consider:

Women, ethnic minorities, the urban poor, indigenous peoples – the historic outsiders of technologies of power - are forming up the ranks of new regional global underclasses of the information and technology 'poor'.


In his 1967 exploration of the effect of technology in determining the socio-economic order, Heilbroner posits in the ‘simplest terms’:

…did medieval technology bring about feudalism? Is industrial technology the necessary and sufficient condition for capitalism? Or, by extension, will the technology of the computer and the atom constitute the ineluctable cause of a new social order?

(Heilbroner, 1967:175)
There is much to explore here, not least the question of technological determinism. However, suffice to say that we can identify and exemplify historical phases and political relationships by the dominant technologies of the time – such is their significance.

**General (mis)perceptions of technology**

It will be evident by now that this paper is concerned with the broadest of understandings of technology – this is viewed as a pre-requisite for any kind of proper education in, through, about or for ‘technology’. Others have recognised the difficulties of working with such an enjoyably unstable concept. For example, as Young (1991) put it:

> Technology has no unambiguous meaning except with reference to specific technologies, though it has powerful rhetorical and ideological connotations. It subsumes and is often equated with a whole range of notions such as being modern, progressive, practical, politically neutral, economically relevant, productive, efficient, quick, reliable, accurate. (Young 1991:235)

It has been possible to identify a handful of ‘orthodoxies’ that are commonly applied to the field when ‘technology’ is referred to in ‘everyday’ ways. These (mis)perceptions are often the result of a genuine lack of awareness but they can be perpetuated mischievously - particularly for political ends. They include seeing technology as: being only concerned with the ‘new’; being ‘objects’; being ‘neutral’; being ‘hi-tech or I(nfo)-tech’; being ‘applied science’; being ‘inevitable’; or, being ‘incomprehensible’. (Keirl, 1999)

These orthodoxies serve to illustrate, at a simple level, the way in which a complex and dynamic phenomenon can be atomised, trivialised or marginalised. It may well be the case that, as Green (1994:xxxix) has put it, ‘framing technology is like trying to nail jelly’ and this is a more useful aphorism than many of the prescriptive definitions that abound.

**Schools and technology**

Having scanned some historical perspectives of societal organisation in relation to technology what then of the nature of Technology Education in schools in Australia?

Nomenclature such as Technical Studies, Domestic Science and Industrial Arts reflect both the roots and the nature of the field for the first sixty or so years of the 20th century. The curriculum or, at least, its population, was a gendered one with workshops for the boys and kitchens for the girls. Despite initiatives and policies to address the kinds of gendered uptakes of these school subjects it remains the case that, at the beginning of the 21st century, there are considerable gender imbalances in the field of Technology Education.

In the last decade, the notion of a ‘learning area’ for ‘technology’ (the nomenclature varies across the country) has provided an umbrella for a variety of (secondary sector) subjects as well as a half dozen professional associations. The subjects might include agriculture, computing, design,
electronics, engineering, home economics, industrial arts, media, and technology studies. There are others too.

Most technology subjects ‘bridge’ learning areas in quite deliberate ways. For example, home economics educators see the subject contributing to the Health and Physical Education and Studies of Society and the Environment learning areas too. Such bridging reflects the incapacity of a broad ranging subject to be ‘boxed’ into one learning area and illustrates limitations of such curriculum organisation.

In the case of another example, that of Design and Technology, there continue to be struggles and debates over its identity, its scope and its content. Such discourse has continued in the UK for over three decades with the outcome that it has grown in stature and credibility both within and beyond its realm – not without significant political struggle. Cynics have, at times, made their contributions by arguing that such a holistic entity be dismantled and cast to the winds – the practical/crafts and design wing to Arts education; the social aspects to Social Studies and the materials/physical principles to the Sciences.

This argument belies the reality of a holistic and, it will be argued, highly valid educational phenomenon that can own its place in contemporary and futures-focussed curriculum. Today, the maintenance of curriculum bastions in balkanised secondary education continues to be questioned while, in the primary sector, the power of (design and) technology education as a vehicle for curriculum integration is increasingly attested.

However, while excellent practice is emerging and is doing so against the orthodoxies discussed, against curriculum tradition and against vested interest, there remain deep concerns about the field’s own traditions and millstones as well as about the interests at play that seek to mould Technology Education in particular ways.

Layton’s (1994) analysis of the international surge in growth of this field continues to provide an illuminating portrait of competing interests in just what the purposes, shape and direction of Technology Education should be. Some of these are dominant and readily visible. Others are the ‘wannabe’s’. Some are exclusive of others. Each claims an arguable case and can be seen for it’s political and social role. Layton offers: economic instrumentalists; professional technologists; sustainable developers; girls and women; defenders of participatory democracy; and, liberal educators. Fuller discussion of these interests in their Australian context is offered elsewhere (Keirl, 1999).

