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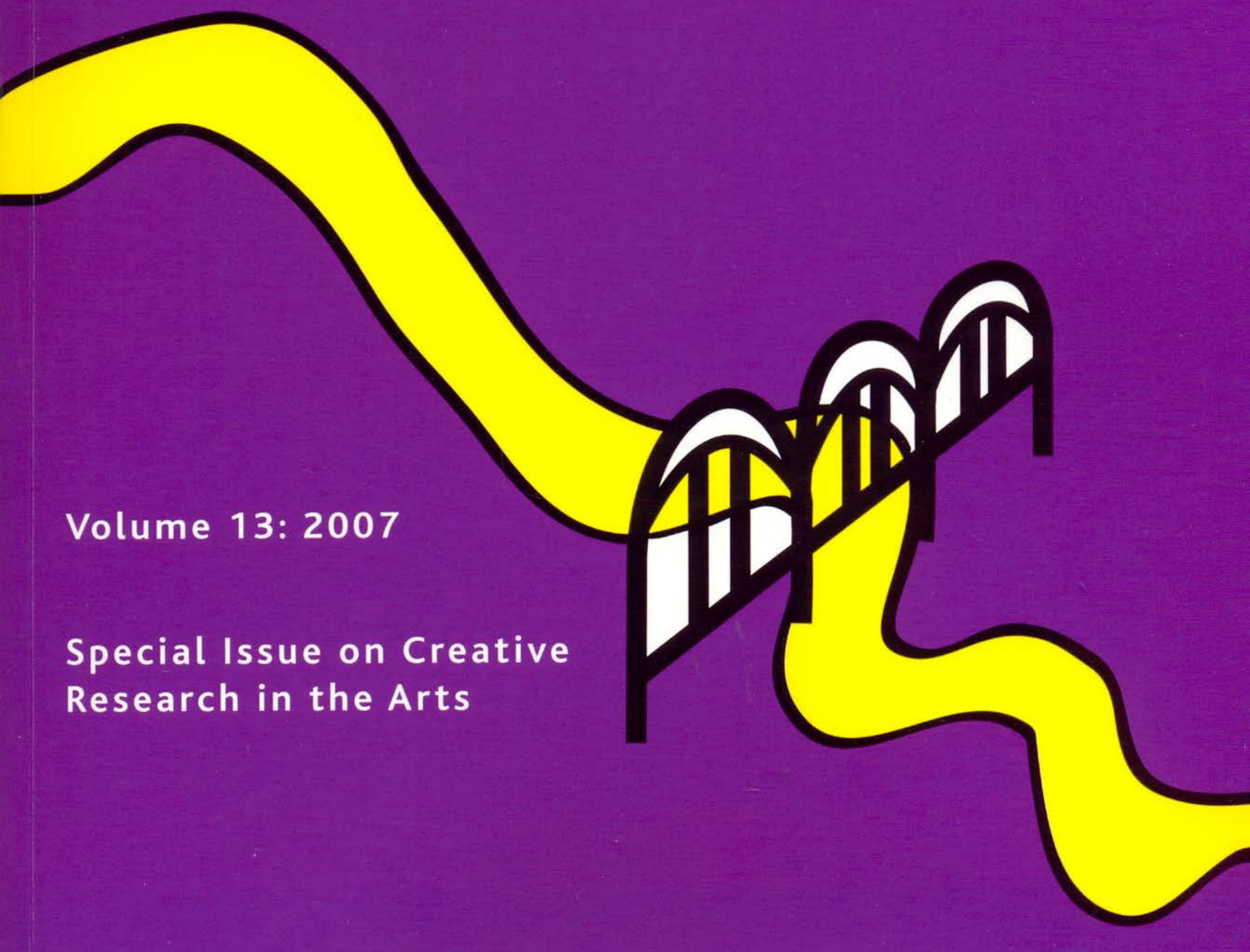

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This special section focuses on new developments in curriculum, a topic of current interest in view of the introduction of the new New Zealand curriculum in 2007. The new curriculum calls for creative responses from teachers, teacher educators and others interested in the material and content of teaching. For the first time in New Zealand, pedagogy has been included in an account of the school curriculum, so the editors welcome any papers which reflect interaction between curriculum and pedagogy as well as subject-oriented or content-focused papers.

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REFLECTING ON THE DEVELOPMENT OF A NEW SCHOOL SUBJECT: THE DEVELOPMENT OF TECHNOLOGY EDUCATION IN NEW ZEALAND[1]

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ABSTRACT *The last 10 years have seen the production of curricula in Australia, the United Kingdom, USA, Canada, Hong Kong and New Zealand that emphasise the importance of students developing technological literacy. This paper traces the development of a new subject – technology education – in the New Zealand curriculum and explores the politics of development of a new subject as well as the theoretical stances and research that contributed to its development from 1992 until 2005. This paper outlines the various stages of development including curriculum development, teacher development, and the move to creating a classroom research agenda to enhance the teaching and learning in technology education. The paper reinforces the notion that significant gains can be made in curriculum, teaching, learning and assessment when research and development are conducted in an on-going manner.*

INTRODUCTION

Internationally there has been a trend to develop curricula that emphasise the importance of student technological literacy: in particular in Australia, the United Kingdom, USA, Canada, Hong Kong and New Zealand. This paper traces the development of technology education in New Zealand since 1993. There are three basic purposes behind this form of education: to improve the economy of the country; for its intrinsic value as part of individual development; and as an introduction to culture. McCormick (1992) has spelled out these purposes in more detail, but a number of other authors have given different names to cover the same ideas (Layton, 1994; Jones & Carr, 1993). Probably the most compelling reason for studying technology is that it is a major and, some would argue, a determining feature of the world we inhabit. As part of culture, young people need to be introduced to it so they can understand its nature and be able to participate in it at some level or other. Technology therefore stands alongside other ways we represent culture (science, mathematics, music, etc.) This makes it more difficult to represent (and to agree on its nature) but it is no less an aspect of culture than the major areas of knowledge and understanding that are represented as subjects. If technology is indeed a determining feature of the world we inhabit, it follows that young people, as future citizens, need to understand how it shapes the world. Technology is a value-laden activity and citizens need to understand and control many of the

[1] Inaugural Professorial Address, October 2005

decisions that are made about it. Therefore, education must prepare them to do this by dealing with the technical, social, political and economic issues that underlie technological process. This will allow them to take part as active citizens of their society.

