INITIATIVES IN TECHNOLOGY EDUCATION:

COMPARATIVE PERSPECTIVES

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Refereed Papers
Papers asterisked* in the Table of Contents of this volume have been peer reviewed to comply fully with the verification requirements for the Australian Department of Education, Science and Training (DEST), Conference Publications (full written paper, blind refereed)

Initiatives in Technology Education: Comparative Perspectives.
Proceedings of the American-Australian Technology Education Forum held at the Sheraton Marina Mirage, Gold Coast, Australia, 5-7 January 2003.

ISBN 0 909291 75 6

Desktop Publishing by Samantha Normoyle
Cover Design by Kevin Saunders

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Introduction

There is growing concern amongst policy makers and educators about the capacity of educational systems to develop in students the ability to make responsible technological decisions in their lives. The importance of these technological decisions is local as well as global. *Initiatives in Technology Education: Comparative Perspectives*, as the name suggests, provides a set of perspectives on the current state of technology education in America and Australia. The perspectives are provided by leaders in technology education within the two countries and represent the range of technology education professions, from teacher educators to curriculum officer, state supervisors, professional association officers and statutory authority personnel.

The introduction of comparative analysis in the study of technology education is an emerging area of research in the field. Although the major objectives of the learning area are similar across different countries, the particular ways in which the area is theorized and implemented presents a significant challenge when a comparative perspective is employed for the analysis. These challenges are important starting points for the future development of the field.

This book explores the ways the issues that are significant for both countries are addressed. The individual papers reflect the particular positions and circumstances of each author and as a consequence, the perspectives range from government policy to case studies of professional development, to research issues. A rich set of overlapping and interconnected, although different perspectives provides both snapshots of current issues and practices, and pointers for future directions.

The context for this analysis is similar in the sense that both countries have similar governance structures where education is provided by state level authorities who have a history of acting independently of other states. This has sometimes led to a lack of coherence of programs across states. However, in both countries technology educators are trying to shape a learning area that is both national, and regarded as one of the central means for enhancing technological literacy among students. In America the impetus for the initiative is the *Standards for Technological Literacy*, while in Australia it is the *Statement on Technology Education for Australian Schools*.

All contributing authors participated in a forum held in Queensland, Australia in January 2003 where the issues addressed in this book were presented and discussed. That forum and the preparation and publication of this book were funded by the Technical Foundation of America, with the assistance of staff from the Centre for Technology Education Research at Griffith University. The aim of the book is to make a significant contribution to the debates about what and how technology education can be implemented in different settings. It is therefore essential reading for policy makers, practitioners, and academics in the area.

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History

Technology education as a learning area in Australian schools is relatively new. In 1987, the Australian Education Council (AEC) began a series of initiatives that led to the publication in 1994 of nationally agreed curriculum statements and profiles related to eight learning areas, one of which is technology. In 1990 the K-12 Technology Curriculum Map (Australian Education Council) revealed a shift in emphasis in many schools toward gender equality, flexible outcomes and a variety of teaching and assessment strategies. The 1994 documents extended this trend.

The declaration of technology as a learning area had profound implications. Firstly, all subject areas in secondary schooling from which technology education developed were located within the elective areas of the curriculum. The implication was that these subjects provided learning experiences relevant only for specific groups of students with particular interests or career destinations in mind. Indeed, some of these subjects were regarded by students and the community as relevant only to a particular gender. Secondly, in the case of primary education, technology had not generally been part of school programs, and primary teachers have little experience to draw on to develop programs. The challenge for technology education was to determine the learning experiences that are essential for all students, and are unique to technology education or best undertaken within the area.

The most significant rationales for the development of technology as a discrete learning area were related to the technological nature of society and equity of opportunity for students. Australian culture was rapidly becoming highly technological, and all students needed to have the opportunities to develop, experience and critique a range of technologies as part of their core education. This rationale aligned with concerns for gender equity in technology education, with more flexible, open ended and collaborative approaches to delivery, and with a range of key competencies for all students.

A Statement on Technology for Australian Schools (Australian Education Council, 1994) set out what was regarded as the technology learning area. This included the place of technology in society, the need for all students to experience technology education and the form in which it should appear in the school curriculum.

Probably the most significant aspect of the change to technology education is the concept that as a learning area it contributes to all students' general education and therefore should be studied by all students in the compulsory years of schooling.

Since it is a new learning area, the status of technology in the curriculum is not well established and is therefore variable across the states and systems in Australia. In some states for example, technology subjects are compulsory and in others they are elective, though it is offered in some form in 95 percent of schools (Williams, 2001).

Technology Education in the Curriculum

Since the publication of *A Statement on Technology for Australian Schools* (Australian Education Council, 1994) all the states and territories have established technology learning areas through the development of frameworks, curriculum and support material to be implemented up to 2006. Various titles have been adopted in different states (Technology Education, Technological and Applied Studies, Technology and Enterprise) but they contain similar elements. There is a significant degree of consistency in the definitions of technology used by education systems in Australia. Technology is defined broadly, and key common elements of the definitions include 'the application of knowledge and resources' and that it is used 'to extend human capabilities'. There is strong general agreement that technology involves a process, that is, there is an identifiable method used in the development of technology. This process is most commonly referred to as design, but it is not defined or described in detail. Similarly the relationship between the concepts or knowledge of technology and the processes of technology is not extensively explored.

