Holistic Technology Education

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How do we know when we are teaching technology holistically and why must we do so? Increasingly, more is asked of technology educators to be holistic in the understanding conveyed of technology itself and so in curriculum, assessment framework and modes of delivery. In NSW two good examples of this has been the shift from Engineering Science to Engineering Studies where social/ethical and environmental factors have to be learned while in the new and emerging 2003 Design and Technology 7–10 syllabus 'holistic solutions' are described. This paper advances historical and theoretical research and articulates classroom practice changes for holistic technology education with particular emphasis on offering a grounded frame of reference to guide student learning and understanding in the holistic character of any technological activity and decision event. A First Principles framework for structuring learning for holistic understanding of technologies and processes in design is therefore presented. The case is made for technology to not merely be a 'know how' learning experience, but necessarily and increasingly also a 'know why' learning experience. The latter being essential for innovation and transfer, especially for adapting to and taking decisions towards solutions that may need to accommodate rapid-change settings.

Introduction

A school that adopts curriculum which aims for an holistic understanding of technology, does so because it produces a better educated person, than a curriculum which does not. The notions of holistic education are in themselves not new. Work on the importance of holistic education date back in Western settings to include Pestalozzi (1746–1827), Thoreau 1817–1862, Emerson (1803–1882), Alcott (1799–1888), Dewey (1859–1952), Steiner (1861–1925), Montessori (1870–1952) and more recently (Dufty, Dufty, Australian Curriculum Studies Association & Holistic Education Network 1994) and (Fowlers 1998). Significant work on holistic education maintains its influence on much of contemporary education policies and pedagogy. This is evident in many generic Public School policies and syllabus rationales across curriculum. However, what is relatively new in Australia is that expressions such as 'holistic solutions' are entering design and technology Secondary School syllabi and research (stated or implied). There is a need to understand technology itself holistically in order to teach it with greater knowledge transparency to learners. The object being to develop more informed and capable adapters, designers and developers in our increasingly technologically driven and reliant lives. The new NSW 7–10 courses due for release in 2003 state both generic requirements for content to respond to holistic themes and specific requirements in the new 7–10 Design and Technology course for 'holistic solutions'. It is timely then to examine useful schemas for how education can be structured to assure that learning
experiences in technology courses are indeed holistic in presentation, assessment and reporting. What is needed is a robust universal framework.

Often a counter point to holistic themes entering science, technology and innovation/design education has been whether the Australian commercial sector sees any value for school graduates with technology studies to gain core holistic capabilities. There is mounting evidence that this is indeed a desired vocational attribute. Just as reporting is a driver for what schools will focus upon in the delivery of their courses, so too is it an emerging expectation for corporations and organisations to report on 'The Triple Bottom Line': profit/loss, social and environmental balance sheets of effort and expenditure (Elkington 1997; Wand 2002). Increasingly, a desired innovation capability is for employees to naturally be disposed to include social and environmental decision factors in their contribution to enterprise and production.

A schema for holistic technology education

There can be many approaches to understanding the phenomenon we label technology. Presented here is a phenomenological view to offer the reader a deeper grounding into why certain conclusions are drawn and schemas proposed. A schema gives teachers a framework to evaluate just how holistic a lesson or curriculum is. A framework for deciding what educational tasks to include and how to construct the education context and experience for technology and design students.

We begin with the premise that holistic technology education is a necessary, rather than desirable, outcome of schooling. Many teachers would argue that they already teach technology holistically. However, the question we must pose is, how do we know? Q (1): How do we know we are teaching technologies holistically?

There are many responses teachers give to this question. Typically they range from 'because my students discuss many issues in the design process' to 'I make sure they engage in social and environmental perspectives'. What remains a problem with such responses is that what is holistic is not grounded in some universal reason or coherent context. Why should discussing social or environmental issues be included for claims of holistic technological learning? I have seen the typical frustration where teachers often conclude that to teach holistically one needs to teach and consider everything. At this point we are lost. Very often, at this point, we find the task to revert to traditional tool skills and task technique is all we can do. We revert to our narrow, but comfortable zones of teaching and learning.