TECHNOLOGY IN NEW ZEALAND SCHOOLS PRIOR TO 1993

Technology education for all students is a relatively new phenomenon in national and international curricula. Although New Zealand has a long history of technical education in the senior primary and secondary school (Burns, 1992), a framework for technology education for all students has only recently been developed (Jones & Carr, 1993). Aspects of technology have been included in many existing school programmes and some programmes have included 'technology' in their title. However, these have not been presented and undertaken in a coherent way. Technology, as it has developed in past curricula, encompassed a limited range of skills, processes and knowledge resulting from a narrow perspective. As a consequence, students have not had the broad experiences in technology which they need to successfully contribute to society.

CURRICULUM DEVELOPMENT IN THE 1990s

New Zealand underwent major curriculum reforms in the early 1990s (Bell, Jones & Carr, 1995). The development of a national curriculum in technology was part of this reform. There had been a growing dissatisfaction with the curriculum, assessment and qualifications during the 1970s and 1980s in New Zealand. Calls were being made for the curriculum to be responsive to the country's needs for people highly skilled in science and technology, and with the languages and cultural sensitivity needed to maintain international economic competitiveness. In 1990, the government embarked on a project to revise the curriculum in primary and secondary schools, under the banner of 'the Achievement Initiative' (Ministry of Education [MOE], 1991). Many of these ideas were influenced by the curriculum reforms that were taking place in England and Wales. The policies emphasised raising standards, levels of attainment and the notion of progression linked to accountability, and the contracting out of the development process. These were coupled with the call from different political and educational groups to address the curriculum issues of computer and information technology, equity, languages and multiculturalism (Bell et al., 1995).

As part of an educational review process, a Ministerial Task Group Reviewing Science and Technology Education was set up jointly by the Minister of Education and the Minister of Research, Science and Technology, in June 1991, and which reported in 1992 (Ministry of Research, Science and Technology, 1992). Membership of the task group came from commerce and from those directly involved in science and technology education at the secondary and tertiary levels. A wide range of submissions were received, mainly from professional organisations, both educational and enterprise-based. Early on, the Task Group addressed the concern that education was seen by students as providing information which was often of little relevance to their lives, and which was seen as important for passing examinations rather than informing the life of students. Problem-solving skills and communication skills were seen as being neglected in favour of the acquisition of knowledge (Bell et al., 1995). In addition, the research revealed a strong desire for learning in science and technology to occur in contexts which were significant for New Zealand including agriculture and horticulture. Some of the recommendations from the Task Group concerning technology education were that

- the importance of teaching and assessing interpersonal, communication and broadly-based practical skills should be recognised,
- the curriculum should define a broad range of knowledge and skills which would be recognised by assessment procedures developed for the curriculum,
- a technology curriculum be developed as an area in its own right, although the Task Group noted confusion over its definition,
- there be adequate teacher training and resourcing for technology education;
- technology curricula should not be imported from overseas, and
- the inclusiveness of technology education be emphasised, including Māori input and the use of Māori language.

The curriculum reforms of the 1990s were determined by the *New Zealand Curriculum Framework* (MOE, 1993), which provided an overarching framework for the development of curricula in New Zealand and which defined seven broad essential learning areas rather than subject areas. The seven essential learning areas that describe in broad terms the knowledge and understanding that all students need to acquire are 1) health and well-being, 2) the arts, 3) social sciences, 4) technology, 5) science, 6) mathematics, and 7) language and languages. The *New Zealand Curriculum Framework* required that all national curriculum statements in the essential learning areas specify clear learning outcomes against which students' achievements can be assessed. These learning outcomes or objectives must be defined over eight progressive levels and be grouped in a number of strands. In addition, the framework requires that its principles must be reflected in the learning area documents. These principles relate to learning and achievement, development of school programmes and aspects of social justice and equity. Each strand in a curriculum has a list of achievement aims and is divided into eight levels of 'achievement objectives', which aim to describe the progression of learning from Year 1 to Year 13.

DEVELOPING THE POLICY FOR TECHNOLOGY EDUCATION

In 1992, the Ministry of Education contracted the Centre for Science, Mathematics and Technology Education Research at the University of Waikato to develop a policy framework for technology education in New Zealand. The contract required that there be wide consultation; best practice be taken into account, nationally and internationally; it be consistent with other Government policy in education; it take account of resources, teacher change, teacher development, qualifications frameworks, etcetera; and, where possible, it give a range of options. The development of the policy had to fit within the structure of the *New Zealand Curriculum Framework*, in terms of levels, strands and achievement aims and objectives. There were six policy papers (Jones & Carr, 1993):

- rationale for technology education, including a working definition;
- general aims and expected learning outcomes of technology education;
- achievement aims of technology education;
- strategies for implementation of technology education;
- approaches to teaching and learning technology; and
- access to technology education for all.

A seventh policy paper, assessment in technology education, was completed at a later date.