It is a combination of the field’s traditions with the particular interests of the first two of Layton’s groups that articulate the powerful and narrow curriculum focus of Technology Education today. Having been always, if nothing else, a ‘practical’ field, then skills have been a preoccupation of both content base and pedagogy. Whether the material has been food, metal, textile or wood, schooling has been concerned with the ‘show-how of know-how’. Students were taught the nature of the materials and shown the techniques of working those materials. The outcome was that students ‘made’ ‘things’. Mind–body processes were developed by mimicking the teacher’s demonstration and practising them in/on one’s own work. All students did the same work and assessment was almost totally quantitative against ‘standards’ of ‘workman(sic)ship’ and ‘finish’.
What has been described is generalised but close to the truth and was certainly applicable until around the 1970's. Hopefully it is far less the case today but these practices do still exist. A central issue is not the question of whether students should learn the skills and values necessary to create quality products. This might be desirable in any circumstance were the resources available. What is of concern is the valorisation of trying to prepare all students as highly skilled operatives over, alternatively, offering all students genuinely educational experiences that apply to life and learning beyond school and/or industry. It has only been a small step for governments, industry and professional technologists to invoke the language of skills, competencies and standards along with reductionist assessment strategies in order to consolidate a ‘vocational’ agenda and, with enough money in the right places, a justification of the prolongation of an instrumental and technical curriculum.

In many ways this phenomenon is merely a reflection of the state of play in schools in general. As Boomer (1999b) points out, there is ‘massive inertia’ in education and a shift from a dominance of transmissive methodologies to a dominance of constructivist ones is to be sought. He acknowledges the kinds of societal and political obstacles that stand in the way of developing ‘culturally transformative schools’ and points to what he calls the ‘national schizophrenia’ of, on the one hand, wanting reconstructed schools capable of creativity and innovation whilst, on the other, promulgating a ‘back to basics’ ethos of tight discipline and drilling (Boomer, 1999b:78).

The instrumental approach has been welcomed (even seen as a lifeline) by many in the technology education profession who see no good reason to change or to explore new curriculum thinking or models. And this remark does not apply, as one might think, only to the longer-serving members of the profession. Because the very processes of teacher preparation and technical learning in the past (surely back to medieval times and the guilds) have been archetypal models of the apprenticeship kind – ‘gather round the bench boys and watch me’ – the dependency culture and pedagogy have been consolidated. Even younger teachers who have been taught this way find it very difficult to ‘unlearn’ the methodologies of which they were a very part.

Fortunately it is not necessary to dwell on such constructions as there have been other significant developments across the field in recent decades and the most educationally powerful of these has been that of design. Apart from the fact that design (the verb) is the creative act behind any design (the noun) or technology, the recognition of the role that design can play in education is increasingly being understood. Design as a subject has had a marginal and specialised place within some arts curricula and, perhaps in the sense of industrial design in the first instance, it was recognised as being the missing dimension of Technology Education. Today, the compound ‘Design and Technology’ is in increasing use as a descriptor of the field.

It is necessary to sketch out some aspects of design. To design is to work with intention. It is, thus, by any definition, not about accident. Design is about making choices and weighing up competing variables. It is values-rich and not values-neutral. It is not about right answers. It is about uncertainties and working with inadequate information. It is a form of knowledge creation. For all of these reasons design (whether noun or verb) is legitimately open to advocacy, defence and contestation. For all of these reasons, ‘done’ well, it sits most uncomfortably with orthodox
education as well as with orthodox technology education(s). Design education calls for student-centred learning and organization, a curbing of transmissive teaching, the creation of classrooms of uncertainty, the valorisation of doubt and scepticism and critique. All of these are most destabilising for the monarchies of the classroom, workshop, kitchen or computer suite.

Of course design, like anything else in education can be ‘done’ badly. It is not an educationally sound innovation to move from making a CD rack using a set plan, prescribed construction techniques and restricted sizes of (say) timber to making a CD rack using an outline plan, prescribed construction techniques and restricted sizes of (say) timber and being allowed to shape the ends to one’s preference. This is ‘design with the corners knocked off’ – the phenomenon of being able to make only minor adjustments to (the teacher’s) restrictive and prescribed project. It must be emphasised that the pedagogies of good D&T practice are many and varied and the skilled teacher uses multiple approaches to attain rich educational goals. The practice just criticised may well have its place but, hopefully, that place will be defensible, once-off and used in a very short period of time. What this example leads to is what might be called the ‘design-skills interface’ and this is a contested area within the profession.

There exists the argument that students cannot design without having significant knowledge of how materials perform and how to work them. This is valid enough but is sadly, and sometimes mischievously, used by teachers to avoid design for eternity, or at least until Years 11 or 12. So a (secondary) curriculum is constructed that is skills and materials rich. This is defended as a ‘preparation’ for designing after the students have ‘learned the skills - the basics’. Deliberately or otherwise, this a) preserves the status quo – both of content and of pedagogical style; b) affirms severely limited thinking patterns and options for students; c) valorises levels of technical competence of high and marginalizing standards – a form of elitism; d) reflects industrial and ‘production’ models of practice; e) is heavily equipment- and specialist knowledge-dependent; and f) reinforces negative gendered and cultural practices. Thus at a time when excellent practice is emerging in Design and Technology in the primary sector students often move to secondary situations to hit a wall that obstructs, inter alia, creativity, imagination, reasoning, the questioning of values, and individuality. If these were not enough, such curriculum organization effectively marginalises the very students who have so much to offer it and so contributes to its own demise.