There are elements of similarities in the structure of the state curriculum frameworks, which have been derived from the national Statement on Technology for Australian Schools. For example a number of states have incorporated the strands of process (design), information, materials and systems. In addition to these, other defining strands include critiquing (SA), materials and movement (Vic), health and safety and working with others (Tas), enterprise, technological skills and technology in society (WA), resources, domains and human impacts (NSW). The core of the majority of technology programs involve students generating ideas and acting on them through the integration of theory and practice.

In the titles ascribed to subjects, technology is commonly linked with other concepts, for example 'materials, design and technology', 'science and technology', 'technology and enterprise'. This may suggest that existing notions or definitions of technology are inadequate to describe the scope of the intended learning, and this is an emerging area of the curriculum still in the process of definition.

There are few curricula in technology that describe an accompanying body of knowledge, though in some instances new subjects have been developed with the introduction of technology as a learning area. This has left teachers to modify existing subjects to conform to the new approach.

While states have or are establishing clearer directions for technology education through curriculum frameworks, its implementation has been problematic. This is partly because there is a conflict between the curriculum, which is quite revolutionary in nature, and its implementation, which cannot be revolutionary but is developmental and must build on past practice. Teachers have to develop their understandings of technology education and implement new strategies over time. But the technology education curriculum does not incrementally develop from what has existed in schools in the past, it is revolutionary in both knowledge and associated pedagogy.

Technology Education in Primary Schools

At the primary school level technology education practices tend to have developed out of art and craft and science. In primary schools, technology education is generally delivered through an integrated approach with other learning areas.

Despite the fact that technology is still a new area of study for many primary teachers, 90% of schools indicate that they teach technology in all grades. The emphasis of much of this technology is Information Technology, embedded in a range of subjects, rather than relating to broad technology education. School based decision making and curriculum planning mean that there is a variety of technology education occurring at a classroom level. Often the curriculum programs in this area are determined by individual interests and enthusiasm of the teachers and principals, and the educational priorities in particular schools.

Technology and Science still tend to be bracketed together for primary education as illustrated by recent government reports (ASTEC, 1997) and some learning area documentation. In 1996 a limited evaluation of the NSW *Science and Technology K-6* syllabus was undertaken, finding that teachers allocated between 60 and 120 minutes per week to technology. However the majority of teachers were at the lower end of this range. This appeared to be similar for Catholic, Independent and Government schools. The evaluation also found that:

- the technology component of the Science and Technology Syllabus was not fully understood by teachers.
- class programs tended to favour content relating to natural and physical science.
- supply, storage and maintenance of consumable goods (batteries, corks etc) is considered a barrier to the full implementation of the syllabus.
- four major factors appear to determine the selection of units and the extent of Science and Technology teaching: teacher understanding and confidence, student interest, the availability of resources, and content being taught in other Key Learning Areas.

It is only in NSW that a specific syllabus exists: Science and Technology K-6. Schools in all other states devise their technology syllabus and classroom activities from state developed K-12 frameworks.

The relationship between technology education generally and the area of Information Technology and computer studies is not clear, and the terminology tends to be interchangable. In many primary schools there is a focus on computers but not on other areas of technology education.

Many primary teachers of technology lack the training and consequent experience and confidence in planning and implementing technology activities for their pupils (ASTEC, 1997; Williams, 2001). The facilities and equipment are generally not conducive to a broad range of technology experiences, though there has been significant developments with computers and information technology.

Technology Education in Secondary Schools

Technology Education is delivered through a range of technology related subjects in the secondary school including Home Economics, Technical Studies, Computing, Information Technology, Media, Industrial Arts, Design and Technology, Agriculture and Business Studies.

In all states and territories, technology education (as delivered through subject contexts such as Design and Technology or Home Economics) is either a centrally mandated part of the junior secondary curriculum, or the majority of schools ensure students study some technology. The pattern is that technology becomes an elective in later years.

Because technology education, as it is taught in the classroom, has developed from the content and skills drawn from traditional subject areas such as Home Economics and Industrial Arts, it appears to retain some of the perception that it is based in older style hand skills. This is emphasised by the teachers of technology who still focus on the technical skills needed in a particular context (wood skills, textile skills etc) and do not always support a broader understanding of the innovative processes and design approach needed for students to understand how technological solutions are developed within society.

The difficulties faced in the implementation of technology education in primary and secondary levels of schooling are different. Primary teachers lack knowledge and expertise to give them the confidence in technology, and secondary schools have a tradition of independent technical subjects from which technology education must develop. Progression for students is difficult to map, and the links between these two levels of schooling are not strong.

Status of Technology Education

A national investigation was conducted in 2000/2001 involving literature reviews; surveys, focus groups and interviews with teachers, education administrators, curriculum developers, parents and business leaders; and observations in schools. Based on the results, it can be concluded that:

1. There are diverse perceptions of the nature and scope of technology education. It is seen in various quarters as a form of practical science; a study area in which students develop cognitive, attitudinal and manual skills that prepare them for

everyday living, employment, further training, and to a lesser extent, university; a study area seen by many as predominantly catering for low achieving students and others not motivated by 'more academic' subjects; a study area in which students learn to understand and use emerging new technologies; and finally, a vehicle for the integration of learning undertaken in other areas of the school. This latter perception is linked to a view of technology as a computer based learning area. This lack of a shared understanding of technology education is perceived to be a barrier to the enhancement of status of the study area within the school and wider school community.