Wide consultation had already been undertaken by the Ministry of Education, which included national workshops, meetings, and representations to the Ministerial task group on science and technology education. These workshops and meetings included representatives from enterprise, community groups, primary, secondary and tertiary educational groups (including tertiary technology groups), professional organisations (including teacher professional groups), and teacher unions. The writing of the policy papers involved distilling the outcomes from these meetings, developing initial papers and frameworks and undertaking further consultation with the relevant groups.

Literature reviews were crucial to this process in terms developing understanding of a structure for technology as a discipline (e.g., Kline, 1987; Layton, 1994; Pacey, 1983; Pinch, Hughes & Bijker, 1987; Staudenmaier, 1985; Wajcman, 1991); student learning and learning in technology in particular (Brown, Collins & Duguid, 1989; Kimbell, Stables, Wheeler, Wosniak & Kelly, 1991; Perkins & Salomon, 1989; Resnick, Levine & Teasley, 1991); technology curricula internationally and critiques of it (e.g., Fleming, 1989; McCormick 1992; McCulloch, Jenkins & Layton, 1985; Medway, 1989, 1992; Smithers & Robinson, 1992); and theoretical aspects of technology curriculum design (e.g., Johnson, 1992; Petrina, 1992; Zuga, 1992). The development of the policy papers attempted to reflect a broad notion of curriculum. Zuga (1992) categorises curriculum designs in terms of academic, technical, intellectual, social and personal. There was an attempt to include all these aspects in developing a technology curriculum for New Zealand.

The academic emphasis is in terms of developing an understanding of technology and technological knowledge. The technical strand is in terms of skill development, techniques and resources. The intellectual emphasis is in terms of creative solutions, problem solving and metacognition (Johnson, 1992). There needs to be a strong link between content knowledge and thinking. The social dimension should include critical consumerism, reconstructionist ideas, curriculum for social purposes and the consideration of social concerns. The personal dimension is concerned with citizenship roles in a technological society (Petrina, 1992). Experience in developing science curricula warned the writers away from separating processes and knowledge, and towards making sure that the technology curriculum reflected technological practice rather than a narrow view of school technology.

FROM DEFINITIONS OF TECHNOLOGY TO TECHNOLOGY EDUCATION CURRICULUM

Technology education contributes to the intellectual and practical development of students, both as individuals and as informed members of a technological society. The general aims of technology education in *Technology in the New Zealand Curriculum* (MOE, 1995) are to develop

- technological knowledge and understanding,
- technological capability, and
- an understanding and awareness of the interrelationship between technology and society.

The three interrelated general aims provide a framework for developing expected learning outcomes, and make a valuable contribution to formulating a balanced curriculum for technology education. In the New Zealand technology curriculum, the technological areas included materials technology, information and communication technology, electronics and control technology, biotechnology, structures and mechanisms, process and production technology, and food technology.

KEY FEATURES OF THE TECHNOLOGY CURRICULUM

The individual objectives over eight levels arise from the general aims of technology education, each of which is discussed next.

1. *Technological knowledge*

Students need to develop an understanding of the principles underlying technological developments such as aesthetics, efficiency, ergonomics, feedback, reliability and optimisation. These knowledges and principles will be dependent on the technological area and context the students are working in. The understanding of systems is essential in developing knowledge in technology. Students will also need to develop an understanding of the nature of technological practice and how this has similarities and differences in different technological communities of practice. It is important that students have an understanding of a range of technologies and how they operate and function. An understanding of strategies for the communication, promotion and evaluation of technological ideas and outcomes is integral.

2. *Technological capability*

Technological activity arises out of the identification of some human need or opportunity. Within the identification of needs and opportunities, students will need to use a variety of techniques to determine consumer preferences. In technological activities students should develop implementation and production strategies to realise technological solutions. Part of this will involve students in developing possible ideas that will lead to solutions, and developing and using strategies to realise these ideas. Within this process students will need to manage time, resources and people, and produce the outcome that meets the identified needs and opportunities. Students should communicate their designs, plans and strategies and present their technological outcomes in appropriate forms. Part of this process is the devising of strategies for the communication and promotion of ideas and outcomes.

3. *Technology and society*

Students should develop an understanding of the ways in which beliefs, values and ethics promote or constrain technological development and influence attitudes towards technological development. Students should also develop an awareness and understanding of the impacts of technology on society and the environment.

THE DEVELOPMENT PROCESS

The curriculum development process involved three distinct groups. These were the contract review group, the Minister's advisory group and the contract writing group. The contract review group was formed by the Ministry of Education and monitored the contract in terms of whether the outcomes in terms of the contract were being met. The Minister's advisory group was facilitated by the Ministry of Education but offered advice to the Minister of Education on the technology curriculum development. The contract was held by the Centre for Science, Mathematics and Technology Education Research (now Centre for Science and Technology Education Research) at the University of Waikato and played a co-ordinating role. Then there were writing groups in different technological areas and other key areas, as well as reference groups for each writing group. The team leaders and writers were selected for their expertise in the field, ability to work together, and representativeness in terms of various interest groups.

Eleven writing groups were formed: 1) Materials and Graphics; 2) Textiles; 3) Food; 4) Electronics and Control, 5) Biotechnology, 6) Information and Communication; 7) Technology and Society; 8) Primary (Year 1-8); 9) Māori; 10) Girls and Women; and 11) Miscellaneous. These writing groups represented technological areas and issues that needed to be considered. The Miscellaneous group included people from mathematics, English, drama and other subject areas that might contribute to technological development. The primary group were responsible for generating and checking the primary school objectives, and learning experiences and assessment examples developed by other groups. The Māori group had a similar role in terms of generating and auditing the objectives, learning experiences and assessment examples in terms of Māori technological knowledge for the future. The girls and women group examined the objectives, learning experiences and assessment examples in terms of gender inclusiveness. The total number of writers used was 85, and the average size of each team was a core of eight writers. Each writing group had a reference group which included other teachers, technologists, engineers, university lecturers and members of other community groups. These reference groups responded to draft material from the writing groups. The total number of people involved in whole writing process exceeded 300.