Phenomenology of technology and knowledge development allows a teacher to use a first principles approach to the task based on a universal schema (framework). With first principles a teacher can indeed determine what to include in lessons and evaluations to ensure reasonable holistic coverage of any technical education. Surprisingly, we discover that technology education and practice is not only a how to experience, but significantly a why should experience: the latter is fundamental to the human act of creating new knowledge itself not just using knowledge. Why should capability is important for principles development to foster understanding for the reason why of things in many settings. Holistic education in technology enables transfer of understanding to novel life long encounters, a quality lacking in much of how to training in technology. Both are
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required. However, we lack details in why should learning in technology.

**Knowing and understanding through practical engagement in technology learning**
The schema developed here begins with foundations in understanding how technical or material experience, as a phenomenon in human activity, develops a socially defined view of what is knowledge. When can we claim we know something? Dialectics and Praxis are very useful reasoning tools to understand the nature of an answer to this question in the context of technology education. Why is this important? Because there is a good case that 'knowing' and especially 'understanding' occurs best through holistic educational experiences in technology if structured properly compared to other modular or task skill approaches. It is significant in our construction to recognise that theory and practice dichotomies, as currently presented in many schools in technology, is a problem. "Theory is taught through practice and good practice is grounded in good theory" as my education lecturer often drilled. We do not really want to present technology education as separating conceptual tool experience (how to think skills) with physical tool experience (how to do skills). We do not want to see 'theory classes' estranged from 'practical' classes, nor that 'theory' be devalued or even employed as punishment in learning technology and design.

Tool is defined here as anything we give use-value to as a tool. A brick or our fist is a tool if we decide to use it as a club. A car is a tool if we decide to use it as a means to get us from A to B. An engineering algorithm is a tool if we decide to use it to determine a load on a beam. In each case, tools help us do things normally to manipulate a material (whether that material is at a scale we relate to in ordinary experience (like our bodies being moved from A to B, or the nut being crushed with a brick) or extraordinary (abstract) material like information/data material that we manipulate with an algorithm tool.

Curriculum and pedagogy that normally segregates these things raise substantial educational concern and has so for many years. For Dewey, "A divided world, a world whose parts and aspects do not hang together, is at once a sign and a cause of a divided personality. When the splitting up reaches a certain point we call the person insane. A fully integrated personality, on the other hand, exists only when successive experiences are integrated with one another. It can be built up only as a world of related objects is constructed" (John Dewey 1963a, p.44).

Dewey was quite strong on this issue. We need to show how things are interconnected, related to each other to give the technology or technique meaning to students. This prepares the importance for holistic education. A segregated 'education' for Dewey was not an education, "On the intellectual side, the separation of 'mind' from direct occupation with things throws emphasis on things at the expense of relations or connections" and, "[Education] must find universal and not specialised application" (Dewey 1916, p.143). Dewey's work opens clearly one of the differences between technology education and technical training. The latter being geared to vocational specialised short term task skills, the former life long capability. Our concern is technology education that shows us the first principles for teaching technology
understanding, for holistic education: the interconnectedness of technologies and techniques. Our next question may therefore be,

Q (2): What exactly should be interconnected in our teaching of technology?

The following builds a case to answer this question. We will build the first principles of what the minimums are for an holistic technology educational experience ideally, expressed in universal terms to permit knowledge transfer in teaching and learning for any technology curriculum. The learner needs to possess lifelong principles and so capability in technology and design matters.

From dialectics to praxis in technology education: Building understanding and knowledge

The road from Dialectics to Praxis is an interesting one for technology educationists as it addresses twists and turns (even head flips) from knowing as an essentially theoretical (idealistic) process to understanding as a social material (surprisingly Design and Technology like) process. We will begin with Hegel.