2. It is apparent that for many in the school community the status of a study area is directly related to its perceived role in the academic preparation of young people for university. Whilst it may be argued that only a fraction of secondary students follow this pathway, the comments of participants in this survey provided further evidence of the strength of this view within the community.

   In this context, the main barrier to improved status relates to that view of technology education in which it is perceived to be a practical 'hands on' area of study bereft of academic challenge and rigour, and which serves the needs of lower achieving students in the preparation for employment and training. The linkage of technology in some quarters with vocational education or trade training contributes to this perception.

3. Specialist technology teachers are particularly critical of the manner in which their area is perceived and resourced. Inadequate funding for the area is seen as an issue because it impacts on the breadth and quality of technology learning experiences available to the students. Major funding concerns include the need to replace aged workshop equipment and facilities, provide maintenance and technical support to teachers, upgrade classroom computer facilities and to stay abreast of ever changing (and costly) developments in computer hardware and software.

   Funding constraints were also seen to impact on the quality of teaching and learning by requiring teachers to take larger classes in both workshops and computer classrooms. Matters of access and equity with regard to computers was also an issue.

4. Teachers' lack of confidence in their knowledge, skills and experience with technology education continues to be a barrier to the status and ongoing development of the area. The perception that teachers of technology need professional development to enable them to effectively embrace the new teaching and learning paradigms and its impact on the overall status of the study area is reinforced by the emphasis given this aspect by non technology teachers, parents and local business people. It is suggested that this may reflect concerns within the community regarding the speed with which technology teachers are embracing the new technologies and strategies with consequential implications for the quality of technology teaching and learning.

Issues

Vocational and General Technology Education

'One of the most significant developments in Australian senior secondary education over the last few years has been the dramatic increase in the number of students involved in VET in schools' (MCEETYA, 1998, 31). The overall increase in the number of schools offering VET programs between 1997 and 1998 was 29%, by 2000 involving over 90% of all secondary schools in Australia (MCEETYA, 2000).

This rapid increase of vocational technology programs in the post compulsory years began with the introduction of various vocational education initiatives by the Commonwealth and state governments (Carmichael, 1992, Mayer, 1992), and also came about in response to school based initiatives to develop curriculum to meet the needs of the increasingly diverse post-compulsory student population. Many of these initiatives emerged from the technology area. The results of these initiatives were to introduce accredited vocational subjects from the National Broad-based Modules (NBBM) scheme into the senior years of schooling, and to identify and include specific vocational competencies into existing senior school subjects. These initiatives have been nationally coordinated through organizations such as MCEETYA, and through the implementation of National Training Modules, Registered Training Organizations and the Australian Qualifications Framework. This trend toward national consistency is continuing.

Many subject areas that are now included in the technology learning area at the compulsory secondary level have had a vocational orientation in the past, such as industrial arts, home economics and agriculture. During the past decade the curriculum emphasis has moved toward more general educational aims concerning the development of awareness, conceptual understanding, and consideration of the broader issues of technology in society.

In some states such as Australian Capital Territory and Northern Territory, vocational subjects are not taught independently but are embedded in the general year 11-12 technology subjects, in others the two are taught separately (New South Wales), and others have a mix of options which may be organized at the discretion of the school (Victoria, Queensland, South Australia and Western Australia). Work placement is an accompanying component of the vocational training in about 50% of schools, involving over 40% of all students participating in vocational education in schools (MCEETYA, 2000). In NSW, work placements in vocational studies are mandatory.

The focus on VET in some government initiatives has the potential to segregate the breadth of technology education to a focus on this subset of VET rather than its holism. This could lead to the dominance of this area over the broader goals of technology education to produce technologically capable individuals.

The vocational component of technology education is vibrant and vital, and the strong growth of vocational technology programs has had a significant impact on schools, and this will continue. The links between the compulsory and post compulsory years of schooling, the general and vocational approach to technology education, are not strong, but there are some indications that these links are developing to focus both aspects on important generic skills. Vocational education is growing in importance as an educational route for an increasing number of students, and in concert with the general component of technology education experienced in years K-10, this is a powerful area of the curriculum.

Teacher Supply and Demand

The shortage of technology teachers in Australia occurs in a context of low appeal of a career in teaching. 'Those with technological competence recognise better career prospects elsewhere. Graduates entering schools have available only limited term contracts and no clear career prospects. These realities compound and contribute to teacher discontent and a lack of public support' (Watts, 1998, p13).

A report titled "School Teacher Demand and Supply: Primary and Secondary" prepared by the National Teacher Supply and Demand Working Party for the Conference of Education System Chief Executive Officers (MCEETYA, 1988), considered the outcome of the interaction of supply and demand for teachers and predicted a balance between supply and demand in some states and territories, and a shortage of teachers in others, but with shortages in some specialist areas. This prediction was based on the assumption that there existed a large pool of qualified teachers not presently employed, who would augment the supply of graduates into teaching, and that any shortfall could be addressed relatively quickly through short courses such as Graduate Diplomas of Education.