Technology Education and, indeed, its antecedents remain thoroughly under-researched. Here is an area with a huge social and cultural history but with very low status in education. In comparison with the bastions of English, Mathematics and Science, for whatever reasons, Technology Education has no appreciated pedigree. The ‘practical’ fields may not warrant it. Perhaps more likely, ‘studied’ areas aggregate more study. And the ac-prac divide is deepened.

So long as Technology Education is ‘pegged back’ by vocational agendas and not understood or valued for that which it contributes in an existential way through its very experiential nature, or for that which it demands of students as designers through creativity and values articulation, then it has a limited defence to offer as a genuinely educational enterprise.
The jollification around Information and Communications Technologies (ICT’s)

Nothing that has been said about the vocational, the practical, about design or pedagogies does not apply equally to ICT and, in particular, to the computer.

There are some major concerns with regard to the computer both beyond and within education. Here is a tool or a machine, versatile and very marketed. It is powerful in its ways but, as with any tool or machine, it is nothing without its users. Nomenclature for this aspect of technology has been confusing and is ridden with misunderstanding. Often, varying descriptors are used – ‘the technology’; ‘technology’; ‘ICT’ (rarely in full); learning technology – when the user means ‘computer’. With this particular technology has come a plethora of media hype and confusion – often intended – about power, potential, capability, speed and so on.

Public education or knowledge about technologies in general is very limited, passive and accepting, uncritical, and focussed on a few perceived benefits. What is probably least realised is that the accepting of such technology into our lives requires considerable adjustment to our behaviours to the extent that we are seemingly dependent on the machine and cannot consider life without it.

The invisible pedagogy of the computerised curriculum is systems oriented and like the hidden curriculum of Computer Literacy its concealment is essential to its primary function of socialisation.

(Broughton cited in Beynon, 1992:23)

To take one (non-computing) example which some societies have lived with for most of a century. We do not think of it first: as a killing machine (either by almost instant and painful means or by pervasive and slow means); as designed to become obsolete in a set period of time; as energy inefficient; as antisocial; as fundamental to the perpetuation of a whole range of associated environmentally exploitive technologies; as central to associated industries and bureaucracies; or as a key to our economic system. Rather, the car is our personal lounge-room-on-wheels, which we should renew regularly and to which we all have an entitlement.

We have not had an education in place to question the advance of computer-based systems as time-consuming (recalling the decades-old prediction of the leisure time that would be created); to question their built-in and rapid obsolescence; to question the massive increase of associated paper consumption; to question their use as props, with their associated peripherals of telecommunications, scanning and copying technologies, for a tired economic system; to question their role as backbone of personal, corporate and state surveillance systems; to question their role in labour displacement; to question their capacity for depersonalisation at home and in the workplace; to question their limits as tools of learning - as themselves being incapable of distinguishing amongst fact, fiction, opinion, belief, wisdom, knowledge or information; to question their role as instrument in the establishment of a digital economy to provide the taxation framework to replace an oil-based economy; to question the ways they shape our personal identities and community interactions; or, to question them as another technology of dependence.

One wouldn’t want to be charged with being cynical but an element of doubt would seem reasonable. More seriously, there comes a focal social and political question, well illustrated by
the case of the computer, as to whether we have or even want, any say in our futures. As the festive ICT barrel roll-out rolls on with the jollification of the computer as its centrepiece we might look into our schools and ask if anything like a democratic education is happening with the ‘new technologies’. Even within the field, one might argue that areas such as robotics and control technology are educationally far more powerful, relevant and stimulating than the manipulation of text and graphics. At any rate, they are certainly given disproportionate airing to their societal impact and functions. To go further, on a fundamental democratic issue, might students not be well educated in ethical hacking? The ostracising of the hacker remains a requirement of those who would be in control in the surveillance age. Meanwhile, ethical hacking continues to expose the growing extent of covert digital surveillance in the world.

While schools contribute to the rollout unquestioningly, more traditional technologies lose what place they have in the curriculum. There would seem to be a lack of clarity of educational intent so far as the computer is concerned. The ICT equivalent of ‘design with the corners knocked off’ is pervasive – death by 1000 web-page designs – the material limitations instead being the software while the pedagogical model remains transmissive. So far as a quality D&T education is concerned the issues remain the same. Firstly, data (bits) are just another material form to be worked, shaped, constructed and deconstructed according to the blended and learned balance of the manipulative skills and the design thinking of the student. The limits of students’ creativity are no less or more determined whether the ‘material’ is tangible or otherwise. Secondly, the nurturing of creativity, imagination or critique remains directly dependent on the facilitating milieu and the pedagogy.

