Yep – We Can Do That: Technological response to the curriculum 'needs' arising…

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Abstract

New Zealand has recently released a new national curriculum presented as the New Zealand Curriculum (NZC) (Ministry of Education, 2007). This document has significant implications for the future redevelopment of both the compulsory school curriculum and the non-compulsory senior secondary school curriculum. After a general introduction, this paper is divided into three main sections. In the first section, I explain the 'givens' presented in the NZC, these being the overarching Principles, Values and Attitudes, and the Key Competencies. I also outline the concept of 'Learning Areas' – as opposed to subjects. In the second section, I provide a brief overview of technology in New Zealand and present the key constructs of the revised technology learning area in the NZC. In the third section, I discuss and illustrate ways in which technology education can work to address the 'givens' in innovative ways that support the development of student technological literacy and general citizenship. I conclude the paper with an acknowledgement of potential issues, and express my opinion that while technology is well placed to respond to 'needs' arising, we should also be thinking about how much of this responsibility we should take on.

Introduction

New Zealand has recently released a new national curriculum – the New Zealand Curriculum[1] (NZC) (Ministry of Education, 2007) and its parallel document Te Marautanga o Aoteroa[2] (Ministry of Education, 2008).

The underpinning curriculum reform and development leading to the release of the NZC continued a shift away from traditional views of national curricula as prescriptive documentation of content and/or skills to be 'delivered'. The preceding national curriculum document – the *New Zealand Curriculum Framework* (NZCF) (Ministry of Education, 1993) had already begun to embrace this shift. However the development of separate learning area documents in support of the NZCF was undertaken in a somewhat ad hoc fashion. This led to a significant amount of national curriculum inconsistency in structure, terminology and underpinning theories of learning and pedagogy.

In response to this, a national curriculum stocktake was undertaken in 2001-2002 via a National School Sampling Survey (NSSS). This was followed by the New Zealand Curriculum Marautanga[3] Project (NZCMP) which drew from the stocktake findings and understandings gained from the relatively recent implementation of the National Certificate of Educational Achievement (NCEA) into New Zealand senior secondary schools. The NZCMP ran over a four year period and sought to add languages as a new area, and bring together this and the original seven learning area curriculum documents (of which technology was one) and the NZCF into a single comprehensive and internally consistent document to be viewed as an overarching framework (Ministry of Education, 2002). This document – the NZC was released on 6 October 2007.

The NZC (Ministry of Education, 2007) can be thought of as something similar to a 'code of practice', within which teachers work as professionals, to develop programmes in keeping, but not prescribed by, this document. To work as professionals, teachers are expected to have sound general educational understandings and, particularly in the case of primary teachers, an increasingly deeper understanding of all the learning areas and the similarities and differences between them. It is also expected that an essential component of school and classroom curriculum design would be the incorporation of the needs and interests of individual students, and an understanding of school and wider community's, social, cultural and political perspectives. All of this reflects a significantly increased level of responsibility for teachers and, with that, possibilities for increased 'accountability' practices. In contrast, the State appears to have given itself a 'one step removed' position, and thus the option to shrug off some responsibility 'after the set up'. At the same time, teacher professional development opportunities (particularly pre-service, but also

[1] (For details of the NZC please see http://www.tki.org.nz/r/nzcurriculum/)

[2] This is the official policy document for Maori – medium education in New Zealand schools. Maori are the indigenous people of New Zealand. Maori has been an official language in New Zealand (along with English) since 1987. For the remainder of this paper I will refer to the NZC only, as the official policy for all English-medium schools.

[3] Marautanga is the Maori term for curriculum.

in-service) are being eroded at an alarming rate as funding cuts and decisions reflecting the generally low status of education in the tertiary sector have their effect[4]. These points serve to bring to the forefront the ever political nature of education and teaching practice (Keirl, 2007).

In the next section of this paper, I set aside these issues for a time, for the purpose of exploring what the NZC does provide as support for teachers as professionals.

The 'Givens'

The NZC (Ministry of Education, 2007) provides the State's official policy for all English-medium schools in New Zealand. It presents two related parts – 'Directions for Learning' and 'Guidance'. The Guidance part of the document includes a brief 'Purpose and Scope' section, an 'Effective Pedagogy' section and a section on 'The Schools Curriculum: Design and Review'. This part of the document will not be the focus of this paper. The 'Directions for Learning' is the part that presents the 'givens'[5]. That is, the identified needs to be addressed by schools. Therefore this is the part of the document I will present in some detail prior to exploring the ways in which the learning area of technology may respond to addressing these needs.

Vision and Principles

The first section under 'Directions for Learning' is the Vision. The Vision is summarised as "Young people who will be confident, connected, actively involved, lifelong learners." (Ministry of Education, 2007: 7). The second section is the Principles. These outline the "foundations of curriculum decision making" and relates to "how the curriculum is formalised in a school" (ibid: 9).
The Principles provided are:

- High expectations
- Treaty of Waitangi[6]
- Cultural diversity
- Inclusion
- Learning to learn
- Community engagement
- Coherence
- Future focus

(Ministry of Education 2007: 9)

The Vision and the Principles reflect a commitment to personalised learning where students should have a central position in any learning programme, while acknowledging they are part of a wider sociocultural matrix, and as such, should be educated to participate as effective citizens in the future. This stance can be argued as a realisation of a democratic direction within curriculum theory and development (Elmose and Roth, 2005). The implications of a democratic direction "allows for self-expression, participatory action, and solidarity in a pluralistic society." (Elmose and Roth, 2005: 21). This focus provides a concept of general education that supports student literacy as embedded in the need for critical dialogue and decision making so that students can indeed develop into 'empowered citizens' (Skovmose, 1998). Literacy for empowerment has been described by Elmose and Roth (2005) as *Allgemeinbildung* – based on a broad and general liberal education for all, specifically framed to deal with the increasingly complex contemporary world.

This increasing complexity is linked to the recognition of the implications of a 'risk society' whereby a significant feature of participating as citizens is that "any choices and decisions among different solutions have to be made on the basis of incomplete and uncertain information" (Elmose and Roth, 2005: 16). Therefore a greater capacity for critical thought is required from our citizens. Elmose and Roth argue such a literacy rests upon three forms of knowing – knowing that, knowing how and knowing why (2005: 22).