Another report commissioned by the Australian Council of Deans of Education, "Teacher Supply and Demand to 2005" (Preston, 2000) painted a different picture, indicating that the demand for secondary and primary teachers would exceed supply during the period to 2005.

The evidence in many states however is of significant shortages in areas of technology education. This current shortage of technology teachers will continue because supply will not meet demand. Governments are increasingly realizing this, and 'after five years of warnings from Australia's deans of education that the nation faced a desperate shortfall of teachers, three states have finally decided to act' (Maslin, 2002). In 2002, Victoria, Western Australia and New South Wales launched campaigns to both recruit new teachers and encourage former teachers to return. This provides some room for optimism, together with rising numbers of preservice education courses and targeted strategies for rapid training.

Initial Teacher Education

In Australia, the key factor likely to have a significant influence on future teacher supply is the student completion of initial teacher education courses. A survey of technology teacher education programs in Australia (Williams, 1996) confirmed that a major weakness of all courses was low enrolments. In the survey nine institutions were identified in Australia as offering undergraduate technology teacher education. All institutions offered a four year Bachelor of Education degree in technology education, and all the training programs were under the control of the Faculty of Education. Since this survey was conducted in 1996, many institutions have moved away from this pattern; for example to a double degree structure, graduate entry one and two year bachelors degrees and post graduate diplomas.

A significant change in 1997-2000 was the demise of secondary undergraduate technology teacher education courses in Victoria, New South Wales, South Australia and Tasmania, and an increase in post-graduate technology courses at the secondary and primary levels for all states other than Victoria. A consideration for the introduction of post-graduate courses was that first degree students were suitably qualified, that is they had undertaken an initial degree relevant to the needs of technology education. This remains an issue for all states offering teacher training at the post-graduate levels. Courses for the preparation of primary technology specialist teachers increased.

An increasing level of diversification is currently taking place in technology teacher training degrees, with a range of entry and exit points, links between universities and technical training institutions and courses designed for specific client groups. Concerns have been expressed that minimum standards remain high in order to continue raising the rigour and quality of technology educators, both for the sake of their own professionalism and in the eyes of government and the academic and general community. The increasing number of school VET programmes has the potential to influence technology teacher education courses as systems endeavour to produce teachers for these programmes. In some institutions the result has been stronger links between technical training institutions and universities, and the vocationalization of the technology teacher education programme. However, quality in technology teacher education is dependent on a research based, practical study of a range of industries and technologies and a critical approach to the social and environmental contexts of technology, not a study of a narrow range of specific vocations.

There are still some primary teacher training programs at universities in Australia which do not provide any instruction in technology education, despite the establishment of technology as one of the core learning areas since 1989.

Place of Computing (IT)

Computer technologies have a significant and critical place in Australian society today and are increasingly becoming integral to the operation of most workplaces. As a result there is a continuing need for students to develop competence and understanding in the use of computer technologies. While computers may be used to support learning in all learning areas, it is the responsibility of the technology education learning area to provide progressive and systematic learning experiences for students designed to develop competence and understanding in the use of computer technologies.

There has been increased confusion concerning the role of computing in technology education since the term 'learning technologies' has become almost synonymous with using computers to support learning. Computers will be used as learning technologies across all learning areas in the same way as overhead projectors and whiteboards are used. While students may learn something about computer technologies as they use them as learning technologies this will be ad-hoc and not conducive to the development of useful conceptual understanding. Therefore in the same way as systematic learning experiences may be provided to develop competence in the use of power-tools with wood, technology education must provide systematic learning experiences to develop competence in the use of computer technologies with information and communications.

The complexity of the relationship between technology education and the use of computers has led to serious levels of confusion among teachers, parents and educational leaders. There are extreme attitudes from "computers are not a part of technology education" through to an equation between computers and technology education. In many schools the leader of computing is also the leader for learning technologies which adds to this confusion. Within technology education it is legitimate to focus on computers as an area of study where students will learn about computer technologies, how to use them and their place within society. Computers may also be used as a learning tool but this is a different issue.

Low Status of the Learning Area

While it is clear that in the eyes of teachers and school administrators technology education is finally being afforded the status of an independent learning area there is still some doubt as to its equivalence with other learning areas. Typically technology education has been an 'elective' area in secondary schools and a 'new' area or a peripheral area to science in primary schools. For these reasons it is often perceived as a less important learning area.

This is particularly a problem at the secondary school level where the subjects from which technology education has evolved have been traditionally viewed as 'elective/non-core' subjects. In addition there is little requirement for study in technology education for post-secondary destinations, and there is no clear definition or requirement for capability in technology. Even in primary/early childhood environments technology education is often viewed as a luxury compared with the central importance of numeracy and literacy.

Opportunities and Challenges

There are a number of developments in Australia which potentially impact on technology education either by providing opportunities or challenges.

The Adelaide Declaration

In April 1999, State, Territory and Commonwealth Ministers for Education, at the 10th Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), endorsed new National Goals for Schooling in the Twenty-first Century as the Adelaide Declaration (DEST, 1999).

Education Ministers also affirmed their commitment to national reporting on literacy, numeracy, student participation, retention and completion, vocational education and training, science and information technology. The ministers also noted the need to develop performance indicators for civics and citizenship, and enterprise education.

