

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

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Abstract

Have you ever noticed that when the economy shows strong growth in job creation, the stock market often drops, when jobs are slashed by as many as thousands or that when a company invests in new labour replacing technology in its production, the stock value of the companies involved rises (Chasan, 2006; Isidore, 2005)? Despite all the efforts to produce skilled people in traditional fields, the tide of sustainable employment in those areas, appears to be structurally prohibitive raising basic questions of whether traditional perceptions of Technology in school curriculum remains viable and whether a rethink of why Technology ought be taught is now due for a new discourse. In our complex new world, the one right here and now and unfolding outside the school gate, we ought cast forward and rethink the new opportunities before us with Technology studies as a subject in waiting.

This paper explores the proposition that, in the context of understanding the role of innovation and knowledge in the world economy, it may be time to completely rethink the role of Technology in schooling as having a unique purpose in the curriculum. One that is characterised by its focus on *graduate attributes* rather than specific traditional equipment skilling expressed in the finish of 'objects' and by its responsive behaviour to a modern world economy, with complex social and ecological pressures.

Key words

Innovation education, design and technology, technacy education, graduate attributes, knowledge economy, capacity to synthesise, frontier education.

Introduction

"[In] America and Europe, millions of workers find themselves under- employed or without jobs and with little hope of obtaining full-time employment. The US has lost 12% of its factory jobs since 1998, while the UK shed 14%

of its manufacturing jobs in the same period. Manufacturing jobs continue to disappear in the UK, even though the sector is growing at its fastest pace in four years." (Rifkin, 2004)

How do these patterns sit with a school curriculum when its pedagogy and view of technology studies is overly focussed on traditional tool and manual craft skilling in this new age of a global innovation and knowledge economy?

The study of technology and especially the use of research grounded pedagogy in design education are faced with a new reality. It relates to an understanding of the link between the contemporary world facing school leavers and the need to assert a new basis for what the *technology education graduate attributes* ought be that would enable them to thrive in a knowledge and innovation based economy and workforce. There is a new and clear role for technology educators poised for the taking by contemporary education sectors: to become the school's experts in developing and assessing innovative minds, that are adaptive to change at short notice, solve problems selflessly in teams, and educated to embrace new knowledges, and kinds of technologies, in order to find synthesis in applied solution situations. It may mean that craft or tool skill based pedagogy and assessment focus needs to make room for a second frontier pedagogy to emerge and thrive. One based on the development of creative and adaptive behaviours and a deep structured study of technology that fosters the development of new thinking skills that drive innovative and holistic technological practice (Seemann, 2003a; Seemann, 2003b; Seemann, 2004).

Technology educators seeking to maintain currency may find that their purpose in the school curriculum could become that of flag bearers for innovation education and the holistic study of technologies (such as the deep understanding of technacy) into the future

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

(Seemann, 2003b; Wikipedia, 2006). This new role raises several complex issues. The language of reports by various governments about the role of innovation in the economy and schooling suggests, at one level, a need for an unprecedented shift away from previous pedagogy and at another the use of new jargon that can make it difficult for teachers to accommodate the agenda in their practice (Business Council of Australia, 2006; Department of Education Science and Training, 2003; Innovation Summit Implementation Group, 2000). In addition, teachers are entitled to ask why developing innovation capacity should suddenly be seen as critical to the future of many developed economies?

The broader context of technology and design studies in the global economy

"70-80 per cent of value added to goods and services comes from knowledge work, not manual work and equipment, – In 1989 it was only 20-30 per cent. ...this industrial age model no longer works, that calls people an 'expense' and controls them rather than allowing them to unleash their potential. ...Effective isn't good enough anymore." (Covy cited in Robinson, 2006: 92)

This paper offers technology teachers plain English interpretations of the role of innovation policies and proposed frontier opportunities for the future of Technology education.

As a frontier, much is yet to be scripted, but what is well known is that continuance of a traditional tool skill focus appears to be slipping behind in its value to much of society in this new global age. While this paper will focus on the case study of Australian, specifically New South Wales technology education, it is argued that the global effect described is current and relevant to all technology education futures in similarly developed economies. The paper describes what innovation is thought to include, its link to the knowledge economy and why innovation has been given such national priority in technology education at least in the Australian case example.