In order to fully recognise the implications of such a vision and set of principles I argue there must be equal priority given to realising the potential of students alongside the goal of enculturation into society. The NZC (Ministry of Education, 2007) can be interpreted as in keeping with this, although it does not explicitly state it to be so. This interpretation is based on the dual focus of an 'outcomes based curriculum' and 'on realising individual's potential'. Such a dual focus requires these two goals be brought together in a mutually enhancing fashion. Wells, (1995), has argued that traditionally these goals have been seen in

[4] Two examples of this are as follows: University's nationwide have reduced the number of hours provided in undergraduate primary teaching degrees, to the extent that learning area focused courses in particular, have such limited hours they can do little more than 'introduce' Technology, Science, the Arts, and Social Sciences, Health and Physical Education and Languages. Performance Based Research Funding (PBRF) currently implemented in the Tertiary sector seriously disadvantages disciplines such as education, in favour of high status, money attracting disciplines such as medicine and engineering.

[5] However, at the time of writing this paper, it is yet to be decided exactly which of the NZC 'Given's will be 'mandated' to serve as a compliance framework for schools.

[6] The Treaty of Waitangi is a foundational document in New Zealand that acknowledges the bicultural foundations of Aoteroa and ensures that all students have the opportunity to develop knowledge of, and in, Maori language and culture.

conflict, but they need not be. With a curriculum framework where teachers are positioned as 'professionals' to develop programmes that both value and validate the "knowledge and practices that have been built up and refined by past generations" and to ensure "opportunities necessary for all students to realise their full potential and creativity" (Wells, 1995: 235), these goals have been merged to underpin a general education for citizenship stance. The resultant 'citizen' can therefore be envisaged as an informed critical and creative individual who can participate both independently and collectively in a confident, competent and innovative manner to support and change the world in which they live.

Values

In the Values section, values are described as "deeply held beliefs about what is important or desirable. They are expressed in the ways that people think and act." (Ministry of Education, 2007: 10).
In the document it is stated that all schools should encourage students to value:

- excellence
- innovation, enquiry and curiosity
- diversity
- equity
- community and participation for the common good
- ecological sustainability including care for the environment
- integrity
- respect for themselves, others and human rights

Teachers are encouraged to develop learning experiences that provide students with opportunities to both *learn about values and develop value-related capabilities*. Learning *about* values refers to students learning about their own and others' values, different kinds of values such as moral, social, cultural, aesthetic and economic values, and learning about those values upon which New Zealand's cultural and institutional traditions are based. Developing *value-related capabilities* refers to students developing the ability to express their own values, critically analyse values and actions based on them, discuss disagreements that arise from differences in values and negotiate possible solutions, and make ethical personal decisions and act on them. (Ministry of Education, 2007: 10)

Key Competencies

In the fourth section, 'key competencies' are described as "the capabilities people need in order to live, learn, work and contribute as active members of their communities" (Ministry of Education, 2007: 10).

The five key competencies defined in the document are:

- thinking
- using language, symbols, and texts
- managing self
- relating to others
- participating and contributing

The NZ Key Competencies have been developed from the OECD *Definition and Selection of Competencies* (DeSeCo) project. The DeSeCo project sought to establish "a broad overarching conceptual frame of reference relevant to the development of individually based key competencies in a lifelong learning perspective" (Rychen and Salganik, 2003: 2). In keeping with the DeSeCo work, the nature of the key competencies articulated in the NZC (Ministry of Education, 2007) moves away from the more simplistic view captured in the previous Essential Skills (Ministry of Education, 1993) to one which views competencies from the wider perspective of ensuring "a successful life and a well-functioning society, conceiving the potential societal benefits of a well educated citizenry as including a productive economy, democratic processes, social cohesion, and peace." (Rychen and Salganik, 2003: 5).

However, as a result of various consultations and debates within the education sector (Rutherford, 2004), the competencies in the NZC (Ministry of Education, 2007) show some differences to those advocated by the DeSeCo that can be argued as more than a change in terminology. For example, 'thinking' in this document is presented as a separate competency, rather than upholding the cross-cutting nature it has in the DeSeCo work. This shift reflected the argument that "the knowledge, values, skills and attitudes that compose each competency group would be employed in conjunction with other competencies in meeting the demands of tasks, making the model itself fully interactive" (Rutherford, 2004: 10).

In the New Zealand development, the original DeSeCo 'acting autonomously' was split into 'managing self' and 'participating and contributing'. Within 'participating and contributing' there is a high priority given to *belonging* as reflective of early childhood education alignment and Maori concerns particularly (Carr and Peters, 2004). The other changes are largely language based – 'interacting in heterogenous groups' was renamed for simplicity to 'relating to others', and 'using tools interactively' was renamed for explanatory purposes to 'using language, symbols, and texts'. How these changes impact on the overall integrity of a competency framework is yet to be seen. As stated by Rutherford 'Given the crucial role that

'reflectivity' plays in underpinning the DeSeCo framework the implications of tampering with this need to be fully explored.' (2004:10). In addition, it would be unfortunate if these changes made it difficult for New Zealand to contribute to, and be informed by, ongoing research in line with the DeSeCo work.

Learning Areas

The final section in the document presents the eight learning areas deemed important for "a broad general education" for all New Zealand students (Ministry of Education, 2007: 16). The learning areas provide what has been identified as knowledge and practices of 'worth' for all New Zealand students and therefore can be seen as collectively providing for a foundational multi-literacy. The eight learning areas are:

- English
- The Arts
- Health and Physical Education
- Learning Languages
- Mathematics and Statistics
- Science,
- Social Science
- Technology

The learning areas are described as 'distinct' but with 'natural connections', and as 'a part of general education… laying foundations for later specialisation' (Ministry of Education, 2007:16). However, it is not clearly explained in the document what the concept of learning areas underpinning this terminology is. This lack of definition and differentiation between a learning area and the more traditional notions of a subject, were also features of the previous national curriculum. The NZCF (Ministry of Education, 1993) made the shift to learning areas, but due to a lack of clear explanation, the majority of schools did not recognise the significance of this shift in terms of the opportunities it offered to move past subject structures. It is unfortunate the NZC did not seek to rectify this, particularly given its desire to make learning in the secondary sector less compartmentalised. While it is noted in the Guidance section under Effective Pedagogy that "teachers can help students make connections across learning areas" (Ministry of Education, 2007: 34) and in The School Curriculum: Design and Review that "links between learning areas should be explored" (Ministry of Education, 2007: 39), the discussions surrounding this tend to reinforce notions more in keeping with subject focused programme development. The potential for the concept of learning areas to open up spaces for teacher collaboration and programme development that encourages more holistic learning opportunities *across* learning areas is therefore significantly underplayed in this document. However, it does still exist, albeit at a more implicit level.

Technology in the New Zealand Curriculum

The release of *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) marked the first formalised curriculum in technology education and represented a significant shift away from 'dealing' with technology through different technically oriented syllabi and the piecemeal inclusion of technological aspects within science and social science. Instead this document sought to present technology as a coherent learning area with the aim of developing holistic notions of technological literacy, with distinct theoretical underpinnings and expectations for classroom practice (Compton, 2001). The focus of the 1995 technology curriculum was on developing technological literacy through undertaking technological practice. This focus on technological practice was to be achieved through the integrating of the three strands (Technological Knowledge and Understanding, Technological Capability and Technology and Society).