There are a number of areas within the National Goals Statement that could potentially impact on Technology Education including information technology, vocational education and training and enterprise education. To the extent that these areas exist within the technology education curriculum provides an opportunity to capitalize on their focus and promote technology education in achieving relevant and common goals. The alternative is a focus on these areas without the context of technology education, resulting in not only lost opportunities for development but the potential relegation of technology education to a superfluous context.

Teachers for the 21st Century

The Quality Teacher Initiative, *Teachers for the 21st Century*, provides for $80m over 3 years including $74 to support quality teachers. This is to lift the skills of teachers in the 'key priority areas' of literacy, numeracy, mathematics, science, information technology and VET, and to work with teacher associations to develop professional teaching standards in science, literacy and mathematics.

This initiative also provides both threats and opportunities for technology education. Opportunities lie in the development of skilled technology teachers who specialize in IT and VET. The threats are more numerous and relate to the possible fragmentation of the learning area by focusing on IT and VET, and, in the absence of a teacher association, the development of standards that exclude the unique characteristics of teaching technology.

The Chance to Change

Australia's Chief Scientist, Robin Batterham, released a preliminary discussion paper (August 2000) which was typical of the discussion related to Science, Engineering and Technology (SET) in Australia in that science was assumed to encompass technology, and technology education was accorded no status. Despite submissions drawing attention to this anomaly, the report was released in November 2000 addressing Australia's SET capability called *The Chance to Change* (Batterham, 2000). Its thesis was that 'science, engineering and technology underpins our future as a thriving, cultured and responsible society' (p9). Its focus is on innovation, higher education and research and development, but it does recognize schooling as an important basis, but with no recognition of the potential role of technology education. Public recognition of technology education at this level seems to be regressing rather than progressing.

Innovation Summit

An Innovation Summit was held in Melbourne in February 2000 with more than 500 participants, organized by federal and state governments, the research community and industry. A report was produced as a result of the summit called *Innovation: Unlocking the Future* (DISR, 2000). It was clear to technology educators that Technology Education, through its constructs related to enterprise, design and innovation, had a role to play in the development of the government agenda in the promotion of a resourceful, ingenious and creative population to help ensure Australia's competitiveness. The hurdle is that many people do not understand the nature of technology education and so cannot make this link.

Innovation: Unlocking the Future (DISR, 2000) and the recommendations therein, together with The Chief Scientist's Report, *The Chance to Change* (Batterham, 2000), formed the basis of another report, *Backing Australia's Ability* (Commonwealth of Australia, 2001). *Backing Australia's Ability* is 'a practical approach to innovation that is focused, funded and producing real results' (p2). The report recognizes the need to 'educate for innovation' (p5) in a context where 'the knowledge economy and increasing influence of ICT are two areas driving a growing demand for workforce that is adaptable, creative, entrepreneurial and highly skilled' (p6).

Again, the opportunity is there for technology education, but the key to capitalizing on that opportunity is the promotion and development of an awareness of the capability of technology education.

Enterprise Education

In 1998 Enterprise Education was nationally funded for $3.4m over 3 years; the package Enterprise Education in School (EES) was launched by the Curriculum Corporation, but it mainly operated through the business studies area of schools and has not been effectively implemented across the broader technology education area.

The current national Enterprise and Career Education program was announced in 2001 and provided funding of $25m to 2004. Components of this programme include a Foundation to develop capacity for school-industry engagement, an action research project and professional development. There are opportunities within each of these components for technology education to be active, but because the link between technology education and enterprise is not explicit for many people, the input from technology education is not sought for this type of programme.

Review of Teaching and Teacher Education

A discussion paper, *Strategies to attract and retain teachers of science technology and mathematics* was released in September 2002 (DEST) as a precursor to a review of teaching and teacher education. The discussion paper seems to indicate an intent to seriously deal with issues related to each of these three areas, both through the commonalities and the unique aspects of each. However this does need to be emphasized through responses to the discussion paper because of the relative complexity of the technology education area. For example Table 1 in the discussion paper: *Students in selected first year subjects within secondary teaching courses*, deals with students under the headings of Science, Mathematics and Computing and Humanities – a classification that would seem to be seriously flawed in a discussion of Science Technology and Mathematics, but is explicable given the complex nature of the technology education area.

Technology Education Action Plan 2012

As a result of a national investigation into technology education in 2000 and a conference in Melbourne in July 2002, a draft Action Plan for technology education has been released in September 2002. This draft maps a series of integrated strategies for the development of technology education grouped around strategies related to a technology education network, research, promotion and advocacy, inservice and preservice teacher education and curriculum. The plan has potential because the commonwealth government has funding available to support the initiatives. It will however require considerable effort and dedication by technology education professionals to implement the plan.

Professional Association

The absence of a vibrant active representative professional association inhibits the development of technology education in a number of ways. It means there is no conduit between the government or other organizations and technology teachers, and advocacy opportunities are not taken advantage of as they arise.

Standards

The move toward standards seems to be inevitable. It is promoted by the Federal government and advocated by professional associations. *Standards of professional practice for accomplished teaching in Australian classrooms* is being developed by a consortium of the Australian Association for Research in Education, the Australian Council for Education and the Australian Curriculum Studies Association. Curriculum standards are being developed by the professional associations in the areas of English, mathematics and science. The USA and UK have content standards for technology education, and New Zealand is conducting research in that direction.