The draft curriculum statement was trialed in schools during 1994. This provided teachers and others with the opportunity to respond to the draft statement. The responses generally indicated that teachers were supportive of the general structure and philosophy of the document. However, there was a need to reduce the number of objectives and strands given the number of other curriculum documents with which teachers were dealing. There was general consensus that the strands should reflect directly the three general aims of the technology curriculum; technological knowledge and understanding, technological capability, and technology and society. The final curriculum statement was released in October 1995.

TEACHER SUBCULTURES AS AN INFLUENCE ON CHANGE

Teachers' concepts and practices have shown strong links with the initiation and socialization of teachers into subject subcultural settings (Ball & Goodson, 1985; Goodson, 1985). Therefore, teachers have a subjective view of the practice of teaching within their concept of a subject area (Goodson, 1985). This view is often referred to as a subject subculture, and leads to a consensual view about the nature of the subject, the way it should be taught, the role of the teacher, and what might be expected of the student (Paechter, 1991). Given the lack of an existing technology subject subculture, other subjects' subcultural impact on technological classroom practice becomes very complex. There are a multitude of subcultures impacting on technology education in a variety of ways, depending on the teachers' subject backgrounds, concepts of technology, and their concepts of learning and teaching both within technology and generally. Paechter (1991) also pointed out that the teachers' beliefs about what was important for students to learn in their existing subject were transferred to technology education. In our case, since technology was a relatively new curriculum area, teachers' awareness of their own conceptualisations of technology as a learning area was limited (Jones & Carr, 1992).

In the study conducted by Jones and Carr (1992) on teachers' perceptions of technology and technology education they found that all the science teachers who were interviewed saw technology education in terms of applications of science. In terms of teaching, technology was perceived to be a vehicle for teaching science and often as something extra to the conceptual development in science. There was concern expressed about non-science teachers incorporating the scientific aspects of technology into their lessons. At the time of the study, in both the primary and intermediate school setting, teachers were trying to integrate computers into their classrooms. In the primary school there was one computer per class and at the intermediate school the computers were located in a resource area. Many of the teachers at the primary and intermediate school viewed technology in terms of computers. For these teachers, technology meant using computers or other technology to solve problems. Although they might be aware of the range of technology they tended to focus on computing. For example, as stated by one teacher, technology meant "not using pen or paper but using computers to solve problems" (Jones & Carr, 1992, p. 234). Teachers also mentioned problem-solving in relation to finding out how things work. When talking about technology, teachers mentioned problem-solving both in the context of using computers and finding out how things work. Technology was seen as a mechanism for solving a problem or as a vehicle for approaching a particular type of problem-solving: that is, finding out how things work.

Moreland (1998) reported that although the teachers stated they needed to learn more about the teaching of technology, they felt they had enough skills and understanding to be teaching technology and could do it in the classroom. One teacher with a science strength set the students applied science tasks (e.g., design a hot air balloon after studying flight). Technological principles were not involved. The criteria were in terms of why things happened and a narrow focus on outcomes. Northover (1997) noted that all the science teachers she worked with viewed technology as being applied science and technology as skills and skill development. The teachers went for minimal change and added technology into existing programmes rather than developing new programmes or new learning outcomes. She found that these teachers generally expressed an interest in technology education and commented on the motivational aspects of technological activities. Teachers often saw changes in their perceptions of technology and technology education as a means of better understanding the curriculum document. However, they did not see the value of the development of a coherent technological knowledge base to their own learning and teaching practice. The dominant science subculture in schools proved to be a powerful conservative influence. Teachers who evidenced a changed view of technology and biotechnology at earlier stages throughout the teachers' development had, by the end, often reverted to the perspective held initially. In fact, where teachers did make changes to their perceptions initially, the cognitive dissonance set up by the disparity between their views and their practice was often resolved by reverting to a previously held view.

The strategies developed by the teachers in their classrooms when implementing technological activities were often positioned within that particular teacher's teaching and subject subculture (Jones & Carr, 1992; Moreland, 1998; Northover, 1997). These subcultures are consistent and often strongly held. The subcultures had a direct influence on the way the teachers structured the lessons and developed classroom strategies. Teachers developed strategies to allow for learning outcomes that were often more closely related to their particular subject subculture (e.g., science and language) than to technological outcomes. Teachers entering areas of uncertainty in their planned activities often reverted to their traditional teaching and subject subculture. Their views of assessment, their expectations of the students and their views of learning influenced possible learning outcomes identified by teachers in technological activities. When students were carrying out technological activities, teachers often reverted to learning areas with which they were comfortable for identifying possible learning outcomes rather than technological outcomes. What these research studies highlight is that it is crucial that if technological learning outcomes are seen to be desirable for students then there needs to be a clear understanding of technology and technology education.