However, this requirement caused a number of problems for teachers, particularly because the achievement objectives provided in the technology curriculum did not integrate across the strands, but were atomised within each strand. Therefore the 'progressions' they sought to support were not based on progressing technological practice as a whole, and in fact tended to reflect a 'language' based activity progression. That is, level 1 achievement objectives often began with 'students can identify …' while at level 8 students would be expected to 'critically analyse …'. This reflected the dearth of research at the time on the teaching, learning and assessment of technological practice in New Zealand classrooms. Subsequent research (Compton and Harwood, 2003; Compton and Harwood, 2005) sought to specifically address this issue resulting in the development of new 'components' that could be used to clearly identify technological practice learning outcomes and support progression focused on increasing sophistication of the practice being undertaken. These research findings, alongside other research into teaching and formative assessment in technology (for example, Jones and Moreland, 2003; Moreland et al, 2001), sought to provide teachers with more specific guidance around identifying key aspects to focus on when supporting student technological practice, as well as building a growing understanding of pedagogical content knowledge for technology.

Between 2001 and 2002, teacher attitude to, and

implementation experiences of, the technology curriculum were explored as part of the National School Sampling Study (Jones et al, 2004). Evidence was also coming to light from National Certificates of Educational Achievement assessments that the nature of the technological literacy being developed by students through a focus on technological practice alone was limited in breadth, depth and criticality (Compton and France, 2007a). As a result, gaps in the 1995 technology curriculum constructs were identified and policy papers were developed to address these through the exploration of two possible new strands for technology – a Technological Knowledge strand (Compton, 2004) and a Nature of Technology strand (Compton and Jones, 2004). A two and half year research contract was subsequently set to identify the components that should sit within these new strands for the purposes of revising the technology curriculum as part of the NZCMP (for details of this research and its findings see Compton and France, 2007a; Compton and France, 2007b).

The resulting technology curriculum within the NZC (Ministry of Education, 2007) therefore seeks to extend the concept underpinning the aim of technological literacy. Undertaking technological practice is still seen as important within this concept, but the need to understand the philosophy of technology as a domain and develop understandings of key technological knowledge, have now been recognised as additional aspects required for the development of a broad, deep and critical technological literacy (Compton and France, 2007a). This extended concept of technological literacy is in keeping with that discussed more recently as the common international 'goal' of technology education where there is a focus on developing technological literacy that supports an informed and critical citizenship for the future (Dakers, 2006).

The revised curriculum in technology presents three strands as key to providing learning opportunities for students to develop such literacy – these being the Nature of Technology, Technological Knowledge and Technological Practice. Eight components overall have been established across the three strands. Together, the eight components take into account all four of the concepts of technology Mitcham (1994) argues as being important if the full potential of technology education is to be realised. Table 1 provides an overview of the strands and their components and includes links to Mitcham's key concepts (shown in italics).

The identified components[7] for each strand were developed into eight levelled achievement objectives to support the development of learning experiences that supported student progression, formative assessment interactions within classrooms, and the reporting of student achievement.

In the next section of this paper I explain how technology as a learning area can address the general educational goals and associated 'givens' outlined in the NZC (Ministry of Education, 2007) across the compulsory and senior secondary school sectors. To aid this explanation, I draw on illustrative examples of technology education in New Zealand schools.

A Technological Response to the 'Givens'

Addressing the Needs arising from the Vision and Principles

The nature of the 2007 technological literacy outlined above is reflective of the critical literacy discussed previously by Petrina (2000) and more recently within much of the writing captured in the recently published –

Technological Practice	Nature of Technology	Technological Knowledge
Brief Development *(Technology as Activity)*	Characteristics of Technology *(Technology as Volition)*	Technological Modelling *(Technology as Knowledge)*
Planning for Practice *(Technology as Activity)*	Characteristics of Technological Outcome *(Technology as Artefact)*	Technological Products *(Technology as Knowledge)*
Outcome Development and Evaluation *(Technology as Activity)*		Technological Systems *(Technology as Knowledge)*

Table 1. Technology Curriculum Constructs in the NZC

[7] For further explanation of all components please see http://www.techlink.org.nz/curriculum-support/papers/index.htm

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Defining Technological Literacy: Towards an epistemological framework (Dakers, 2006). I argue such a technological literacy serves to enhance democratically-aligned educational goals, and provide a base for students to understand their existence and potential future role in the wider technological world. Because technological innovation is central to the fabric of a 'risk society', technological literacy conceptualised in this way becomes a key contributor to the development of Elmose and Roth's (2005) concept of *Allgemeinbildung* as outlined earlier. That is, contemporary democracy requires a high level of critical thought from citizens to enable them to function effectively and in an empowered fashion in an uncertain world. The three forms of 'knowing' identified by Elmose and Roth as essential for such citizenship can be clearly linked to the three strands in technology. Students developing technological literacy as part of their overall foundational literacy are provided with a direct means of enacting opportunities for the development of these three forms of knowledge. For example, 'knowing why' encompasses the philosophical understandings inherent in the Nature of Technology strand, 'knowing that' encompasses the conceptual understandings of Technological Knowledge strand and 'knowing how' encompasses the competencies and understandings from the Technological Practice strand. Knowing how has often been undervalued in past general educational experiences and its central role within technology ensures this is no longer the case. Taken together, these three strands provide opportunity for students to be enculturated into the contemporary technological world through understanding validated technological knowledge (primarily through the technological knowledge strand) and socio-technological practices (primarily through the nature of technology strand), while also allowing for the creative potential of individuals to be realised (primarily through the technological practice strand).

Developing programmes in technology that support the aim of developing a broad, deep and critical technological literacy therefore provides ongoing potential to embed the principles outlined in the NZC (Ministry of Education, 2007). The technological practice strand in particular ensures that authentic opportunities are provided for students to engage with the community in various ways and that they confront key future focused themes such as sustainability as a core part of their participation. Working with authentic needs and/or opportunities creates a high

Picture retrieved Dec 2008 from http://www.technion.org.nz/GIF-tech-education/beacon-practice/Materials/CP802-street-luge/index.htm

Picture retrieved Dec 2008 from http://www.technion.org.nz/GIF-tech-education/beacon-practice/Materials/CP802-street-luge/outcomes.htm

Three secondary teachers worked together from two schools to create a memorable learning experience for their year 11 students (average age 15) focused on the extreme sport of street luge. The students were all involved in designing, building, and race-testing a luge. Students accepted the challenge and developed high expectations of what they could achieve. Given the risk element involved in the final event, the students quickly ascertained they would need to access the best material and mechanisms knowledge currently available and employ verified safety practices and establish rules if they were to 'survive' the race and have a chance of winning the 'best' luge prize. In addition, students gained credits in technology achievement standards as part of their NCEA. The motivational effect from the excitement and pure fun element was significant and led to teachers noticing a distinct increase in commitment to meeting deadlines and completing the final outcome to a very high standard. The overall success of this unit means all three teachers intend to repeat the unit next year. The students from 2008 will have the opportunity to act as 'street luge mentors' for the 2009 cohort, thereby providing some of the local expert knowledge they did not have access to during their own technological practice.