The predicament in the development of standards for technology education in Australia is reflected in the questions who would develop them, and how would technology standards relate to VET and ICT standards?

Conclusion

Technology education is an established part of the general curriculum in Australia. It is formative and developmental, and continues to face challenges to its core, broad status in the current context of state curriculum diversity and the absence of national leadership. Not only are there few powerful advocates for the learning area, many do not understand the nature of technology education, and with a focus on areas such as ICT and VET, there is the very real danger that these areas will come to represent the learning area.

Nevertheless, much progress has been made in the last 8 years to provide a solid foundation of sound practice in many schools. With the continued commitment and dedication of technology education professionals, the potential is there for technology education to become a valued core component of all students education.

Much hinges on the acceptance and funding of the Technology Education Action Plan (2002-2006). This will serve to develop a solid research base in technology education, heighten the awareness of the core elements of technology education and unify progress at a national level. The battle for continued progress will be very difficult in the absence of a national action plan.

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Technology Education in the U.S. – A Status Report

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Introduction

At an international meeting, it is not uncommon for someone to inquire, "How are things in the U.S.?" The question is obviously rhetorical because where would one begin with any kind of reasonable and comprehensive response. Is the expectation for an update on the Bush Presidency and the war on terrorism? Or perhaps the question has to do with the status of the stock market, international trade, airport security, or even something as simple as the weather.

A similar dilemma comes to mind when one attempts to portray the status of technology education in the United States. The status of technology education in the U.S. is obviously a very large and complex topic, and one that could be approached from a variety of angles and perspectives. One approach could be to provide a broad overview of a wide range of topics, which would have the advantage of being comprehensive. At the other extreme, one could select and treat one or two topics in some depth. The following discussion will attempt to strike a kind of balance between these two extremes; maintaining some scope while providing a foundation for some in-depth discussion.

The presentation consists of three sections. The first section will consist of demographic data for the profession in the U.S. The purpose of this part of the presentation is to provide a broad context for understanding a broader range of issues. Hopefully, this information will be useful throughout other conference presentations as well. Part two will present an overview of important initiatives that have (and are) affected the direction of technology education in the U.S. The final section will consist of a discussion of key issues and challenges that are facing technology educators in the U.S.

Demographic Information

The information presented in this section will focus on two primary areas: (a) university level data including information about faculty, program size, and graduates and (b) public school level data including teacher supply and demand, program size, and gender/ethnicity distribution.

University Level Data

Information for this section was obtained from an analysis of two editions of the Industrial Teacher Education Directory, published by the Council on Technology

Teacher Education (CTTE) and the National Association of Industrial and Technical Teacher Educators (NAITTE). The directory, now in its 40th annual edition, contains a variety of self reported information including types of degrees granted and numbers of graduates on a per program basis, in addition to faculty information (i.e., names, academic rank, teaching focus, and contact information). The two issues of the directory that were analyzed contained data for the 2001-02 and 1997-98 academic years. The 2001-2002 directory is the most current issue. The 1997-98 issue was included in order to provide some near term benchmarking perspective.

According to the directory, there are currently 101 universities or colleges preparing technology education teachers in the U.S., which represents an increase of three from 1997-98. Of these, eight (8%) identified themselves as either industrial arts or industrial education, which is down from twenty-two (23%) of programs using those monikers five years previously. These programs currently are distributed across 43 of the 50 states in the U.S. (see Table 1). With rare exceptions, the highest concentrations of programs are in the mid-west U.S., where industrial arts programs have thrived historically.

Table 1

Distribution of Technology Education Across the U.S.

Number of Technology Education Programs per State	Number of States per Level
5	5
4	3
3	10
2	8
1	18
0	7

According to the *Directory*, there are currently 140 technology education faculty members teaching at the university level in the U.S. The median number of faculty members identified as technology education faculty per institution was three in 2001-02, which is up from a median of 2.5 four years previously. It is interesting to note that in 2001-02, 38 (38%) of the institutions listing technology education as a degree option, listed no faculty designated as technology educators in the directory. Of these 38 programs, 27 indicated that they had graduated technology education students. Further, six of these 27 programs indicated that they had graduated 20 or more technology education students in the past year.

These data illustrate the complexity of attempting to understand the scope of university level supply and demand in the U.S. In most universities, technical courses are delivered, not by faculty designated as technology educators, but rather in classes designed for and delivered by industrial technology faculty (i.e., courses in CAD, automated, electronics, construction techniques, etc.). While many faculty who were prepared as teacher educators have moved into industrial technology positions, many have retained an allegiance with technology education. In a number of institutions, much of the teacher preparation coursework is delivered by faculty in Colleges of Education.

These factors make it extremely difficult and even misleading to attempt to extrapolate the number of university level technology teacher educators from existing data.

The picture is somewhat clearer regarding the number of technology education graduates from university programs. This past year, 652 students graduated with technology education degrees (compared with 654 four years previously). The median number of graduates per institution (for those universities graduating technology education majors) was 14 in 2001-02. While these numbers are encouraging and represent, in many cases, an increase from previous years, it is somewhat discouraging to note that 29 (29%) of the 101 technology education degree granting institutions reported zero graduates in 2001-02. Additionally, only 19 schools (19%) graduated 10 or more students in 2001-02.