For over a century, that which might be termed ‘Technology Education’ has been constructed in instrumental and technical ways with the skilling of students being linked to the workplace and productivity. The only major difference that can be witnessed with the computer is that this technology has been increasingly marketed into the household and, as Roszak (1996) has argued, what is termed ‘education’ can amount to little more than advertising for computer manufacturers. Any tool or machine can enable and empower a student and it is through a design-based and student-centred transformative pedagogy that this can happen. This is a separate matter from the meta-issue of a proper Design and Technology education that critiques technologies in their societal and political manifestations. Such an education illuminates how technologies are used to position women and men, segregate society and marginalise ‘others’; it shows how technologies change our behaviours and identities; it exposes technologies’ role in environmental degradation; and, it demonstrates the organisational and monitoring efficacy of technologies in the hands of employers and politicians.

Despite this brief critique of ‘computer education’, there remain other issues concerning Design and Technology education and technologies in general. Some curriculum and pedagogical concerns have been aired to illustrate perceived educational shortfalls. Rather than playing a constant game of curriculum catch-up with industry counterparts and getting mesmerised by the instrumentalism of competencies, skills and vocationalism it might be wise to look further. With growing discourse on ‘futures’, ‘identity’ and ‘thinking’ as core curricular interests, it would seem that schools and what might be understood to be a technology education have room for improvement.
In his review of Melvin Bolton’s ‘The Road to Now’ (Bolton, 2001), Damien Broderick comments on the book’s coverage:

…ranging from the basics of primitive life through the long epochs when people were, in a sense, wildlife, and on to the tumultuous cascade of urban humanity. The sheer speed of cultural change is dizzying.

…In this long perspective, nothing has remained unchanged, especially humankind. We respond brilliantly to challenge, or our memes do. (The) computer…need not be our master: it is an emblem of advanced, cheap technologies that will carry us along the road to now and into a future where, with luck and effort, we can set right the error of ignorance and start acting like mature humans rather than grumbling or over-awed slaves.

(Broderick, 2001)

Emergent technologies and Technology Education - can we ‘set right the error of ignorance’?

Broadly speaking our technologies to date have popularly been conceived as material in nature – objects, tools and so on (the orthodoxy of technology of things). We have been less inclined to consider language, arts and media as technologies yet all are products of human creativeness whether intentionally designed or (arguably) evolved. This point is made by Kurzweil (1999) who, usefully, sees technology as ‘the continuation of evolution by other means’ and, drawing on the Greek techne, points to ‘…the study of crafting…the shaping of resources for a practical purpose.’ (Kurzweil, 1999:16). He stresses resources rather than materials and this is an important point when considering data, chemicals, cells or whatever else. (Another key word that is not unproblematic here is ‘purpose’.) He goes on to argue that:

What is uniquely human is the application of knowledge – recorded knowledge - to the fashioning of tools. The knowledge base represents the genetic code for the evolving technology. And as technology has evolved, the means for recording this knowledge base has also evolved, from the oral traditions of antiquity to the written design logs of nineteenth-century craftsmen to the computer-assisted design databases of the 1990’s.

and:

_Homo sapiens_ are unique in their use and fostering of all forms of what I regard as technology: art, language and machines, all representing evolution by other means.

(Kurzweil, 1999:16-17)

Our species is technological (Mumford, 1934; Burke & Ornstein, 1995). We cannot be who we are without our technologies. To understand our ‘being’ is to understand our technologies. Whether the term ‘civilised’ is reasonable remains problematic when applied, if not to the species as a whole, to some societies within it. Tied in with our critiques of democratic life or civil action come critiques of the technologies we have developed and adopted. An abundance of writing confronts the technological world of the last few decades (for example: Packard, 1960; Toffler, 1971; Dickson, 1974; Kranzenberg & Davenport, 1975; Hill & Johnston, 1985; Graves, 1986; Schumacher, 1986; Jones, 1990; Wajcman, 1991; Green & Guinery, 1994; Pursell , 1994; MacKenzie & Wacjman, 1999) and most recently, Joy (2000) helps focus matters when he posits ‘Why the future doesn’t need us’ and argues that when current technologies of robotics, genetic
engineering and nanotechnology are combined (and their merger is to be anticipated) they are ‘threatening to make humans an endangered species’ (Joy, 2000).

For a number of reasons, it is not easy to make accurate predictions about the outcomes and influences of emergent technologies and when highly educated writers do so they are often charged with writing science fiction (which might more properly be termed ‘technology fiction’). Along with the charge comes the remark of ‘Wow, scary’. Such is our cultural incapacity to understand, or enjoy a discourse about, the deep relationships we share with our technologies that we seem to be comfortably unempowered to cope with any kind of futures-focussed technological dialogue. Sclove (1995) has usefully referred to this phenomenon as living with an unnoticed temperamental elephant in our lounge rooms. It would seem perhaps to be a case of ‘that’s the way things are going’ or ‘you can’t stop progress’ – both dispositions that enhance the under-exposed realm of technological determinism. It would also seem that, in the case of past, established and emergent technologies, ignorance might no longer be bliss.