Table 2. Illustrative Example[8] of Technology Supporting Vision and Principles

[8] *For further details please see http://www.technion.org.nz/GIF-tech-education/beacon-practice/Materials/CP802-street-luge/index.htm*

level of expectation and commitment for students, and success in meeting these results in a growing level of empowerment and sense of 'place'. In this way technology contributes significantly to the NZC vision of developing "confident, connected, actively involved, lifelong learners" (Ministry of Education, 2007: 7).

Table 2 presents an example of how learning in technology:
- Provided an authentic opportunity for students to be part of the wider community
- Supported students to meet high personal and social expectations
- Encouraged coherence in student learning by bringing together skills and knowledge from a range of sources
- Allowed students to become actively involved in supporting others learning through mentoring of future students

Addressing the Needs from Values Education

All eight components within the three strands of technology provide opportunity for 'values rich' experiences, and as such technology has the potential to create in students a "critical ethical consciousness" as espoused by Keirl (2006), as key in technology education and indeed key to future democratic citizenship.

Student success in understanding and undertaking technological practice relies on understanding values and the development of value-related capability. Through *Planning for Practice*, students have a strong focus on caring for the environment as they develop their capability to manage resources efficiently, and make ethical decisions around sustainable development. The ongoing reflection and evaluation of past practice inherent in this component ensures the exploration of their own and others values, and developing understanding of how values impact on decision making. Undertaking *Brief Development* provides students with explicit opportunity to explore the values of others, as the identification of an authentic need or opportunity is based on a comprehensive exploration and critical analysis of a context, associated issues, and a wide range of stakeholders' values and desires. In defining specifications, student will be required to understand a range of different types of values in order to ensure the fitness for purpose is established in its broadest sense[9]. Stakeholder values from the wider community will therefore need to be analysed and compared, and any areas of contestation identified and resolved, in order for the brief to be developed in a way that is acceptable to all key stakeholders as well as being cognisant of impacts on other people or the environment in the future. *Outcome Development and Evaluation*, allows for a strong focus on achieving excellence and showing perseverance in producing an outcome of worth. An 'outcome' in this sense may be the use of existing technologies, development of technological knowledge, design concepts, plans, briefs, models, or technological outcomes (products and systems). Decisions as to which of these is the most appropriate, rely on extensive reflective and critical analysis of what is of value and why, enabling students to develop their capability in ethical decision making and to act in accordance with these decisions. The development of an outcome involves the generation of design ideas and the refinement of potential outcomes through ongoing experimentation, analysis, testing, and evaluation against the specifications of the brief. Exploration of materials in terms of functional and aesthetic value against environmental cost should be undertaken as extensively as possible in order to interrogate designs and resourcing as fully as practicable prior to the selection of materials and the development of any final outcome. Outcomes, and the practice undertaken to develop them, should be critically reflected on and evaluated from a range of perspectives to ensure 'fitness for purpose'. This in turn provides opportunities for students to explore others responses to outcomes, and understand these in terms of the values that are associated with them.

Table 3 presents an example of how learning in technology focused on the technological practice strand:
- Provided an opportunity to work with another school community and develop understandings of the values of others.
- Developed empathy for others in order to appreciate some of the specific challenges of teenagers confined to wheelchairs.
- Allowed opportunity to explore personal values and those of society towards physical impairment.
- Encouraged values-based decision making and action to meet others needs.

Developing a philosophical understanding of technology inherently involves students in developing views on the value of technology and its outcomes and the way in which this changes across time, physical and social location. A focus on *Characteristics of Technology* demands that students explore a range of different types of values.

[9] *Referring to 'fitness for purpose in its broadest sense', ensures the determination of the 'fitness' of the practices involved in developing the outcome, as well as the 'fitness' of the outcome itself.*

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Bonnie, a year 13 technology student (age 17), worked with a local school for wheelchair bound students. When exploring the context of the local school, Bonnie identified the need for new wet weather gear for the students to ensure they could attend events and go on trips when the weather was cold, windy and wet. Bonnie had to understand the perspectives and values of her client group, and find ways to prioritise these while working to the physical requirements of the students, their wheel chairs and the school environment. She established that the existing gear had several weaknesses: its drab brown colour did not appeal to teenagers, its shape and length meant it got caught in the wheels of the wheelchairs, it was difficult to put on, and the students felt it was restrictive on the wearer. Being a teenager herself, Bonnie had a lot of opportunity to clearly examine her own values, how these differed or were similar to those of her client group, and how these were influenced by a range of factors, including reduced mobility and public perceptions of and provisions for those with physical impairment.	 *Picture retrieved Dec 2008 from http://www.technion.org.nz/student-showcase/materials-soft/bonnie.htm*

Table 3. Illustrative Example[10] of Technological Practice Supporting Values Education

Analysing the history of technological development provides insight into the way in which different people's and institutions' values have influenced past technological decision making and technological practices, and how these in turn have impacted on the values of others. This component provides opportunities for informed debate of contentious issues and the complex moral and ethical aspects involved. The socio-cultural and political drivers behind past developments can be explored and analysed in order to better understand how issues of diversity, equity, and respect for others have been addressed – or not, in past scenarios. It also allows for an analysis of the way in which these drivers impact on the values and views of people in different societies and socio-economic groupings towards technology related decisions, and the value placed on technological outcomes, within contemporary contexts. Exploring technology as an interventionary force that provides potential to enhance the capability of humans to transform, store, transport and control materials, energy and information, allows students opportunity to reflect on what and whose values have been prioritised in the past. In this way the notion of 'enhancement of capability' can be problematised and critiqued in terms of who has benefited and who has not, from such developments. An evaluation of technological outcomes involves an exploration of the purpose behind its development, how this purpose was justified as of value, and how this may change as the values of both designers and users change. Examining a range of historical, contemporary and potential future technological outcomes therefore provides opportunities for students to interrogate the notions of what is fit for purpose across people, time and place. Understanding the epistemological differences across disciplines also allows students to understand how and why different types of knowledge hold different value as 'evidence' across contexts and cultural groups. The highly collaborative nature of contemporary technological practice allows students an opportunity to examine the way in which technologists work together to resolve, or not, issues of difference associated with personal, professional, political and economic values. A focus on *Characteristics of Technological Outcomes* provides opportunity to examine the physical and functional nature of an outcome and explore how this relates to its overall fitness for purpose. Exploring examples of mal-function allows students to explore the way this can impact on people's views of the value of technology, and the level of social acceptability of high impact innovations.