Public School Level Data

The university graduate (supply) data become more critical when compared with the current and projected demands for teachers at in the public schools. A series of teacher supply-demand studies have been conducted at Old Dominion University in Virginia over the past decade. According to the most recent data, there are 16,525 technology education teachers at the middle school level and 18,702 in the high schools across the U.S. (Ritz & Hassan, 2002). In an analysis of the data on a per state basis, most states have less than 1,000 technology education teachers (see Table 2).

Table 2

Distribution of Technology Education Public School Teachers

	Middle School Level	High School Level
Number of teachers	# of states	# of states
0-50	11	11
51-100	5	5
101-250	14	9
251-500	9	12
501-1000	6	10
1001-up	5	3

The growth in the overall student population in the U.S (from 49.8 million in 1994 to 51.3 million by 2006) coupled with the large number of anticipated retirements and attrition of technology teachers points to increased demand for teachers (AAEE, 2000; Gerald & Hussar, 1996; Sanders, 2001; Weston, 1997). According to the Ritz and Hassan study, over 3,600 new technology education teachers will be needed by 2005 (see Table 3). These projections are worrisome, particularly when technology teacher education programs are only producing less than 20% of the new teachers needed to fill these positions.

Table 3

Anticipated Vacancies

	Middle School	High School
1996	1549	1684
2003	1123	1615
2005	1317	2331

A recent status study of technology educators identifies additional characteristics of technology teachers (Sanders, 2001). Approximately 10.1% of technology education teachers are now women. While these numbers remain disproportionably low, they represent significant improvement from the 1% reported in a similar study conducted twenty years ago by Dugger et. al (1980). Approximately 23% of technology teachers are over 50 years of age, while nearly 30% are less than 40 years old. Teacher participation in professional organizations is similar to that of other disciplines. Approximately one fourth of the nation's technology teachers belong to the International Technology Education Association (ITEA), while slightly fewer attend the organization's annual conference (Sanders, 2001).

The Sanders (2001) study also presents useful student demographics information. According to those results, females represent approximately one third of the technology education student population. The numbers are higher at the middle school level (46.2%) where many school districts require a unit of technology education. The situation is less positive at the high school level where female enrollments drop to less than 20%. Approximately one fourth of technology education enrollments (26.2%) are from minority populations and a similar percentage (22.9%) are identified as special needs students, while 12.2% were identified as gifted and talented.

Summary

In summary, based on available data, there are approximately 100 teacher education institutions preparing teachers to teach technology education in the U.S. These programs are currently graduating about 650 students per year (approximately 14 per program), but all of these graduates do not seek certification as teachers. Based on available supply and demand data, it is clear that the supply of new teachers is lagging substantially behind the current capacity of our teacher education institutions. Clearly, if technology is to continue to grow and thrive, it will be necessary to address the issue of capacity in teacher education. This growth will be particularly vital and necessary if the potential for expansion of the discipline into the elementary grades is to be realized.

Key Initiatives

Over the past two decades, a number of initiatives have been launched that have had a major impact on the scope, direction, and focus of technology education in the U.S.

Some of these have been internal to the profession, led by the ITEA, and other professional organizations such as the Technology Student Association (TSA), the Council on Technology Teacher Education (CTTE), etc. Perhaps more important, technology education in the U.S. has benefited enormously from initiatives and support from agencies and individuals from outside of the profession.

Jackson's Mill

In 1981, the top leadership from the (then) American Industrial Arts Association (AIAA) gathered in West Virginia to conceptualize the profession for the future. Today, we simply know it as *Jackson's Mill*. Technology was identified as a formal area of study, parallel with the sciences and humanities. Curriculum development efforts proliferated, structured around technology's major systems: construction, communications, manufacturing, and transportation. A decade later, another symposium, led by Savage and Sterry yielded *A Conceptual Framework for Technology Education*, and extended *Jackson's Mill* to embrace bio-related technologies as content for technology education. The significance of these two efforts was twofold. First, it served to clearly shift the content focus of the profession from industry to technology. Second, it yielded a conceptual framework for curriculum development organized around systems of technology. These represented important shifts in emphasis.

Name Change

In 1985, at the AIAA conference in San Diego, the name and identity of the profession officially changed to the International Technology Education Association (ITEA). This change (along with name changes of ITEA-associated councils) proved to be expansive along at least two dimensions. It formalized and extended the scope of the content base of the profession beyond *industry* to *technology*. The name change also expanded (at least symbolically) the boundaries of the profession beyond American shores to the international community.