Australian Case Study

Confronting the profession of technology educators in Australia and most other developed countries is the new and emerging, and essentially frontier role of Technology studies in school curricula. This role may be described as "to develop innovative minds, adaptive to change at short notice, educated to embrace new knowledges, and to find synthesis in applied situations based on an holistic and deeper understanding of the nature of technology itself, especially its purpose and its context" (Department of Education Science and Training, 2003). There is also a need to form a new generic of standards based on holistic technology and innovation education. Such a rethink of technology in the curriculum may mean that traditional craft or tool skill pedagogy needs to stand to the side, and possibly run in parallel with, a second pedagogy based on the development of creative and adaptive attributes, a deep structured study of technology and design and the exploitation and application of new thinking schema. In reality, this may well mean rethinking weightings in assessments, teaching to foster "on-the-spot reasoning ability, a skill not basically dependant on our experience" (Belsky, 1990, p. 125), studying technologies more deeply and socially and building a new pedagogy justified via evidence driven pedagogy research in cognition, the ability to synthesis information in solutions well, social capability in teams, and communication and applied innovation methodologies for the classroom and studio lab.

Technology educators are in a unique position like no other subject area in the curriculum where they can redefine their purpose as flag bearers for innovation education and the holistic or synthesised study of technologies into the future. This new role raises several complex issues. The language of reports in government agendas on innovation education suggests, at one level, a need for an unprecedented shift away from previous pedagogy and at another the use of new jargon that can make it difficult for teachers to accommodate the agenda in their practice (Department of Education Science and

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

Training, 2003). In addition, teachers are entitled to ask why developing innovation capacity should suddenly be seen as critical to Australia's future? This paper offers technology teachers plain English interpretations of the role of innovation policies. It describes what innovation is thought to include, its link to the knowledge economy and why innovation has been given such national priority in technology education.

'Innovation' has in recent years become a catch cry term among political leaders, enterprise captains and the general media in Australia. The momentum behind this term is far more substantial than would normally be expected from fashion and craze.

The challenge before technology educators is to both understand and appreciate the substance of the term in the modern global economy and to interpret a new reality about the value now being placed on technology education in that economy. The message is quite decisive from the economists and the State: make no mistake, innovation, knowledge and diffusion of capacity, now dominate the drivers of economic growth and are steadily shifting to niche market positions the heroes of previous years: labour intensive manual and craft skill competencies. Technology teachers really are at an unprecedented crossroad even if not fully aware of the new economic pressures placed on learners. While 'traditional craft' competencies are expected to remain and even strengthen in niche, especially rural, albeit smaller and specific markets, they no longer represent, in developed economies like Australia, America, Europe and selected Asian States, the dominant contributor to economic growth and so material quality of life.

The main factors driving production are diffusion of knowledge and innovation capacity building. Interestingly, the non-vocational case for technology education, the humanities purpose, has in many ways also joined innovation as a new key supplement to capacity building: especially in the areas of social and ecological ethics in production and effective company governance (Elkington, 1997; Wand, 2002).

Innovation, more than traditional labour skills, drives productivity: the Australian Example

"Economic growth is the single most decisive factor influencing a country's living standard and innovation above all else provides the engine of growth, almost regardless of the condition of the larger economy. This innovation, along with the knowledge development and management that drive it, are the building blocks of an information society and a knowledge economy." (Fee & Seemann, 2003: 1).

Since Educational Sloyd was gazetted in the 1910 NSW syllabus (New South Wales Department of Public Instruction, 1910), since the boosts in manual construction and production skills in post World War II years to accommodate mass immigration and since booming primary industries and the rise of the dot.com information age – the most significant justification for the inclusion of technology education in schooling has been to produce productive citizens trained to feed and exploit the dominant economic forces of the times. Since at least the mid 1990's, innovation and knowledge diffusion have become the new economic forces of technological development and the value of technology in the economy. Accounting for the usual ten year or more lag for public education systems to acknowledge and 'react' to established economic drivers, it is only now that Australia's education systems are awakening to the need to think about how it will transform itself to a very new way to re-design curriculum and adapt and shift pedagogy in technology education. Given a hundred years of tradition, this shift will take some time to diffuse into the practice and especially the culture of many technology teachers. We are likely to see the transformation unfold asynchronously over the next one to two iterations of school syllabuses and teacher education courses. The need for this cultural shift is so significant, the Australian Federal government has recently, and somewhat unusually, posted the humanities side of research in innovation as a national priority funding theme associated with the conservative research grant priorities of the

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

Australian Research Council. They seek research proposals that address the following national theme:

"Understanding the factors that lead to highly creative and innovative ideas and concepts, and the conditions that lead to their introduction, transfer and uptake is critical for any nation that aspires to lead the world in breakthrough science, frontier technologies, and in other forms of innovation. Promoting an innovation culture and economy requires research with a focus on developing and fostering human talent, societal and cultural values favourable to creativity and innovation, and structures and processes for encouraging and managing innovation." (Department of Education Science and Training, 2003b)