Table 4 presents an example of how learning in technology focused on the nature of technology strand:

- Provided an opportunity for students to explore how values may differ in a cross-cultural setting.
- Allowed opportunity to explore how what is perceived as valuable changes across time and social groups.
- Encouraged students to explore and articulate personal views on how and why technological outcomes are valued.

Technological Modelling includes functional modelling to explore the feasibility of a design concept for a yet-to-be-realised technological outcome, and prototyping to explore the fitness for purpose of the technological outcome itself. Both are key tools in technological practice that support informed predictions of possible and probable

[10] *For further details please see http://www.technion.org.nz/student-showcase/materials-soft/bonnie.htm*

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A year 4-5 unit (average age 8-9) focused on the nature and development of tools for 'gardening'. Looking specifically at tools used by early Maori for tending crops and more contemporary tools on the market today in New Zealand allowed the teacher in this unit to explore both the relationship between the materials available and the required functions for both and how changes in these can be linked to the dominant values of the time. The high value attributed to working the land in early New Zealand settlement – both by Maori and early Pakeha was clearly apparent in the number of tools owned by households and in their design. As times have changed and subsistence agriculture for food has been largely replaced by commercial growers, so to have individual ownership and valuing patterns changed. During the unit, the students had a chance to explore their own and others views on how values impact on technological development in a cross-cultural setting. Traditional tools used by Maori to work the land were analysed and discussed in terms of their past and current use. Modern gardening tools were also analysed. This context provided opportunity for students to begin to understand the influences behind past technological developments, and analyse their own points of view and how these have impacted on their own developing values and 'ways of knowing'.	 **Traditional Maori Ko (Hoe)** *Photo courtesy of Tom Ward. Retrieved Dec 2008 from http://www.tepapa.govt.nz/TePapa/English/Learning/OnlineResources/Matariki/GardeningTools/Ko.htm*
For example, an eight year old Maori boy made the following comments in response to a question about why tools were made and have changed: *Student:* I don't know… 'cos the Maoris don't appreciate the Pakeha invention… they want to make their own ones. *Teacher:* Ok so Maori make their own inventions – but why – why do people make new things? *Student:* probably 'cos the Pakeha is the enemy to the Maori. Maybe the Pakeha don't want to use our Maori ones… Clashes between indigenous people and colonising forces provide a rich and often fraught context for such exploration. The perception of devaluing indigenous knowledge and technological outcomes was a very strong feature of this boy's view, and having the opportunity to articulate these was ultimately an enriching experience for the teacher and the class as a whole.	 **Traditional Maori Kaheru (Spade)** *Photo courtesy of Tom Ward. Retrieved Dec 2008 from http://www.tepapa.govt.nz/TePapa/English/Learning/OnlineResources/Matariki/GardeningTools/Kaheru.htm*

Table 4. Illustrative Example of the Nature of Technology Supporting Values Education

consequences of proceeding, and therefore underpin justifiable decision making based on functional and practical reasoning. Functional reasoning provides the reasoning behind 'how to make it happen?' and practical reasoning provides a focus for 'should we make it happen?'. Therefore, understanding the role of different types of values in technological modelling is critical to its success. The component of *Technological Products* allows for a focus on the material nature of those artefacts that exist in the world as a result of human design, due to their perceived value, at the time of their development.

Understanding the relationship between the properties of materials and their performance capability is essential for understanding and developing technological products. Technological knowledge within this component includes the testing of materials to determine appropriate use to enhance the fitness for purpose. Appropriate use will be reliant on understanding the values associated with all stakeholders. The impact of material use and development on product life cycles will be also be important in understanding sustainability as a recognised high value concept in caring for the environment. The

component of *Technological Systems* allows for a focus on the interconnectedness of components designed to work together to control the transformation of materials, energy and information. Again, appropriate system development and the acceptability of technological system integration with other systems (for example, social, physiological) is reliant on understanding the values associated with a wide range of stakeholders and how they prioritise their own needs and those of others. Redundancy and reliability within technological system design and performance will also need to be understood as part of how technological systems are perceived by people and evaluated in terms of risk acceptability. Exploring the use of a black box approach when working with technological systems provides opportunity for students to understand the value and disadvantages in such an approach.

Table 5 presents an example of how learning in technology focused on the technological knowledge strand:

- Provided an opportunity for students to explore why what is of value changes across contexts.
- Encouraged students to explore and articulate how things of value to one group of people may disadvantage others.

Addressing the Need to Develop Key Competencies

Due to a coherence of purpose and theoretical underpinnings there is a high level of correlation between technology and the key competencies as derived from those of the DeSeCo project. Both serve to challenge and support students to become empowered to take a significant role in a multifaceted, complex and changing contemporary world. There are also very strong theoretical links underpinning each, with a focus on an individual's viewing and understanding of the social world as a part of 'being' in that world. Strong epistemological links are apparent, whereby in both cases knowledge is conceptualised as a social construct linked to purpose and context. Both view cognition, behaviours, attitudes and

In a year 5-6 unit (average age of students was 9 or 10) a teacher used the context of the 2008 Olympic Games to explore changes over time and New Zealand's history of athletics. Technological systems became a central focus for the 'technology immersion' part of this unit. In groups the students identified and explored one particular technological system relevant to the Olympic Games, and then discussed all these systems to enhance their understandings of technological systems as a whole. A 10 year old girl was involved in developing her understandings of timing systems used to time athletes in these games and how these differed to those used in the past and at her school athletics day. The value of accuracy was a key feature that resulted from her comparing and contrasting of these. In addition this context provided her with the opportunity to explore the notion of a black box within a technological system. By the end of the unit she could clearly articulate her thoughts about the notion of a black box, including how it differs in value across different groups.

For example during an interview she stated the following:

Interviewer: What do you think a system is?

Student: A system is a something with… kinda like a process… with an input, an output… um reliability and a black box.

Interviewer: What is a black box?

Student: um… a black box is… say… I can't really explain it that well so I'll give you a… stopwatch. Inside this stopwatch… all you can see is the outside and what you can see is all you know. But inside the stopwatch there are certain materials and things that are hidden from us. So only the experts who make it – they only understand. So if you were a person who works at a supermarket… you know which buttons to push on a cash register… but inside a cash register – you don't know what's in there and how everything works… but you do know what buttons to push.