Yet education, if it is about anything, ought be about challenging ignorance and, designing and creating futures. If, as Broderick says, ‘…we can set right the error of ignorance and start acting like mature humans’ then it will be because of a technology education quite different from that which we have at present. What then are the kinds of emergent technologies, scenarios and issues that we can consider in a debate about redesigning technology education? The recently broadcast television series ‘Aftershock’ (ABC, 2001) presented useful snapshots of such technologies and possible futures, while other authors have offered greater depth of discussion on particular technologies.

Lifelong learning
The Aftershock programme covered such topics as human immortality – the use of stem cell research to locate a gene to simply switch off. ‘Programmed cell death research will allow us to choose exactly when, if ever, we die.’ (ABC, 2001). Here of course, the implication is that the choice will be ours i.e. a personal one. Why so? Who gets to live? For how long? Will the choice be available to everyone on the planet? Will governments or their agents decide how long we should live? (If yes, then the choice will no longer be ours.) If most people want to extend their lives what are the resource implications for the planet, for other people? How will life insurance be re-framed? How does this fit with the concept of mental health? Will we look forward to our deathday after lots of birthdays? This one example of technological practice alone illustrates there are not only significant ethical issues at play but also fundamental cultural, social and political ones too.

Choosing kids, cars and cures
To take a couple of other rapidly developing fields, human cloning is now a prospect for market enterprise and, with biotechnology in general, the chance of designing people (babies) is a reality though the version at the moment is still rather ‘design with the corners knocked off’ – you can nominate a few customised details but don’t think you’ll design the whole. This is similar to the ‘choices’ we have with designed products – the extras on a car or the layout of rooms in a new house. We (will) have opportunities to design biotechnologies to cure many diseases yet three core questions are rarely addressed. First, what were the causes of the illness in the first place and are these causes being eradicated? For example, there may have been a pollution, dietary or
lifestyle issue as a progenitor of the disease. Second, what will be the related costs and effects of the ‘cure’? Third, will such cures be universally available?

Romals or anibots?
Singer (1995) has argued that a measure of our own humanity and ethical being lies in how we treat, and live with, animals. We can anticipate biotechnological practices where, in our judgement, we should be able to design animals for purposes of fun, play, sport, work or for comfort. Meanwhile we already see the ongoing development of toy pets that are very basic, sometimes furry, sometimes talking, robots – the tamagotchis, furbies and poo-chis. The merging of biotechnologies with robotics presents the prospect of manufacturing pets or animals with myriad design variables to be drawn upon in order to fulfil ‘practical purposes’.

Stranger identities
It is over thirty years since the first human transplant and, as Somerville (2000) points out, this was a milestone for medical ethics. Today one of the focal points of bioethical discussion is that of xenotransplantation. We are now able to contemplate the genetic design of animals in order to facilitate more readily, (that is, by minimising rejection issues) organ transplants from animals to humans. Somerville contends that:

> The broadest and deepest level at which we must consider the impact of xenotransplantation technology will have is on our societal-cultural paradigm – our shared story. As (is) also true for human reproductive cloning, xenotransplantation raises issues related to our sense of identity. Does xenotransplantation take us yet one more step away from an integrated theory of personal identity and towards a modular theory of human identity – away from seeing ourselves as the unique, indivisible human beings that we are and towards seeing ourselves as simply a series of interchangeable parts? Or could the “miracle” that this technology makes possible deepen our awe and wonder about ourselves, our world, and life in general? In xenotransplantation…we need genuine, collective moral thinking and ethical exploration.

(Somerville, 1999:103)

Redeveloping ourselves as devices
So far as xenotransplantation is concerned we may be mixing it with other species but there are other possibilities. The merging of human and machine – as cyborg – is a prospect to consider. Mechanical solutions to medical problems have been under development for centuries. They have moved from the external – crutches, spectacles, ear trumpet, artificial limbs – to the internal - cochlear implants, hips and pacemakers. However, as genetic engineering continues to develop, we are also learning the potential for biological solutions too. As the Aftershock series pointed out, one lab now uses animal-derived tissue to create a muscle-driven robot that feeds on glucose while another is growing human skin merged with computer chips. Caudhill devotes her 1992 text to the notion of ‘building an artificial person’ pointing out that a robot is a ‘strictly mechanical in nature’ whereas an android ‘may be partially constructed of biological materials’ and is ‘an intelligent device that appears more or less humanoid’. (Caudhill, 1992:6)
**Designed (‘)realities(‘)**

There are other arenas for exploration too – the changing future of drugs; the increasing amounts of time and range of activities that we commit to ‘virtual reality’; the re-emergent ‘leisure myth’ that we were promised with previous ‘new’ technologies and work practices; and, the continuous and pervasive shaping of our lives in the market mould (ambiguity intended). What Packard (1962) originally documented in 1957 remains on track today and into the future. Trans-global corporations are now moving towards selling a lifestyle as their product. No longer will it be the advert for a singular product in the programme breaks but the whole programme that is owned and moulded in the corporation’s image - with which we will identify.