The challenge facing frontier technology and design teacher graduates joining their well-seated peers

The shift towards a truly innovation and knowledge driven technology curriculum in schools is expected to phase in over the next several years. We can anticipate a transitional tension between new generation graduates, who while possibly well educated in innovation education, are nonetheless, seeking to hone new practices for the first time anywhere, making them particularly vulnerable to criticisms not only from established technology teachers, but also occasionally from their like minded peers. This is the challenge of innovation diffusion: a skill most State education systems are traditionally poor at managing and it is a vulnerable phase. We are well to note that this trait has characterised societies for near on 500 years.

"There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new order of things... Whenever his enemies have the ability to attack the innovator, they do so with the passion of partisans, while the others defend him sluggishly, so that the innovator and his party alike are vulnerable." (Machiavelli, 1961) (First Published in 1513AD)

Throughout Australia's public education history, the non-economic and purely educational argument for technology in the curriculum has also developed. From the influence of the New Education to John Dewey's work on experiential learning (Alexander & Dewey, 1987), the voice for the non-vocational case for technology education has simultaneously grown: albeit not as successful as a dominant theme compared to the economic case. Now that innovation and knowledge have become the most dominant forces for economic growth, the economic case for technology education is well supplemented with the humanities and ecological case like never before.

Innovation requires better skills in collaboration, communication and in particular, capacity to adapt to and exploit new knowledge, technologies and systems that are higher at risk of failures in the first development stage of the knowledge diffusion and absorption process. The Federal Government is asking schools and technology teachers to model to students the characteristics of being innovative as noted below:

"At all levels, our society will require creative individuals able to communicate well, think originally and critically, adapt to change, work cooperatively, remain motivated when faced with difficult circumstances, who connect with both people and ideas and are capable of finding solutions to problems as they occur – in short, individuals with the array of skills constituting a well-developed capacity for innovation." (Department of Education Science and Training, 2003: 5)

In order to appreciate the significance of innovation in the knowledge economy it is useful to gain a basic understanding of the notion of productivity (Brousell, 1998; Starr, 1992). Sketched out below are key ideas of productivity as it relates to companies involved in production of goods. It is important to appreciate that innovation and knowledge are not simply fashionable ideas or fanciful academic philosophy; they are directly linked to

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

the systematic and economic pressure to be productive and to capture new markets faster and more often than one's competitors.

The plain English rationale for innovation and the knowledge economy

While a little more complex than presented here, over all, its about three basic drivers:

- 1) Competition to improve company productivity,
- 2) Competition to generate the next innovation, and
- 3) Competition to be among the first to diffuse innovations.

Clearly, innovation education in technology is not a simple matter of "just good design" or "just being creative" as many experienced technology teachers conclude. Nor is it a theoretical or philosophical topic: it's real, it's affecting employment and it's not showing signs of mitigating in the world beyond school gates. There is a whole array of key knowledges and dispositions to be fostered and reflected in the production of even the most practical technology project in the classroom or workshop.

1) Competition to improve company productivity – in plain English

For a company involved in the production of goods to survive and especially to grow, it must be competitively productive. There are only a few ways a company can increase its productivity. Listed below are the main ones:

- **Make more stuff.**

This assumes the extra stuff produced will be purchased. In companies that are still manual labour skill (craft) intensive, this would mean either making labourers work longer hours or buying more labourers into the process of production. Both will enable that company to make more stuff and so be more productive. However, not only are labour costs relatively significant but the value of the labourer is entirely embodied within them. That is, the manual labour power and skill of the labourer is entirely

tied to the individual's body. The company cannot easily get rid of the labourer and still have his/her skills and labour effort shared to masses quickly (you can't email the labour and the skill for example to many others to use!). You cannot quickly replicate the labour and skill or change it quickly in a new combination with another person's labour and manual skills. In short new ideas are slow to diffuse across the company where production is manual labour (craft) dependent (rather than smart technology dependent).

- **Make the same amount of stuff, but make it cheaper.**

If a company can reduce its costs, it increases its profit margin per unit sold and as such, it is more productive as a work place. For share holders, this is a good thing and partly explains why stock prices of manufacturing companies rise when employees are sacked or replaced with newer more knowledge intensive technologies.