Interviewer: What would be the advantages and disadvantages of a black box?

Student: Well… from my perspective, I think it would be good to know what is actually inside the stopwatch and how everything works. But the people that make the stopwatch, they don't want anyone else to know so that they won't – you know – take over the spotlight and… it's a way of hiding things and stuff so that we don't know what they are and we don't get to make that. So people that are making the stopwatch get some progress and we don't get to… and they get some money.

Table 5. Illustrative Example of the Nature of Technology Supporting Values Education

values as inherently integrated in learning, and thereby make similar demands on learning programmes. All the strands within technology education would support and be supported by an increase in sophistication across the key competencies.

Critical and creative thinking are clearly valued as essential in technology and technology education has been identified as a place where creativity can be uniquely fostered (Lewis, 2005). Metacognitive awareness and reflective processes are also discussed as essential in learning about and working in technology. As Kimbell and Perry (2001) point out, the ability to 'helicoptor out' is key for students in technology in order to "take stock and review what is being done and why; what alternative approaches might be adopted and why" (p.14). Opportunities for the enhancement of creative and critical thinking are clearly identifiable whether working within innovative problem solving situations, debating contentious issues, or projecting into alternative scenarios during the analysis and/or development of a technological outcome. Such thinking is essential to making informed decisions that are based on ethical, as well as functional grounds, allowing for an understanding of fitness *for* purpose, as well as explorations of the fitness *of* any stated purpose.

The specialised language inherent in technology provides significant opportunities for extending students' competency *in using language, symbols and texts*. An extensive range of available technologies (including language, models, symbols, and specialised and non specialised procedures and equipment) are explored alongside a range of knowledge bases, including technological knowledge. This will be reinforced within informed technological practice where critical evaluation as part of ongoing experimentation, analysis, testing and final evaluative judgement requires students to not only understand specialised language, symbols and texts, but also to operationalise these understandings across a diverse range of contexts. Developing a philosophical understanding of technology as a discipline requires students to be familiar with a range of historical and contemporary texts, and understand many forms of codified language.

When students undertake their own technological practice, whether individually or as part of a group, students are required to develop *self management* skills in order to effectively plan ahead and manage resources efficiently to ensure informed and responsive practice. In order to work effectively and ethically, students must develop their own self regulating procedures as well as identify those of

A year 12 class (average age 16) worked with a local client to develop an innovative lighting product for an inner city café/restaurant and club called Sandwiches. The students were provided with initial learning experiences around lighting to increase their skills and understandings before embarking on designing and refining an appropriate lighting product for their client. The nature of the stakeholders required the students to generate *creative* ideas, while ensuring they were *critically* tested to ensure functional and aesthetic feasibility. Being able to undertake ongoing reflective evaluation was important in this process. The outcomes needed to be of a high quality and comply with all relevant safety codes as they would be trialled in situ. This required working and understanding with a *range of text* types and communicating effectively using *specialist language*. It was critical to the success of this project for the student to *self manage* to ensure effective and ongoing communication with the key stakeholders.	 *Picture retrieved Dec 2008 from http://www.technion.org.nz/GIF-tech-education/beacon-practice/Materials/BP603-bright-ideas/outcomes.htm*  *Picture retrieved Dec 2008 from http://www.technion.org.nz/GIF-tech-education/beacon-practice/Materials/BP603-bright-ideas/delivery2.htm*

Table 6. Illustrative Example[11] of Technology Supporting the Key Competencies of Thinking, Using Language, Symbols and Text and Managing Self

[11] For further details please see http://www.technion.org.nz/GIF-tech-education/beacon-practice/Materials/BP603-bright-ideas/index.htm

others to ensure the overall practice is coordinated and successful. The project based pedagogy supporting much of technology learning relies on students becoming "...autonomous learners, taking responsibility for decisions and living with their consequences." (Kimbell and Perry, 2001: 7). The ability to understand and undertake technological practice cognisant of the wider sociocultural context, allows for a developing sense of self identity across a range of life contexts within and outside of formal education.

Table 6 presents an example of how learning in technology:

- Provided an opportunity for students to explore and work with specific safety codes of practice.
- Encouraged students to think creatively and critically.
- Provided a context where self management was critical to student success.

Technology programmes provide opportunities to develop ongoing and mutually beneficial community relationships critical for developing student competency in *relating to others* and *participating and contributing*. Because of the inclusion of multiple knowledge and skill bases (both technological and those from other disciplines) in technology, it is common to require expertise from the community and/or industry. Inviting people in as valued experts provides a healthy platform for ongoing future relationships regarding student learning and cohesion across local work places and/or communities. Students also work alongside service organisations, local businesses and other community groups to meet a school or community need. This type of working relationship allows all parties opportunity to develop a better understanding of the ethics, beliefs and understandings of respective groups and individuals, and thus enhance future interactions. All technological practice and resulting technological outcomes are situated in specific sociocultural and physical locations resulting in both opportunities and constraints. Conflicts and potential collective action are often underlying issues. Functioning effectively within such highly dynamic and complex environments requires extensive knowledge and understanding of many stakeholders – both direct and indirect. Being empowered to operate across a wide range of social groups is therefore key to increasingly sophisticated technological practice and broad and critical understandings of technology's role in contemporary society.

Table 7 presents an example of how learning in technology:

- Provided an opportunity for students to participate in the community and contribute to the well-being of another.
- Encouraged students to relate effectively to their client to ensure their solution meets their needs.

Taking the Concept of Learning Areas Seriously

The atomisation of learning within schools has long been recognised as a problem. Given the obvious connections across disciplines in the lived world outside of school, it is high time schooling addressed this issue in more than a token mention within a curriculum document. Technology is "deliberately and actively interdisciplinary" (Kimbell and Perry, 2001: 19) and as such provides an authentic site for developing and maintaining cross curricula links. As argued by Seltzer and Bently (1999), innovation increasingly relies on the interface between different kinds of knowledge, allowing insights from one discipline to be applied to others. Technology also provides opportunity for students to understand how and why evidence claims and argumentation differ across disciplines and therefore the need to acknowledge differences when working to develop new initiatives when working across boundaries.

Picture retrieved Dec 2008 from http://www.technion.org.nz/student-showcase/materials/matthew.htm

During his year 13 technology programme, Matthew (age 17) worked with a client Tony Granger. Tony is immobile from the waist down and is unable to pick up items on the floor. Mathew had to *relate to* Tony at a level that would allow him to explore his specific needs and develop an outcome that would serve as a useful 'third arm' rather than a frustrating tool. Through the development of this device, Mathew *participated* productively for a time in the community of the Disability Centre and *contributed* significantly to Tony's ongoing management of his disability.