**Designed endings**

If there is one thing at which we excel technologically it is the capacity to kill. In discussing the future of war, the Aftershock programme comments:

> We’re not in the trenches anymore. The computer age will also take over the battlefield, with computer hackers more useful than men (sic) in fatigues. Experts predict that modern battles will be fought computer to computer, with countries hacking into and destroying troops by their hard drives.

*(ABC:2001)*

Yet we know that this is only a limited scenario. The potential of chemical and biological warfare has been with us for most of the 20th century. As Sheridan reported recently, in many centres, in many countries, it would seem that the capacity to produce biological weaponry is well established. In less than two months after Sheridan’s article global discussion has moved from ‘capacity to produce’ to ‘possibility of use’ to ‘actual use’. Sheridan’s writing is evocative. Anthrax – the ‘gold standard of biological warfare…(with)…a 100% mortality rate’; Ebolapox – the ’most genetically engineered combination’; Smallpox – ‘no one is immune to it now that it theoretically no longer exists…it is assumed that some of the cultures have been sold to rogue states’; Plague or Black Death – ‘drug resistant varieties have been developed’. He concludes:

> Nothing, not even a nuclear weapon, is so singularly well designed for the use of sophisticated terrorists…Mankind (sic) thought the spectre of the plague was banished by antibiotics and modern drugs. But now we have invented new plagues that can defeat even our drugs.

*(Sheridan, 2001)*

**Watching you watching me watching us**

The ABC called one episode of their programme ‘The Death of Privacy’. This is a reasonable assertion in places (homes/work/communities/countries) where communications technologies proliferate. This aspect of technology in our lives brings many associated democratic concerns and these are discussed in more depth in a parallel paper. (Keirl, 2002 Ref if accepted) The pervasiveness of surveillance technologies today is far beyond most people’s awareness and networks continue to expand. The commonest justification for surveillance is ‘security’ yet the outcome of our increased security is that we become increasingly insecure – personally, socially or nationally – with the further perverse outcome of seeking yet more ‘security’. Along with
most other technological products, surveillance systems rapidly become obsolete and newer ‘smarter’ ones are sought and designed.

**Intelligence plus…**

Gardner (1983) did education a great service in challenging the notion of a single, general, measurable ‘intelligence’ and offering his theory of multiple intelligences. The holism of our being and the question of consciousness continue to be a challenge to ‘artificial intelligence’ (AI) the pursuit of which has been under way for some decades. Whilst the processing and manipulation of data has been the fundamental of this technology, and computational power continues its exponential growth, there can be no doubt that the question of consciousness is a central one.

Reporting on the Riken Project in Japan, Sigman (2001) sets out the anticipated stages of research and development and comments that:

> By around 2010 researchers hope to have developed structures that will think (this will come before the awareness of thought) and to be able to make memory machines that do not need to be programmed, but are capable of intuitive thought and logical reasoning. In 15 years it will be possible to create computers with intellectual and emotional qualities, capable of experiencing feelings. In 20 years there will be supercomputers that can establish amicable relations with human society…a symbiotic relationship between humans and computers…robots capable of taking a part in human intellectual life.

(Sigman, 2001)

Sigman sees these changes as ‘…far stranger than the genome, the internet or cloning. They are the greatest offensive ever against humanity. They threaten to topple us into post-humanity.’

Drexler (1996), Kurzweil (1999), Joy (2000), and Somerville (2000) all articulate the vision of the evolution of AI beyond being a machine and gaining consciousness. They raise questions about our existence with such ‘machines’ and who will be empowered in such circumstances to make what kinds of decisions about quality and continuity of life. Thus, might we be adjudged, by our creations ‘them’-selves, to be inefficient, sentimental, logical, superfluous? Might we be contributors to our own genocide? Might we become the pets? Might our demise as we know ‘ourselves’ simply be our role in our evolution? Thus, in turn, how can we shape the future? – the design challenge; How ought it be shaped? - the ethical challenge; Have we the will or determination to shape the future? – the determinist challenge.

**Intelligence plus a little help from their friends**

Lastly for this round-up of emergent technologies, a recent advert researching current nanotechnology (nano – one billionth of a metre) practice in Australia described the technology thus:

- The ability to work at a molecular level, atom by atom, to create larger structures with fundamentally new molecular organization.
• Creating materials and systems whose structures and components exhibit novel and significantly improved physical, chemical and biological properties, phenomena and processes due to their nano-scale size.

• Applications may be found in electronics and computing technology, human health, diagnostics, food production and processing, environment and in advanced materials.

(Ernst & Young, 2001)

In the world of nanotechnologies Drexler (1996:80) points out that a ‘designer’ may be human or AI and will build, at a molecular level, nanocircuits and nanomachines. Drexler talks of ‘replicating assemblers’ (Kurzweil uses the term ‘nanobots’) and their capacities to ‘…be able to make almost anything (including more of themselves) from common materials.’ (Drexler, 1996:172). With some understatement, Drexler does caution, ‘…if we handle them properly’. As has been the case for every technology – how we engage with nanotechnology matters and recognising its downside matters. He describes what is known as the ‘gray goo’ problem – where the replication never stops and goes on to either take over species or ‘obliterate life’. Kurzweil concurs:

Finally, a really important requirement is that it needs to know when to stop replicating…Without self-replication, nanotechnology is neither practical nor economically feasible. And therein lies the rub. What happens if a little software program (inadvertent or otherwise) fails to halt the self-replication? We may have more nanobots than we want. They could eat up everything in sight.