George Wilhelm Friedrich Hegel (1770–1831) was a German idealist philosopher born in Stuttgart. He was an idealist because for him thought does not merely correspond to reality; it produces reality (Speake 1979). 'Dialectic' was Hegel's name for the pattern that logical thought must follow. Broadly, he argued that conscious thought proceeds by contradictions. Its process was by triads, where each triad consisted of thesis, antithesis and synthesis. The concept of 'sharp' is not adequately understood without reference to an alternative 'blunt'. Both the thesis 'concept of sharp' and the antithesis 'concept of blunt' define each other and therefore require each other. To see each concept as related, as mutually defining, is their synthesis. At this moment a new level of reasoned understanding is achieved. Put another way, a person starts with a proposition, the thesis; this is consciousness as 'understanding' and proves to be inadequate by itself. The person's mind must therefore generate its alternative, the antithesis. However, this on its own also proves inadequate. The resolution of the opposites, therefore, requires they be taken up into a synthesis. This is the level of conscious thought as reasoned understanding. From here, the whole triadic process may be repeated, the synthesis leading to a 'new thesis' and so on. This is elaborated in Hegel's 'Phenomenology of Mind (1807)' (Vazquez 1977, p.371).

The essence of Hegel's dialectics is 'the grasping of opposites in their unity' (Hegel & Miller 1989): a significant first step in building our First Principles for holistic technology education. This is the immanent goal or 'telos' of Hegel's philosophy. In the words of Suchting, "So, in Hegel, Spirit is essentially rational freedom and the source of the dialectical development; the conflict between the necessity for Spirit to attain its telos and the various successive inadequate conditions for this to occur ...insofar as the system has an immanent telos the development envisaged is one towards reconciliation of conflicts in a larger harmony, hence, the Hegelian dialectics is conservative in its very foundations and not merely as a consequence of certain historical and personal factors" (Suchting 1983, p.181). Important to Hegel's philosophy of dialectics is that 'knowing' for him begins, proceeds and ends at the level of ideas. For him, matter is a product of mind, rather than mind being the highest product of matter.
Feuerbach and Hegelian dialectics: The head flip
Ludwig Andreas Feuerbach (1804–72) was a Bavarian philosopher and theologian. Although he was Hegel's student, much of his work was critical of Hegel's idealism. Broadly, Feuerbach was a materialist in the sense that he distinguished between consciousness of an object and self-consciousness, while at the same time connected the material object with the subject by pointing out that consciousness of the object always reveals some element of self-consciousness, "In the object which he contemplates, man becomes acquainted with himself, consciousness of the objective is the self-consciousness of man" (Vazquez 1977, p.75).

Feuerbach is important because his view of knowing and understanding introduced material objects as a necessary, not merely desirable, condition for knowledge. This revelation further builds our First Principles for holistic technology education. Object experiences are now significant. For Feuerbach humans are sensual beings, not spiritual beings as in the Hegelian sense. "I unconditionally repudiate absolute, immaterial, self-sufficing speculation, that speculation which draws its material from within...I found my ideas on materials, which can be appropriated only through the activity of the senses. I do not generate the object from the thought, but the thought from the object" (Matthews, n.d., p.2).

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It is often said, Feuerbach inverts Hegel, turns him on his head. For Feuerbach, mind now becomes the highest product of matter rather than matter being a product of mind. In the words of Matthews: "[Feuerbach] focuses on body rather than mind; material rather than spirit; this world rather than the next" (Matthews, n.d., p.2).

The Young Marx on Hegel's idealism and Feuerbach's materialism: Resolving the theory-practice opposing views of knowledge
Karl Marx (1818–83) was regarded by some as more of a social theorist, interested mainly in economics and history than any particular philosophical doctrine. Essentially Marx, too, inverts Hegel's idealism. He extracted and supported Hegel's notion of dialectics, but rejected his idealist approach. He supported Feuerbach's inversion of Hegel, but differed from his concept of materialism in terms of the central notion of human practice, specifically the social dimension of practice (Matthews, n.d., p.2).