TEACHER DEVELOPMENT: CHANGING TEACHERS' VIEWS AND PRACTICES

It would appear that the introduction of a 'new' learning area in schools, such as technology, is problematic. Teachers' existing subcultures in terms of teaching and learning, subject area and school, in association with their concepts of technology, influence the development of classroom environment and strategies, and consequent student activities. In order to introduce technology into the classroom, it is important not only to have a developed concept of technology but also awareness and understanding of technological practice. As a result, teacher development programmes have been developed to enhance teachers' understanding of this new area (Compton & Jones, 1998). These programmes were based on a model that emphasised the importance of teachers developing an understanding of both technological practice and technology education. Two different programmes were developed and trialled in the New Zealand context: 1) the Facilitator Training programme; and 2) the Technology Teacher Development Resource Package programme. The Facilitator Training programme was a year-long programme, and ran in 1995 and 1996. It involved training a total of 30 educators (15 each year) from all over New Zealand. The Resource Package was trialled in 14 schools over a 3-6 month period in 1996. The evaluations indicate the successful nature of these programmes and the usefulness of the model as a basis for the development of teacher professional development in technology education. Our experience to date would therefore suggest that the following key features should be taken into account when developing technology education teacher professional development programmes that are consistent with the New Zealand national curriculum statement in technology and with past research findings. The key features of the programmes were the importance of developing

- a robust concept of technology and technology education,
- an understanding of technological practice in a variety of contexts,
- technological knowledge in a number of technological areas,
- technological skills in a number of technological areas,
- an understanding of the way in which people's past experiences, both within and outside of education, impact on their conceptualisations of, and in, technology education, and
- an understanding of the way in which technology education can become a part of the school and classroom curriculum.

In a review of 600 research articles on curriculum, assessment and pedagogy, Carr et al. (2000) argued that teacher knowledge of their subject (content knowledge), how students learn (pedagogical content knowledge), and the interaction of these two factors are essential to support learning. Good teacher knowledge of the content of their subject was found to have a positive effect on decisions to change pedagogical strategies to create learning opportunities. In addition, sound content knowledge seems to have a positive effect on planning, assessment, implementation of curriculum and curriculum development. The construction of a knowledge base for teachers is pivotal for effective technology teaching and for expecting teachers to add technology teaching to the learning areas that they are required to teach. Teacher knowledge of the discipline is related to the use of various assessment processes, since it is crucial that a teacher has knowledge of the discipline to provide direction for learning. When teachers are unsure of their discipline's structure they are not well equipped to guide learning in it or to assess that learning. Black and Wiliam (1998) showed that there is a very close link between teachers' formative assessment practice, the components of a teacher's personal pedagogy, and their conception of their role. They have identified that the implementation of effective formative assessment practice in classrooms will often require significant changes both in the way teachers perceive their role in relation to their students and in their classroom practice. Formative interactions with students become distorted if there is a lack of subject knowledge and pedagogical content knowledge. Therefore, to be effective in technology, teachers will need to develop extensive knowledge related to the nature of technology and technological practice, knowledge in technology, such as the technological concepts and procedures, and general technological pedagogical knowledge.

THE NEED TO BUILD A RESEARCH DIRECTION FOR NEW ZEALAND

In developing technology as an area of study and learning in schools, it was crucial that a research culture be developed. In examining past reviews of research to consider what need to be done in the future, there is the danger that the field becomes understood by the research undertaken, not by what needs to be done. Therefore, past reviews need to be critically examined if they are to contribute to future directions. The following reviews provided for a starting point. Olson and Henning Hansen (1994) identified two strands in technological education research. These were vocational preparation and the social significance of science and technology. They noted that there are few research agendas in technology education. At times there appears to be a stronger link between science and technology rather than viewing technology education as an area in its own right. Gilbert's (1994) agenda for research in technology education is based on past work in science education and this can limit aspects that are examined. This partiality of what work has been done is then is reflected in material compiled for books (especially those used in postgraduate study courses) and defines the field for those who come to study it. For example, McCormick, Sparkes and Newey (1992) and McCormick, Murphy and Harrison (1992) cover technology in three countries, technological capability, learning in technology and the implementation of teaching and learning technology. There are strong links with science in many of these themes. In a meta-analysis of articles in the *Journal of Technology Education*, Petrina (1998) noted that there was little published in the area of critical theory and argued that the field so far has been conservatively inclined. In all of the reviews it would appear that there is a need to define technological literacy and set out a research plan related to the key characteristics related to student technological literacy. Lewis (1999) argues that there needs to be a multi-dimensional sustained programme of work in the area. A major review of 600 articles on curriculum, pedagogy and assessment (Carr et al., 2000), found that much more research was required in classrooms and, in particular, more long-term studies were needed. Technology education is no different.

An examination of the nature of technology indicates that technological knowledge is socially constructed and context dependent; where human mental processes are situated within their historical, cultural and institutional setting (Wertsch, 1991). Technology is, therefore, essentially an activity that involves not just the social context but also the physical context, with thinking being associated with and structured by the objects and tools of action. Greater emphasis on researching students' learning in technology education, including ways in which this learning can be enhanced, is required. While there is published research about what students do when involved in technological activities (e.g., Jones, Mather & Carr, 1995; Kimbell et al., 1991; Kimbell, 1994; McCormick, Murphy & Hennessy, 1994), there has been little published work which analyses these findings in terms of the students' learning of technological concepts and processes. Therefore, in developing a research culture, the classroom was the key site for investigation.

CLASSROOM RESEARCH

Classroom-based research has led to the recognition of the central and crucial role of the teacher in educational reform (Atkin & Black, 2003). Emerging research suggests that understanding classroom formative interactions is one of the keys to enhancing student learning of and engagement with science and technology. With the increasing emphasis on assessment for learning it has become evident that teachers need a detailed understanding of student learning. How models of pedagogical content knowledge might be used as a tool for teachers to enhance formative assessment and student learning is not clear (Jones & Moreland, 2004; Loughran, Mulhall & Berry, 2004). Both teachers and researchers benefit when they work together to better understand and enhance classroom interactions (Black, Harrison, Lee & Wiliam, 2001; Jones & Moreland, 2004; Torrance & Pryor, 2001). Building a sense of community (Bell & Gilbert, 1994; Fullan & Hargreaves, 1992) through co-operative inquiry is central to effecting change. A communicative relationship is beneficial to change when there is open discourse, with communication oriented towards understanding and respecting the perspectives of others (Rogoff, Matusov & White, 1996). Therefore, time for teachers to engage in intellectual and professional conversation needs to be in-built, to create a mutually respectful, inquiring community. Underpinning ideas centre on learning as a situated-social knowledge construction process and an active process empowered via collaborative activity (Hennessy, 1993; Lave & Wenger, 1991).