(Kurzweil, 1999:140-141)

Kurzweil also articulates the warfare or terrorism possibilities of nanoweapons readily programmable for very specific (eg geographical) targeting and he argues that the self-replicating nature of nanotechnology makes it a far greater danger than nuclear weapons.

As with any technology, here again is huge potential for good and ill. The significance of the field of nanotechnology for reshaping us and our identities as we travel our evolutionary path is such that, within a generation, its impact will have been enormous. Its significance is also recognised in the fact that the Clinton administration allocated $500,000,000 to nanotechnology research and development.

What has been presented in this section of the paper demonstrates a potentially transformational threshold for our species. Having such a smorgasbord of technologies at our disposal, is it feasible to argue the claim that…

“We can make the world what we want it to be”

This sub-heading can be taken as an assertion not only of our capacity for self-determination but also of our creativity. The problematic bit is the ‘we’ and the implicit collaboration, shared vision and the personal, social, cultural, religious and political sacrifices that might be necessary. But that is a rudiment of design – the weighing up of competing variables to come up with an imperfect outcome, ethically defensible, and itself warranting modification and improvement. The range of emergent technologies cited above is broad and they are ‘emergent’ because they
have their antecedents – they are not discoveries but have creators and intentions behind them. These technologies develop out of where we are now, our recent past and our distant past. They are also our journey ahead.

That journey would seem to be something of a magical mystery tour. It may well seem – according to the last orthodoxy – that it’s all too hard or incomprehensible. The contention of this paper is that the situation need not be so. We know enough now to know that technologies don’t just happen. They are designed and particular pathways are chosen. We know that all technologies have a downside and that there are costs as well as benefits. We know that technologies are part of our existence and our being – they contribute to who we are as much as we do to them.

For all the technologies that we have created and are currently creating there are issues of ethics, determinism and existentialism and these, in turn, influence our epistemologies. What is apparent though is that we have new aggregations of technologies that will so powerfully change humanity as we (think we) know it. There are profound political considerations too. As Guillebaud (2001) has said, the revolutions in technologies are wrongly being considered separately. He contends that the real problems of the future will come from their uncontrolled interaction suggesting that they recreate old forms of domination and are anti-humanism. He argues that ‘…we urgently need a lucid and rational critique of the inter-linked revolutions. If we don’t recognise their cumulative effect, they may destroy not only democracy but humanity itself.’ (Guillebaud, 2001).

A poignant vignette of technological political decision-making was presented recently. Here, with just a single technological issue were encapsulated the ethical, the social imperative, the market imperative (keeping US research ‘at the cutting edge’), the religious objections, politics, identity and human-ness. Under the heading of ‘Bush wavers on an ethical battlefield’ Borger (2001) reported the climate surrounding the President’s (then) yet-to-be-made decision on how far to allow research to proceed in stem-cell technology, saying:

There is more talk about life, being and human identity in Washington right now than you would expect from an entire school of French existentialists...(and that) in the United States…the very definition of human existence is the bread and butter of political debate.

(Borger, 2001)

Of course much of the heat in the particular issue concerned the use of human embryos. It is unfortunate that the ethical significance of many more technological issues cannot be at the forefront of our cultural discourse rather than emerging from it. In one way it occurs that, without any disrespect to an excellent series, the programme ‘Aftershock’ may have been more aptly named ‘Afterthought’ – such is our readiness to accept ethics as a follower of technological evolution rather than using it as a determinant of it. The word ‘using’ is deliberately chosen here – both in its sense of purpose and, also, mindful of Singer’s (1995) thesis that ethics, in an age of self-interest, should be practical. It is almost taken as read today that we will have the technology and the ‘appropriate’ ethics and laws will emerge some time later.
Here the determinist challenge rises and, with it, the design challenge. We may better consider what kind of future we might want (or need) and how we should live. The (ever-increasing) power of computers is the key to our propulsion forward – probably not as machine or flesh but both - into our post-human condition. As was said in the ABC series, on many of the issues there is actually an almost overdue need for the ethical debate to reach a conclusion – ‘we’ve had the luxury of the debate for thousands of years’.

Given the enormity of the potential and the enormity of the issues connected with our technological existence it is clear that we are not at all well placed to determine a preferred future – either individually or collectively. To be able to design such a future it would seem that four conditions would be needed: a collective (political) will; an ethical consensus; knowledge of both how technologies work and what the associated issues are; and, personal and collective senses of identity and humanity. This, of course, is no mean list. In the belief that establishing these conditions is both desirable and achievable the question is begged…

**How well positioned is (Design and) Technology education to help establish these four conditions?**

The contention of this paper is that Technology Education is not at all well placed to establish the four conditions but then it would be quite unreasonable to expect one learning area or, even, single schools to set about this alone. However, there are curriculum constructions which, along with political and social action, can lead to change.