Marx rejected Feuerbach's relation between subject (the person) and object (the world) in which the subject is passive and contemplative, restricting himself to receiving or reflecting reality. Here knowledge was simply the result of the actions of objects in the external world and their effects upon the sense organs (Vazquez 1977, p.118). Marx, therefore, identified the strengths and weaknesses of Hegel's idealism in dialectics and Feuerbach's passivity in materialism. Matthews commentates on this, "The chief defect of materialism is at once the strength of idealism - that is, it fails to recognise the significance of the subject [the person] in the act of knowing. The knower plays an active role in the process of knowing the object...in materialism we have abstract objects [the world] whose nature can be known independently of the subject; in idealism we have an abstract subject whose knowledge is abstracted from and independent of the objects." (Matthews n.d., p.4)
Marx attempted to resolve the problems of idealism and materialism in his system of historical materialism, the central concept of which is the practical interaction, which must occur between a person and his/her material and social environment. In parallel with Hegel's dialectics, the synthesis of people and their environment, via practical human socially contextualised activity, meant that a new level of awareness was achieved. Both the person and the environment were transformed. "Marx proposes a materialism the central specific notion of which is practice: an active relation between subject and object which changes the character of both and is the basis of the generation of knowledge (in further practice)" (Suchting in Matthews n.d., p.4). This leads to another important concept, which Marx addressed in his system of historical materialism.

Q (3): What is it - and how is it - that a person comes to know something of the world?

Marx argues the answer in at least three areas of practice:

(i) "The world is constituted by the material practice of people. The things that we claim knowledge of have been constituted by human labour" (Matthews n.d., p.4). We do not have an adequate knowledge of a tree until we manipulate it, interact with it and/or experiment with it. Broadly, manipulation, interaction and experimentation are modes of human labour. These modes contrast with 'pure' observation and contemplation of a tree because, for example, experimentation (like science or early proto-typing in design work) synthesises thought and practice (if we do it properly) rather than pursuing either on their own. Manipulation is in fact central to experimentation.

(ii) "The world is perceived through senses that are altered by material practice and extended by material practice" (Matthews n.d.). As a classic historical example, Matthews wrote, "This point is brilliantly illustrated by the opposition to Galileo in terms of his telescope being something that disturbed and deformed proper perception of the moon's surface and of other planets. It was only later with developed material and technological practices that the telescope was regarded as a satisfactory instrument and hence, a satisfactory extension of the senses" (Matthews n.d., p.4).

(iii) "Practice mediates between people and the world not just in a haphazard way ... but in a manner which is related to needs [and aspirations] and their satisfaction" (Matthews n.d., p.5). The individual acts to satisfy either basic/fabricated needs or aspirations. The community acts first to satisfy both personal and social needs; for example, cars for transportation needs, produce for nutritious needs, or radar for weapon guidance needs in war.

Marx departs from Hegel and Feuerbach by the importance he places on actual human labour or practice. He adopts a dialectic methodology in that he contrasts and identifies the inadequacy of 'pure' idealism and 'pure' materialism; he synthesises the two at the new level of historical materialism. Thus, both theory and practice are resolved best according to Marx, via human material practice in social context. Marx's Historical Materialism is essentially the foundation of praxis.
Praxis and technics: Arriving at our first principles of holistic technology education

Praxis and technical activity concerns the effect of instruments and tools in the human transformation experience. The contributions of Don Ihde on instrumentation are summarised as key notions to a schema for constructing First Principles in Holistic Technology and Design Education.

Praxis, so far has been concerned with practical human activity and the interaction of mind and matter, or being human and environment. Ihde’s work identifies certain features of this interaction when instruments or artefacts mediate it. The human-environment interaction becomes a more complex paradigm when an artefact modifies the experience. The paradigm:

\[
\text{Human} \rightarrow \text{World}
\]

is modified to:

\[
\text{Human} \rightarrow \text{Artefact/tool} \rightarrow \text{World}
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Examples include:

- (Observer---------Microscope---------Microbe)
- (Student-----------Internet Computer -----------World Information)
- (Human: Sources of Technique------Artefact: Instruments/Tools------World: source of materials)
- (Human: Socio-economic drivers---------Artefact: Polluting Industries---------World: Ecosystem)