Table 7. Illustrative Example[12] of Technology Supporting the Key Competencies of Relating to Others and Participating and Contributing

[12] For further details please see http://www.technion.org.nz/student-showcase/materials/matthew.htm

Yep – We Can Do That:
Technological response to the curriculum 'needs' arising…

Collaboration across learning areas allows students (and teachers!) to see the links across their learning as a whole. Technology is arguably the best placed learning area to provide cross-curriculum education in a coherent and manageable fashion. The reasons for this rest on the inherently interdisciplinary nature of technology as outlined above. While technology, the discipline, has its own distinct knowledge base, other discipline's knowledge and practices are as important as technology's in understanding technological artefacts and practices and/or undertaking technological practice. Another related aspect is that technology, as a learning area, provides an authentic site for students to draw together and develop their understandings and/or practices from other learning areas. It is important to note that what is being advocated here is not curriculum integration but curriculum collaboration. That is, the learning areas have a certain integrity that must be understood, respected and maintained. They each seek to clearly develop an aspect of the overarching multi-literacy being advocated as the overall goal of general education. That is, technology provides technological literacy, science – scientific literacy, the Arts – artistic literacy etc. They cannot be expected to do this without recognition of a level of 'boundedness' in terms of their parent discipline's philosophy (including purpose and epistemology), knowledge and practices. Rather, the potential of a learning area approach to curricula structure is that at the *programme* level obvious connections can be used to develop rich learning experiences that allow students to develop knowledge and practice across any number of learning areas as long as it can be argued as productive to do so. While the learning areas may be connected in particular ways for particular purposes within a particular unit of work, care must always be taken to ensure that the integrity of the learning areas is never undermined. For example, when learning a component of scientific knowledge within a technological setting, teachers must still find opportunity to address how this science learning enhances the student's developing scientific literacy as well as their technological literacy. Rather than taking less 'time and effort' as is often advocated, it is critical to note that robust cross-curricula initiatives will, by definition, be more time consuming and demanding than teaching within a single learning area. However, they also offer an increased opportunity for depth and connective learning that should be worthy of the increased input.

Achieving the potential for technology to play a central role in cross curricula initiatives will rely on a significant level of engagement and understanding from not only technology teachers, but from all teachers and curriculum managers across the primary and secondary sectors. It is unrealistic to assume that technology teachers, particularly in the

Pictures retrieved Dec 2008 from http://www.technion.org.nz/GIF-tech-education/beacon-practice/Teaching-Practice/CP805-stop-motion-film/background.htm and http://www.technion.org.nz/GIF-tech-education/beacon-practice/Teaching-Practice/CP805-stop-motion-film/outcomes.htm

St Patrick's College is a Catholic integrated school and as such has a strong focus on encouraging students to incorporate Christian values into everyday life – including their school work. From 2005 this school has also trialed a cross-curricula project in year 9 and 10. Chris is a great believer in the value of technology teachers establishing links with other subjects, not only to because it offers students advantages but because it also reinforces the holistic, multi-disciplinary nature of the modern workplace. One project carried out in this way was a stop-motion parable project. Chris chose parables as the storylines for the films to help students reflect on the values of the College in a context other than Religious Education classes or Mass. He planned the unit to ensure it was responsive and flexible enough to incorporate learning as required from other areas. The project would require his students to seek expert advice and help from other teachers as well as himself and to reflect on the special character of their school as they developed their scripts and storyboards. Religious education teachers provided help with the storyline, English teachers were involved in the script writing and the Music teachers provided help with the score. Chris points out that staff at his school get on well and are keen to help each other out wherever possible. He also hoped to reinforce the sense of community – a strong feature of St Patrick's – through planning an authentic client/designer relationship between the class and Year 12 and 13 Graphics and technology students who would be asked to design and build puppets and vehicles for the project.

Table 8. Illustrative Example[13] of Technology Supporting a Secondary School Cross-curricula Initiative

[13] For further details please see http://www.technion.org.nz/GIF-tech-education/beacon-practice/Teaching-Practice/CP805-stop-motion-film/preplanning.htm

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secondary sector, will initially have a good enough understanding of the specific literacy requirements of other learning areas, to undertake cross-curricula teaching alone. Working collaboratively with teachers with expertise in the area being connected is therefore critical to cross curricula learning to be successful. In this way, teachers can also begin to develop a sense of the boundaries between their area – what is similar, what is different, and in fact, what is in direct conflict.

Table 8 presents an example of how learning in technology:
- Provided an opportunity for secondary school students to work across a number of learning areas with a number of teachers to develop an outcome.

In the primary sector, working across learning areas may appear to be less difficult given these teachers are already responsible for teaching all areas. However, it is likely that primary teachers may not have an equally in-depth understanding of all areas, and like secondary teachers, may lack a well developed sense of the 'boundary' issues between the areas. These factors can reduce the power of bringing learning areas together to underpin learning experiences. Inviting experts from across disciplines is a good strategy for addressing some of these issues.

Table 9 presents an example of how learning in technology:
- Provided an opportunity for primary school students to draw together knowledge and skills from a range of learning areas and to develop an outcome.
- Encouraged the teacher and the students to seek help from outside experts to allow appropriate knowledge and skills to be developed to ensure a successful outcome.

Conclusion

Technology as a learning area has much to offer if it were supported to become a pivotal player in New Zealand education. I believe it can provide strong leadership in supporting the development of a democratic literacy for all students – in its own right and through its mutually enhancing relationship with values education and the key competencies. By providing students with experiences of a rich and varied nature, where theory and practice are inherently connected, many past issues associated with the goals of general education can be resolved. I also contend that technological programmes of learning can stimulate high levels of student interest and engagement resulting in an informed commitment to current and ongoing education opportunities. Technology offers significant opportunity for quality cross curricula links and therefore allows students more insight into, and capability to deal with, the 'un-atomised' and messy world they experience outside of school.

During a discussion about a lunchtime 'toilet' incident, students in a year 3-4 class (age 7 or 8) identified that there were problems with regards to the toilets. There was general agreement that the toilets were unpleasant to use and from this the teacher and students decided they should do something about them. To achieve a successful outcome, the teacher developed a range of learning experiences related to technology, the arts, maths and English. They worked with a number of 'experts' from the local community to learn art concepts and practices, science understandings, explore health issues and people's response to these. They brought all these together within technological practice to make an informed and sustainable change to their school toilets. In so doing, these students met specific learning outcomes from science, health and physical education as well as technology.