The issues are holistic issues, inter-related and essentially philosophical– albeit seen as practical problems. Some difficulties exist, particularly in secondary and tertiary education, which still perpetuate or are constrained to perpetuate, established agendas. So long as Technology Education is constructed (pun recognised) to reflect the world of products and associated skills then it will remain marginalised, misunderstood and the place for the hewers of wood, the drawers of water and the tappers of keyboards. The field is marginalised by the divisive ac-prac culture and it is increasingly fed and led by the vocational training dollars. ‘Older technology’ dollars are taken to feed the voracious computer agenda without any rationale at all – explanations usually amount to ‘that’s the way things are going’. Regardless of which technology one focuses on, its educational function is instrumental and utilitarian and this is not enough for the purposes of a democratic 21st century education.

Postman (2000) articulates his case, citing Jefferson, for the teaching of reason and scepticism to create ‘citizens of a critical mind’. He offers five suggestions on how this might be done, and:

> My fourth suggestion concerns what I call “technology education”. I do not mean by technology education teaching our youth how to use computers. Forty-five million Americans have already figured out how to use computers without any help whatsoever from the schools. If the schools do nothing about this in the next ten years, everyone will know how to use computers. But what they will not know, as none of us did about everything from automobiles to movies to television, is what are the psychological, social, and political effects of new technologies.

(Postman, 2000:170)
If technology education is to play its role in a futures-focussed and critical education then it must be reconstructed. What is needed is a multi-dimensioned understanding of technological literacy and central, not tokenistic, articulations of both design and critiquing (see, e.g., DETE, 2001). This reconstruction assumes a holistic base for all technologies and not the atomised approach across arts, sciences and social studies discussed earlier. If technology can be understood, as it should be, as being as significant to the species and to culture as language is, then so it might be constructed in the curriculum – with a central and not marginal role, and addressed through all fields of learning.

The profile must be raised. As Heilbroner (1967) argued, ‘…the problem of technological determinism…will remain germane until there is forged a degree of public control over technology far greater than anything that now exists.’ (Heilbroner, 1967:182)

So far as arguing for the gadfly roles of design and critique (both as verbs) in a technology curriculum are concerned, in truth the two are closely interwoven. The argument has been put (Keirl, 1998) that there is a continuum of four stages for any technology - intention-design-manifestation-application - and that questions of ethics and consequence ought to be put at every stage. Thus a critical interrogation at the intention stage – before, even, any design is undertaken – might result in the technology not being realised. As Somerville (2000) suggests in a most practical way, it might be worth considering what she terms ‘ethics time’, that is, time to consider before proceeding with a technology’s design and development. Such a sensible idea will have a battle in the current market regime but it is another example of making philosophical stuff practical.

Despite a reasonable history of some decades in education, the value of design is being increasingly understood for its educational potential. Helping young people understand that another of our traits as a species is that we are choice makers and that choosing is one of the essences of design activity will establish design’s potential in their minds. The realm of design per se can be drawn upon to inform educational practice and comprehensive and ethical sets of design principles can be compared in the work of Mayall (1979) and McDonough (1998).

As ‘21st century’ curriculum policies emerge with talk of students designing preferred futures or designing social futures not only will the four conditions have to be embraced – determinism, ethics, knowledge and identity/existence – but also, as is noted in futures thinking, optimism will need to be central. It is no small challenge to embrace optimism in these times, given the imaginable (negative) scenarios that are possible. Although, as some would argue, as a species we have no option but to be optimistic.

Thus while curriculum reconstruction is essential, so is pedagogical reconstruction. Design, critique, ethics, existentialism, futures, and optimism all call for radically different (albeit complementary) pedagogical approaches to those dictated by the ‘skilling agenda’ and the utilitarianism of the last two decades. At a time when we valorise particular technologies and we condition parents and students to the mirage of the market we don’t see the temperamental elephant. The atomised curriculum is as appropriate as an atomised understanding of today’s technologies. As information technology, artificial intelligence, biotechnology and genetics,
nanotechnology and the neurosciences all combine it is their aggregated potential that is far greater than the sum of the parts. As Drexler puts it: ‘The coming years will bring the greatest turning point in the history of life on earth. To guide life and civilisation through this transition is the great task of our time.’ (Drexler, 1996:239)

In closing one of his essays, Boomer argues for reform:

...so that schools...are allowed to become places of engaged production, more like workshops than lecture rooms, more like the ideal workplaces of the future than the factories of the past. This is not to do away with reflectiveness, civilized conversation, story, wonder and critique.

(Boomer 1999a:143)

It is just the case that quality Design and Technology practice is grounded in real and purposeful production but never without reflection, civilized discourse, story, wonder (and wondering ‘what if’) and, especially, rich critique. As our technological stories unfold it would seem that we recognise ourselves as characters in them, we drift with fascination, awe, and even fear, and we wonder how the tale will unfold. A first step might be to grasp that we are also authors of our stories and we can have some part in their crafting.

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