KEY FINDINGS IN RELATION TO INDIVIDUAL CLASSROOM CHANGE

Between 1998 and 2000, a three-year research project was funded by the New Zealand Ministry of Education to explore and enhance formative assessment practices in technology education. At the time, technology was a new and evolving curriculum area. The project involved 18 primary school teachers from five schools over the three years, as well as two principals. Three of the schools (Years 1-6) were in a city, one school (Years 1-6) was rural and another school (Years 7-10) was in a small town. This project, involving nearly 700 hundred hours of classroom observations, was designed to investigate, develop and enhance teachers' technology education teaching, learning and assessment practices. Psuedonyms are used for all the data presented in this paper. The project had many facets including case-study development; professional development of teachers through a jointly-developed, negotiated intervention programme; classroom observations; teacher and student interviews; and the examination of teacher documents and student work. At the end of the funded stage of the research, our involvement ceased with the schools except for Eastern Heights Primary School (a Year 1-6 city school with nearly 500 students) with which we have maintained an on-going involvement. The researchers were invited by the school to contribute to electronics, environmental and science education during 2001-2003. During this period it became apparent that school-wide changes in assessment practices had begun to develop. As a result, a further research project was undertaken in 2003 to explore the factors that contributed to effective change in formative and summative assessment practices at the individual teacher and school-wide level, as well as in subject areas other than technology.

In the first, larger study in 1998, the research explored teachers' existing technology education practices and related student learning (Moreland & Jones, 2000). It was found that although teachers could identify technological tasks, activities and problems appropriate for their students, they had difficulty identifying specific technological learning outcomes and associated technological knowledge. As one teacher commented:

> I can't see progress in technology. I don't know what to look for. I would hope that the methods I am using are the right ones for technology. I'm sort of trialing things that are right for me, but do they mean anything? So it is difficult, difficult to know what is right. (Moreland & Jones, 2000, p. 292)

Technology was viewed as a subject requiring the practical involvement of students: therefore, many student activities were drawing, making and testing centred. With a focus on activities, teachers' formative interactions also focused on the students undertaking and completing activities. This meant that the feedback students received was usually praise-based, related to task completion and social and managerial aspects, rather than related to enhancing students' technological understandings and skills. The lack of critique of students' conceptual and procedural understandings and skills distorted the guidance teachers were able to give to students for their ongoing learning. As a consequence, teachers found it difficult to create student-learning assessments that were useful for future teaching and learning.

Teachers' pedagogical content knowledge was not refined enough to enable the identification of key subject ideas. This meant they were unable to plan effectively or build their conversations with students around key ideas in order to move student learning forward. Their formative assessment practices did not provide sufficient relevant or detailed descriptive feedback so that obstacles to learning could be identified and tackled. As one of the teachers highlighted:

> With technology, there is nothing. Absolutely nothing, so it's really going on probably teaching background, background knowledge of things, your confidence. I don't know, but on the day it is down to your gut feeling and own professional teaching. (Moreland & Jones, 2000, p. 300)

These issues surrounding assessment for learning focused our attention on enhancing teachers' pedagogical content knowledge in the subsequent years. In 1999 and 2000, the research centred on teachers developing their pedagogical content knowledge so that they could enhance student technological learning through the provision of descriptive feedback. Support and guidance from us were necessary to keep morale positive and to help teachers test out ideas over a sustained period. An extended timeframe also facilitated teacher change as the three years gave time for researchers and teachers to jointly plan modifications, trial and retrial ideas and critique the outcomes. Besides working in an unfamiliar curriculum area, we were also attempting to achieve change in teachers' formative assessment practices overall. It was therefore important to develop many opportunities for analysing the classroom-research findings in order to rethink and synthesise ideas and to give teachers time to find their own way to implement assessment for learning strategies in technology education. As researchers, we did not have 'ready answers'. Therefore, the teachers and researchers were involved with initiating and making changes together.

The focus was on moving teachers away from thinking about technology as a series of tasks defined solely by the broad curriculum achievement objectives and social and managerial skills. Teachers' planning and teaching difficulties in 1998 had related to a minimal understanding of key technological concepts and procedures. The subsequent 1999-2000 use of a planning framework and the development of a more detailed, complex and sophisticated knowledge base in the different technological areas impacted on all project teachers' planning and classroom practices (Jones & Moreland, 2001). As technology education is concerned with complex and interrelated problems that involve multiple conceptual, procedural, societal and technical variables (Jones, 1997), we devised a planning framework that was inclusive of these aspects. It included a specific task definition, overall dimensions of technology (knowledge, capability and societal) and specific learning outcomes in terms of technological concepts, procedures, societal aspects and technical skills. It reinforced the notion of the nature of technology and linked strongly with the technology curriculum objectives. Teachers were also encouraged to think in terms of the task as whole rather than in isolated aspects. The new planning strategies compelled teachers to articulate intended learning outcomes in concise technological terms. By articulating multiple learning outcomes, teachers were able to ascertain their knowledge requirements for teaching technology as well as deducing specific learning goals for their students. With repeated use of the planning framework, they subsequently developed a mental framework for making decisions about what needed to be included when teaching technology (Jones & Moreland, 2001). For example, one teacher stated:

> I will use the framework from now on as it justifies what I am teaching and it is a check-list. A reminder of what to cover. For example, I ask 'is there enough conceptual'? I used it lots. I kept flicking back to it. (Jones & Moreland, 2001, p. 255)

In classrooms, the research team emphasised the identification and focus on specific technological learning goals. Teachers required continuing advice and direction related to this aspect. Support material, modelling appropriate learning outcomes and clear instructions about desired outcomes were provided. Suitable learning outcomes were made known to teachers on an ongoing basis. The struggle teachers demonstrated meant that support strategies became a crucial feature. One-to-one, ongoing support in classrooms and the collaborative workshop atmosphere were important. When teachers' foundations were shaken and feelings of uncertainty surfaced, it was crucial that researchers were understanding, supportive and appreciative of their efforts. The support of others was mentioned throughout the project. For example:

> The interchange of ideas with other teachers in the project has been important in terms of conceptual development, knowledge of practice and the development of technological language. Consistently being refocused and supported by the research team has helped implementation and to support risk taking. (Jones & Moreland, 2005, p. 199)

Enhanced pedagogical content knowledge was noticeable where teachers moved from using general technology concepts to more specific concepts within different technological areas. Teachers' developing conceptual and procedural knowledge enabled them to write specific learning goals, and they began to move with more confidence between the aspects of the nature of technology and the specific technological learning outcomes. When the teachers began their planning, they also identified specific technological learning goals for assessment. They chose more suitable tasks with the potential to develop student technological learning. The shift in focus from providing technology experiences to providing opportunities for developing particular technological learning outcomes was significant. Teachers utilised a more appropriate approach to technological planning and learning when they investigated a range of possible learning outcomes and then selected particular learning outcomes from this range. Students' technological learning became the focus. Teachers were also increasingly cognisant of unexpected and negotiated learning outcomes and were better prepared to allow students to pursue either unexpected or negotiated learning outcomes. Teachers demonstrated greater confidence with formative interactions, particularly in relation to providing appropriate technology feedback. Focus on social and managerial aspects and activities received less attention. Instead, considered direction was appropriately given, leading to more considered and purposeful interactions. There was provision of descriptive feedback, more emphasis on conceptual and procedural aspects, and assistance to develop particular technical skills. As one teacher highlighted:

> My formative interactions have definitely changed. Before I'd go over and see how they're getting on and let them go. But now I'm getting them thinking all the time. I used to accept things whereas now I look to see if the conceptual, procedural, technical and societal stuff is there. (Jones & Moreland, 2005, p. 199)

Teachers also began developing understanding of progression aspects linking technological learning from one unit to the next and linking tasks within units. Tasks were identified to develop particular technological conceptual and procedural aspects rather than just providing a variety of experiences in different technological areas. The use of the frameworks enabled teachers to differentiate between the different levels of student learning and to justify the differentiation. The teachers also noticed more effective student learning in technology in the following areas; nature of technology, conceptual and procedural understanding, technological vocabulary, purpose of activities, self identification of knowledge gaps, and motivation and interest (Jones & Moreland, 2004). Each of these is discussed briefly below.

1. *Greater student understanding of the nature of technology*

There was a broadening of concepts and the development of a shared view of the nature of technology. This broadening was brought about through teachers explicitly engaging their students in conversations about the nature of technology.

2. *Greater conceptual and procedural understanding*

There appeared to be a greater complexity and sophistication in conceptual and procedural understanding of technology. This was evident in both the student conversations and their work. For example, an analysis of Year 2 and 3 student work showed conceptual understandings that drawing is a way to express initial design ideas, that containers need to be appropriate shapes and sizes relative to their contents and that nets can be used for patterns; procedural ability to develop initial conceptual ideas as 3-dimensional sketches and develop initial plans for construction as nets; societal understanding that labelling containers contributes to their aesthetics; and technical ability to draw 3-dimensionally and to draw nets.

3. *More appropriate and prolific use of technological vocabulary*

With the teacher focusing on conceptual and procedural aspects, more opportunities were afforded for students to develop appropriate technological vocabulary. Teachers explicitly targeted these aspects. This is illustrated in the following comment from a 10-year-old student: "I have learned how to optimise material ... heat resistance ... water proofing".

4. *Greater student understanding of the purpose of the activities*

Throughout the teacher-student interactions, teachers constantly assisted students to be aware of the purpose of the activities. The teachers had clarity of purpose that was regularly conveyed to the students. This meant that students at all levels were cognisant of task goals. This was in contrast to previous practices when students had received mixed messages about task purposes and were confused about the learning focus, believing that social and managerial goals were more important than technology: for example, working in a group versus conceptual understanding.

5. *The ability of students to identify their own technology gaps*

In conversations with students, it became apparent that they were much more aware of what they did not know and were prepared to seek advice. The students appeared to be able to identify their own knowledge gaps because they were more cognizant of the intended learning outcomes and whether they were meeting them.

6. *Increased motivation and interest in technology*

The teacher focus on specific technological goals ensured that the classroom interactions were structured around developing appropriate technological solutions. It was evident that student engagement and interest was significantly enhanced. As one of the teachers commented:

> Children showed high interest, were keen to use technological language, were more willing to persevere and their interest confidence and self-esteem increased.