Most of us know the impact of this part of productivity well, especially in recent years. With manual labour skills representing the most significant cost to most companies, much of the effort management makes is on reducing labour costs or at least, often in collaboration with sympathetic governments, effect strategies to suppress rises in wages including organised control of wages such as through workers unions or in the case of conservative government policy, introduce industrial relations laws, such as "Work Choices" in Australia, to enable companies to better control their wages costs (Australian Federal Government, 2006; Schubert, 2005; The Australian, 2006). If you can produce similar 'stuff' cheaper than a competitor you can expect to sell more of it, and they less of theirs, and accordingly your company's productivity would be regarded as competitive. However, another way to reduce costs is to invest in labour-replacing-technologies in the very process of production.

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

The smarter these technologies are, the more productive your company becomes because it is able to produce more staff faster and much cheaper than other companies that are still manual labourer and so manual skill (craft) dependent. The smarter these technologies are (the more knowledge driven they are), say in being reprogrammed to produce a variation to a product instantly, possibly from a world standard programming team located elsewhere on the planet, the faster your company can innovate relative to its competitors.

We have all witnessed the shift in say housing construction technologies. Gone are the days when a builder looked out for the gun 'chippy'. That labourer who could efficiently hammer home six inch nails quickly without bending them through hardwood beams, chip out a run of housing joints and measure and fabricate on site all housing frames to drawing specification. Now, the builder is more interested in housing systems where concrete foundations are pre-laid to perfect levels for marking out floor plans (instead of pillar foundations), the arrival of prefabricated frames, and where assembly is required on site, the simple task to fire a couple of nails into the beam using nail guns in a few seconds of relatively unskilled labour. Un-jamming nail guns, knowing how to assemble frame systems and prior to this, winning the customer over with photo realistic 3D CAD presentations (pick the house you like, and we will build it) now present much better productivity solutions. The construction system is faster, and so lower production costs in labour hours, and consequently higher productivity is achieved. The highly skilled chippy (the artisan of yesterday) is either reduced to an assembler, or faces being too expensive to the builder. However, if that Chippy retrained in the knowledge technology of building systems and CAD design, they may just regain new value! And what is more, that CAD design and knowledge of the housing

system can be emailed to a frame fabrication specialist company, installed into their assembly system technologies and shared quickly through the timber supply and frame production process.

Knowledge has now become the driver of productivity rather than manual labour skills: the latter continues but only and increasingly in niche craft and cottage markets. The craft based manual labour skills are certainly not the dominant force they once were for sustaining the livelihood of masses of artisans. The example above shows that knowledge is not embodied in the individual's labour skills. That knowledge can be diffused across the company's workplace in parallel zones of production at rates limited only by the speed of the internet and this makes knowledge a highly desired capability for new employment markets in technology innovation and development. To the owner of a company involved in producing 'stuff', knowledge systems and knowledge intensive technologies are very addictive.

Innovation in the actual process of production is the key and many economists speak of technologies as 'capital investment' or as 'innovations' (a good thing when it replaces manual labour skills, craft skills and labour intensive tools and equipment).

The most spectacular irony most New South Wales (NSW) schools have witnessed in recent years in technology teacher training has been the recycling of the 1950s teacher supply policy to fast track manual skill artisans who have lost their jobs out of massive redundancies and place them quickly into 'manual arts' classrooms. In the 1990s the Newcastle steel works, in effect, could not maintain competitive productivity partly because it did not successfully invest in more knowledge intensive technologies as the Port Kembla steel works did some years before. Recall that Port Kembla replaced hundreds of manual skilled metalworkers and

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

technicians, and now runs a much more knowledge intensive and modularised maintenance system. It survived where Newcastle didn't.

2) Competition to generate the next innovation – in plain English

Even if a company masters a process of highly knowledge intensive and so lean and adaptive modes of production, which all its competitors are now also doing, it must produce new and interesting (desirable) goods and services. In this game of competition, and assuming productivity in production are essentially equal between competitors, the value of the product itself becomes the next most important point of focus. In this process there are two basic roles for innovation noted in this paper.

- **Make a more interesting and value added product or service than your competitor.**

It remains the case that if a company can produce a more interesting and well designed product or service than its competitors, the sales rate increases and this increases relative productivity. Creativity is an essential capacity and as such technology teachers must work hard at fostering the student's capacity to produce more interesting ideas than others about them. However, creativity is not enough.