The observer does not gain feedback from the world any more, but from the world via the instrument or tool. That is, Tools and so technologies are values rich in their design use and context active in their cause and effect tendency. However, Ihde points out that this modified interaction, although non-neutral, is not necessarily a problem: "My thesis is that any use of technology is non-neutral. However, non-neutrality is not a prejudicial term because it implies neither that there are inherently 'good' or 'bad' tendencies so much as it implies that there are types of transformation of human experience in the use of technology" (Ihde 1979, p.66). Ihde here acknowledges that technologies need to be understood in context and in purpose of application. That is, different kinds of technologies and tools transform our knowledge differently. Also, same tools and technologies placed in different 'world' settings transform our knowledge differently (including same tools/technologies in different social and/or material environment settings (different 'World' settings).

This is significant as it raises the necessity to understand that both choice and design of tools and choice and design of world settings alter our knowledge. Technologies are context sensitive. Designs of tools and environments are socially and environmentally interdependent. To present technology teaching and learning as value and context neutral is to mis-inform the learner. The ability of the learner to naturally consider social and environmental factors when seeking solutions to design and technical challenges is fundamental to a genuine education in technology. Human, Tool and Environment are the minimum elements to any technological activity. That is, Technology cannot be reduced to less than these three elements and as such, Technology is their product. We therefore may need to understand and teach this relationship explicitly.

What develops as important in Ihde's work is the notion that praxis, though
necessarily producing artefacts from the human-environment interaction, must increasingly include artefacts as a mediator in the interaction. Hence, the paradigm:

We now have a basis for determining the absolute minimum inclusions to what constitutes holistic technology education (Seemann & Talbot 1995). To teach any technical process, to evaluate technologies or to take design decisions that ignore this interdependent triad of human, artefact/tool and environment is indeed not an education in technology. In the theme of Dewey, the interconnectedness of knowledge constitutes a key feature of an education. "Any experience is mis-educative that has the effect of arresting or distorting the growth of further experience... Experiences may be so disconnected from one another that, while each is agreeable or even exciting in itself, they are not linked cumulatively to one another...Each experience may be lively, vivid and 'interesting', and yet their disconnected-ness may artificially generate dispersive, disintegrated, centrifugal habits. The consequence of formation of such habits is inability to control future experience" (John Dewey 1963, p.49).

The First Principles of Holistic Technology Education now appears to have structure. A structure articulated elsewhere as technacy education (Seemann & Talbot 1995). When a teacher instinctively claims that they include social [Human] factors and environmental [material] factors in their lesson on specific technologies [artefact factors], they indeed have good reason to believe their pedagogy is heading towards being holistic. However, this coverage cannot be delivered in a general way. It is important to present the interconnections in explicit details at appropriate levels that make sense. A key
requirement is to set assessment tasks for each lesson and unit of work that not only address highly specific links that define the factors in relation to each other, but also their total effect as a design and technology solution. In a very real sense, technology is the product of the triad factors interacting to satisfy a need or an aspiration.

**Conclusions: First principles in holistic technology education**

Teachers who seek a deep justification for deciding what may constitute the bare minimums of holistic solutions in design and technology may refer to the schema proposed. Technology understanding develops holistically through structured or enabling learning experiences that make explicit in detail the inter-connectedness of human, tool and environmental factors where these three factors mutually require and define each other and are acting as both resources and constraints to the applied purpose and its setting. The schema gains strength through historical examination of the nature or phenomenon of technological activity where not only are all three factors defined by each other, but that design and technology experiences, if taught holistically, as interconnected, are a condition to new knowledge creation. Technology education is not merely a know how, but necessarily must be understood and presented in the curriculum to learners as a know why subject. Only then may there be reasoned claims to technology being learned holistically. Peters provides a fitting end. "We would not call a man who was merely well informed an educated man. He must also have some understanding of the reason why of things. The Spartans, for instance, were militarily and morally trained. . . But we would not say that they had received a military or moral education; for they had never been encouraged to probe into the principles underlying their code" (Peters 1971, p.8).

**References**