Picture retrieved Dec 2008 from http://www.technion.org.nz/Case-studies/Classroom-practice/archive-2006/nicer-loos/page7.htm

Picture retrieved Dec 2008 from http://www.technion.org.nz/Case-studies/Classroom-practice/archive-2006/nicer-loos/page6.htm

Table 9. Illustrative Example[14] of Technology Supporting a Primary School Cross-curricula Initiative

[14] For further details please see http://www.technion.org.nz/Case-studies/Classroom-practice/archive-2006/nicer-loos/index.htm

However, just because technology is well placed and capable of doing all these things, is not to say it should feel obliged to do so at every turn! Technology as a learning area, and in particular technology teachers, need to guard against collapsing "under the weight of the unrealistic responsibilities being placed on it" (Layton, 1995 cited in Barlex, 2007). New Zealand, like many other countries, is feeling pressure to move away from a focus on developing knowledge towards a focus on developing skills for accessing and processing information. We see teacher professional development focusing more on supporting effective teaching pedagogy, with little to no focus on what should be taught. Guarding against the push to 'homogenise' disciplines is therefore a priority at this time – just as it was imperative to guard against past tendencies to 'homogenise' people. Tolerance and growth is supported by knowing and encouraging difference and by exploring and celebrating the spaces between.

Those of us involved in technology education have long been aware that no other curriculum area suffers the constant demands for legitimisation. How many times have we been asked: So – what is technology? We begin the long and complex answer to this, only to be rebutted with the follow up directive – 'in a single sentence please – that we can all understand! We may be forgiven for having moved to a place where *proving* 'we can do that' seems to drive everything we do. This is particularly so when under political pressure for the removal of technology from the core curriculum, or to 'equate' technology education with trade training as the answer to the current worldwide shortage of trades people. However, I suggest now is the time move away from the desire to prove ourselves and be more strategic. Holding our nerve in uncertain political environments will require collaboration across nations, as well as across disciplines and sectors. There are many boundaries to be explored and crossed in this sense. As illustrated in this paper, we have ample evidence to clearly say: yes – we can meet the needs derived from 'givens' such as those identified in the NZC (Ministry of Education, 2007). But we should be extremely wary of focusing on meeting these needs if it endangers the distinctive quality and integrity of technology as a learning area, and/or overloads our teachers and students. Therefore, our next move is to begin to seriously address the ensuing critical question: Yes we can meet these 'needs' – but how much of our time in technology *should* we spend doing this?

References

Barlex, D. (2007) Justifying design and technology. Chapter in Barlex (ed) *Design and Technology for the Next Generation*. England: Cliffeco Communications

Carr, M. & Peters, S. (2004). *Key Competencies: interim thoughts for the Ministry's consultation process*. (discussion paper dated 19 October, 2004).

Compton V.J. (2001). *Developments in technology education in New Zealand 1993-1995: An analysis of the reflections of key participants*. Unpublished doctoral dissertation. University of Waikato, New Zealand.

Compton V.J. (2004). *Technological knowledge: A developing framework for technology education in New Zealand*. Briefing paper prepared for the New Zealand Ministry of Education Curriculum Project.

Compton V.J., and France B. (2007a). *Redefining technological literacy in New Zealand: From concepts to curriculum constructs*. In Proceedings of the Pupils' Attitudes Towards Technology (PATT) international design and technology education conference: Teaching and learning technological literacy in the classroom (260-272). Glasgow, Scotland.

Compton, V.J., and France, B. (2007b). Towards a new technological literacy: Curriculum development with a difference. *Curriculum Matters, 3*, 158-175. Wellington: NZCER.

Compton, V.J., and Harwood, C. D. (2003). Enhancing technological practice: An assessment framework for technology education in New Zealand. *International Journal of Technology and Design Education*. 13 (1), 1-26.

Compton, V.J., and Harwood, C.D. (2005). Progression in technology education in New Zealand: Components of practice as a way forward. *International Journal of Design and Technology Education*, 15(3), 253-287.

Compton, V.J., and Jones, A. (2004). *The nature of technology*. Briefing paper prepared for the New Zealand Ministry of Education Curriculum Project.

Dakers, J. (Ed.) (2006) *Defining Technological Literacy: Towards an epistemological framework*. New York. Palgrave Macmillan.

Elmose, S. and Roth W-M. (2005). *Allgemeinbildung*: Readiness for living in risk society. *Journal of Curriculum Studies*, 37 (1), 11-34.

Jones A. and Moreland J. (2003) Developing classroom-focused research in technology education. *Canadian Journal of Science, Mathematics and Technology Education* 51-66.

RESEARCH

Jones, A., Harlow, A. and Cowie, B. (2004) New Zealand teachers' experience in implementing the technology curriculum *International Journal of Technology and Design Education* 14, 101 - 119

Keirl, S. (2007) The politics of technology education. Chapter in Barlex (ed) *Design and Technology for the Next Generation*. England: Cliffeco Communications

Kimbell, R. and Perry, D. (2001). Design and Technology in a Knowledge Economy. London: Engineering Council.

Lewis, T. (2003). Creativity – a framework for the design/problem solving discourse in technology education. *Journal of Technology Education*, 17 (1), 35-52.

Ministry of Education. (1993). *The New Zealand Curriculum Framework*. Wellington: Learning Media.

Ministry of Education, (1995) *Technology in the New Zealand Curriculum*. Wellington: Learning Media

Ministry of Education (2002). Curriculum Stocktake Report to Minister of Education, September 2002. Retrieved October 2008 from http://www.educationcounts.govt.nz/publications/curriculum/5815.

Ministry of Education, (2007) *The New Zealand Curriculum*. Wellington: Learning Media.

Ministry of Education, (2008) *Te Marautanga o Aoteroa*. Wellington: Learning Media.

Moreland, J., Jones, A., and Northover, A. (2001). Enhancing teachers' technological and assessment practices to enhance student learning in technology: A two year classroom study. *Research in Science Education*, 31(1), 155-176.

Petrina, S. (2000) The Politics of Technological Literacy. *International Journal of Technology and Design Education* 10: 181-206.

Rutherford, J. (2004, December). Key competencies in the New Zealand curriculum: A snapshot of consultation. Paper prepared for the Ministry of Education's New Zealand Curriculum Marautanga Project.

Rychen D.S. and Salganik L.H. (Eds.). (2003) *Key Competencies for a Successful Life and a Well-Functioning Society*. Göttingen: Hogrefe & Huber Publishers

Seltzer, K. and Bently, T. (1999). The Creative Age: Knowledge and skills for the new economy. London: DEMOS.

Skovmose, O. (1998). Linking mathematics education and democracy: Citizenship, mathematical archaeology, mathemacy and deliberative interaction. *International Reviews on Mathematical Education*, 30 (6), 195-204.

Wells. G. (1995). Language and the Inquiry-oriented Curriculum. Curriculum Inquiry, 25 (3), 233-269.

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