- **Update and release new products and more value adding features on product and service lines more often.**

It may be possible for one or a few individuals in the company to research and brainstorm an initial range of new and market attractive product and service ideas. However, the internet has now made even this task much more of a race than ever before. It is not enough to produce that great product idea, because now, your competitors are out to better it in some way very quickly, potentially making your 'great product or service' look either a little tired, less featured or slightly more costly. This situation is so significant, collaboration and team communication skills (the humanities side of technology

production) start to rise as real contenders in the range of key and essential capabilities of employees, especially those educated in industrial technology and design.

3) Competition to be among the first to diffuse innovations – in plain English

Innovation is not simply 'good design', 'being creative' nor simply a matter of inventing gadgets. Even if innovation occurs in the process of production, or in the development of a clever product or service design, the final key role of innovation is reliant on its successful diffusion (Rogers, 2003). This aspect is so significant that it can cancel out any of the above successes if executed poorly. Diffusion is substantially about successfully getting products and services to markets, and can also be a measure of getting new knowledges and cultural shifts taken up across a company's workforce: in either case, diffusion is about rate of uptake. Diffusion or rate of market adoption relies on a close relationship between technical understanding of the product or service and social understanding of the intended end-users. Rogers (2003, pp. 10-35.) identified four key elements of diffusion as noted below.

1) The innovation: while innovation is often associated with 'newness' this is not always necessary. It is important to note that the perceived newness of an idea determines market reaction to it. If the idea seems new to the target market, it is effectively an innovation. As such, innovation occurs in matters of degrees. In effect, student projects can legitimately target design features as the innovation, or their whole product or system as the innovation.

2) Communication channels: in diffusion, the message is specifically about communicating a new idea. True innovations are usually difficult to diffuse. Many may claim that Design and Technology, as an innovation in NSW public schools, has found it difficult to be successfully and correctly communicated among many faculties. Communication failures have seen various interpretations of the nature and purpose of the 1991 Design

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

and Technology syllabus. These range from a subject that is essentially 'soft' and theory based, academically too hard for students (and some teachers) to interpret into practice or the other extreme that it is essentially only about crafting 'good looking, well made, functional and physically crafted' products. All of which are examples of communication failure and as such the subject is struggling in many NSW schools to survive in its intended form: it is showing some signs of diffusion failure based on communication failure.

3) Time: there are three sub-elements to diffusion success based on time. Timing of market adoption can determine whether an innovation will be successfully diffused. The time factor may relate to any of those listed below:

- The time between first knowledge of an innovation and the decision to adopt or reject it.
- The earliness/lateness of adoption of some market groups compared to others. Many information technology companies like the general Australian market relative to other countries because we have a reputation of being a nation of early adopters.
- The rate of adoption. How long it takes for certain benchmark numbers of users to adopt an innovation.

4) The social system: Perhaps the most significant factor of all. Knowledge of the social system of intended adopters is critical right back at the first stage of design brief development, product criteria research and interpretation. Technacy (Fleer & Jane, 2004, p.179-180) is one framework that has been used by some innovation oriented organizations (such as the Centre for Appropriate Technology Inc.) to ensure social systems and human factor understanding is built in early in the product or system design stages as a criterion for diffusion success later on. Most technology transfer failures occur due to a failure to understand and build into technology design briefs, the social system

criteria that the product or innovation must attempt to accommodate in its design to have any chance of being successfully adopted.

Conclusion

This paper has presented key ideas underpinning the significance of innovation in the technology education curriculum facing schools and teacher education institutions engaged in a developed economy. Technology educators are facing an unprecedented crossroad: to either attempt to ignore and resist embracing the new culture of innovation education or to fully embrace it into new syllabus design, pedagogy research and practice in the classroom.

There is a case to perceive Technology as a subject in waiting. One poised to be transformed from seeking to produce skilled users of traditional equipment usually in single domain fields, to that of developing expertise for the nation state in assessing and fostering synthesis capacities and as a proactive subject unashamedly contributing to knowledge creation processes rather than the traditions of knowledge application alone.

This new proposed role may require a new educational frontier in pedagogy with teacher education focussed on research driven methods of learning - where assessment is based on diagnosing learner *ability to synthesise contextual knowledges in the process of solution creation and to communicate, apply and manage principles in technology and design development* rather than overly dominating the workshop agenda on traditional tool and equipment skilling alone. The proposition is to create a new stream in schooling where students can choose to enrol in traditional craft skilling, while also enrolling in a course of learning aimed at honing their application of fluid intelligence and ability to abstract and apply ideas successfully to novel economic, social and ecological demands.

Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

Understanding how the innovation economy affects Technology as a valued area of learning is fundamental to the discourse needed in Technology studies today.

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Preparing Learners for the Innovation Economy: It's time to rethink almost everything about technology education

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