Teachers commented that the intervention had a direct influence on other subjects, especially with their planning and formative interactions. They had moved from thinking about progression in terms of a series of activities to examining the conceptual and procedural aspects of student learning. The focus on more precise formative interactions enhanced student learning. Students showed effective understandings about the nature of technology and conceptual and procedural aspects, used a larger variety of more appropriate technological vocabulary, and showed effective understanding of task purposes. They were able to identify their own technology knowledge gaps, were highly motivated and interested in technology and showed effective knowledge transfer between tasks and from other curriculum areas.

> I found it absolutely brilliant and I have transferred that into social studies and I can see where I can transfer it in science easily and I could do it in all other areas as well. I've done it in writing. I was able to do unexpected learning outcomes in health and in social studies. So there was a crossover. Yeah. I was quite excited about it when I got it. (Jones & Moreland, 2005, p. 201)

The comments from the teachers here were about their individual practice. The factors that influenced school-wide practices are now discussed.

KEY FINDINGS IN RELATION TO SCHOOL-WIDE CHANGE

The factors that contributed to school-wide change in assessment for learning practices were investigated (Jones & Moreland, 2005). The participants were the principal (Iris), assistant principal (Dawn), a senior teacher involved in the original project (Lucy) and a senior teacher who used ideas from the technology project but more particularly in science (May). The interviews focused on participants' reflections of the impact of the project in the school and impact on assessment for learning in technology and science teaching, other curriculum areas and the school in general. The interviews were informal, individual, audiotaped and 30-60 minutes long. The transcripts were thematically analysed.

The culture of Eastern Heights Primary School was seen as an important factor in sustaining the project for three years and for implementing changes at the school-wide level. The culture was described as one that allowed teachers to show initiative, take risks, question, examine and reflect. For example, May commented:

> The culture in the school allows us to take risks, encourages us to keep thinking and reflecting but I am never satisfied. (Jones & Moreland, 2005, p. 202)

The principal also commented on building a trustworthy, supportive school culture focussing on developing curriculum knowledge, self-examination and questioning, risk-taking and reflective attitudes. The staff saw the principal as crucial in that she was focused on being an effective leader and on teaching and learning. The staff who were asked and decided to be involved in the original project were seen to be successful classroom teachers and professional, reflective practitioners. Both the principal and assistant principal commented on the professionalism of the staff who had agreed to take part. Although only four Eastern Heights Primary teachers were involved in the initial research project, the research findings were incorporated into whole school planning, assessment for learning practices and reporting systems. The culture of sharing information in the school, as well as team planning, assisted the dissemination process. The original four were enthusiastic about the technology approach and the positive research outcomes were presented to a wider audience in the school. As highlighted earlier in the paper, assessment for learning practices were making a difference for both the teachers in classrooms and for students' learning. It was the gains in students and classroom practices that encouraged other teachers to try out some of the ideas from the project. In planning at the school level, the student learning opportunities were now not thought of in terms of activities or as curriculum coverage but in terms of student learning progress. Although the positive research outcomes in terms of student learning had a significant impact on the uptake of the ideas and the culture of the school expedited this, the teachers also commented that the nature of the research had a significant impact. The researchers had worked with the teachers to develop strategies to enhance teaching, learning and assessment of technology. The teachers saw that an essential part of the research/professional development relationship was working together on a common problem. The joint nature of the problem and collaborative relationship between the different groups was seen as significant. The relationship between the researchers and the school positively impacted on the outcomes of the research. It was important that researchers had classroom credibility and that their role in classrooms was non-intrusive. The researchers were seen as having expertise as teachers, particularly the team members from primary school backgrounds, and having expertise in the area of technology education. It was not only the roles that the researchers took in the classroom that were highlighted. The way the research team guided teachers through the change process, the provision of resources, the acknowledgments of their time and work commitments, respecting them as teachers and the importance of being on a joint project and journey were viewed as enablers for change (Jones & Moreland, 2005).

In summary, in 1998 an exploratory research project was begun in a local primary school. Six years later the researchers and the school are jointly bidding for research projects. Significant changes are evident in the way the school approaches teaching, learning and assessment in science and technology education as well as a number of other curriculum areas. The focus on developing teachers' pedagogical content knowledge through effective planning was seen to have an impact on the assessment for learning practices of the teachers. Research outcomes related to identifying the characteristics of technology as a starting point for thinking about assessment for learning, plus the use of the planning framework with its focus on conceptual and procedural aspects, had considerable impact.

The long time frame was crucial for assisting and sustaining change as it provided time to build a strong supportive relationship between researchers and teachers to plan modifications, trial ideas and reflect on success (Treagust & Rennie, 1993). Time ensured a long period for analysis, reconceptualisation, discussion and dissemination of results. It gave opportunities to step back from the work and reflect: granting scope for rethinking and synthesis. Although researchers provided ongoing support and guidance, teachers needed to see their technology teaching as problematic and to take responsibility for changing their practices. They were their own change agents and a willingness to change was required for successfully modifying teaching practice and shifting thinking (Bell & Gilbert, 1994). Therefore, time for teachers to engage in intellectual and professional conversation was in-built. Time was required to create a mutually respectful, inquiring community so the shared interest of enhancing technology teaching and learning could be fostered.

CONCLUSION

This paper has attempted to outline some of the developments that have occurred in technology education as an area of policy and curriculum development, in teacher development and in enhancing classroom approaches to teaching, learning and assessment in technology. The key aspect to this development has been the formulation of a robust research-informed approach. Much of the early international work in technology education focused on definitions and developing curricula with little emphasis on classroom research whereas, in New Zealand, research and development occurred in much more of an integrated manner. In conclusion, by enhancing teachers' pedagogical content knowledge, significant gains can be made in their assessment for learning practices and subsequently in students' learning. School-wide reform in terms of assessment for learning can result when researchers, the school leadership and teachers work in an effective partnership over a sustained period.

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