Involvement with NSF

In the early 1990s, the profession attracted the attention of the National Science Foundation. The NSF was formally established in 1950 through an act of the U.S. Congress to promote the progress of science and related disciplines. It has been an extremely important and highly regarded institution for promoting the advancement of basic and applied science and for influencing national scientific and educational policy on many fronts. Throughout its distinguished history, the NSF has extended its reach to embrace a number of related disciplines including mathematics, engineering, computing sciences, the social and environmental sciences, and education. Through the advocacy and sustained leadership of Dr. Gerhard Salinger, a respected low temperature physicist and program officer in the Directorate of Education and Human Resources at the NSF, technology education has now been integrated into NSF programming. Since the early 1990s, six technology teacher educators have served terms as program officers at the Foundation, which has served to raise the level of awareness of technology educators and the broader scientific and policy making communities. A number of technology education projects have been funded including those supporting curriculum development, teacher professional development, and perhaps most important, the Technology for All Americans standards project. Clearly, the support of and relationship with the NSF has been one of the most important and positive initiatives for technology education in the last quarter century. The relationship has not only provided opportunities for technology education, it has also served to expose the larger academic community to the potential importance of technology education as a key component of the general education of all students.

Standards Projects

In 1994, through funding provided by the NSF and the National Aeronautics and Space Administration (NASA), a major national effort was initiated to develop K-12 standards for technological literacy. The first standards appeared in 1989, with the release of the *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics. The science community subsequently released two sets of standards including the *Benchmarks for Science Literacy* by the American Association for the Advancement of Science and *The National Science Education Standards* by the National Research Council. Other academic disciplines have developed standards as well.

In the spring of 2000, through the leadership of the ITEA and Dr. William Dugger, the *Standards for Technological Literacy* were released to the profession. These standards are designed to provide a comprehensive conceptual framework and vision for technological literacy and contain benchmarks for what students should know and be able to do with technology K-12. The standards serve to clarify and broaden the content base of the field and also place increased emphasis on engineering and design. Currently, the TfAA project is developing assessment standards, professional development standards, and program standards.

Involvement with the National Academies

Over the last decade, technology education has benefited tremendously from its association with the National Academies of Sciences and Engineering. The National Academy of Sciences (NAS) was signed into being by President Abraham Lincoln at the height of the Civil War in 1863 with a mandate to conduct scientific investigations for the U.S. congress on matters of national importance and strategic concern. Its membership (by invitation only) includes the nation's top scientists, engineers and policy makers. The functional, "working arm" of the academies is the National Research Council (NRC), which annually conducts several hundred studies on matters of national importance. The NRC is highly respected in Washington, DC and reports frequently have substantial impact on national policy.

In recent years, the NRC has conducted several studies that have directly impacted technology education. Near the completion of the *Standards for Technological Literacy*, the Technology for All Americans leadership made the decision to submit the document to the NRC for review. This was a daring move, not only due to the NRC's reputation for rigor, but also because it invited the intense scrutiny of the profession's work to the engineering and scientific communities. While the process extended the project for an additional year and resulted in substantial changes to the standards, it won the valuable endorsement of the NRC and the National Academy of Engineering. Another recent technology education related initiative at the National Academies includes *Technically Speaking*, which was comissioned to make the case for technological literacy.

Curriculum Development

The *Standards for Technological Literacy*, represent a conceptual framework for technology education. They are, however, not curriculum. The next major challenge for the profession is to develop appropriate materials, including enhancement opportunities for teachers. Given the decentralized nature of education and curriculum in the U.S., these initiatives are occurring along a number of fronts. The ITEA has initiated the Center for the Advancement of Teaching About Technology and Science (CATTS), to promote professional development and stimulate curriculum development. Products from that effort are now being published. The NSF has funded a number of projects and the opportunity and need exists for more. Additionally, state Departments of Education around the U.S. fund curriculum work as do developers of commercial publishers and technology education vendors. Ultimately, the impact of the *Standards* will hinge on the extent to which they are translated into curriculum materials that will directly impact students in the classrooms across the U.S.

TFA Leadership Development Initiatives

Over the past decade, the Technical Foundation of America has funded a series of leadership development and other activities designed to promote the growth and development of the technology education profession (including this conference). Collectively these activities have made a significant impact in a number of respects including fostering dialog among technology educators on a national and international scale, encouraging teachers and faculty to test new and innovative ideas, stimulating research, and recognizing technology education leaders for sustained leadership to the profession.

Summary

Certainly, there are other initiatives that could be noted including the development of the research journal, *Journal of Technology Education*, the work of the Technology Student Association, progress with electronic distribution and communication across the profession and much more. Collectively these initiatives represent a body of activity that has served to elevate the status, visibility, and quality of technology education at the national policy making level. Technology education is much better connected with the science, engineering, and mathematics communities and, through the *Standards for Technological Literacy*, the content is as well conceptualized as perhaps at any other point in our history. But significant issues and problems remain.

Issues and Problems

This section of the paper will focus on some significant issues and problems confronting the field of technology education in the U.S. The issues and problems discussed in this section were identified based primarily on an analysis of three significant bodies of work. First, a study conducted by Wicklein (1993) nearly a decade ago using a modified Delphi technique was designed to address precisely this topic. The study also included a futuring component designed to project trends and issues for the field. The second body of work consisted of proceedings of a conference conducted in December 1999 by the American Association for the Advancement of Science (AAAS). Among the purposes of this conference were to examine the status of research in technology education as well as to stimulate research and formulate a research agenda. In addition to respected leaders from technology education, the conference also included researchers from the science, mathematics, and engineering communities. The final work was an article published by Sanders (2001) in the *Journal of Technology Education*. Sanders' study was designed to describe current programs and practice of technology education in the U.S. and was based on two previous studies (Schmitt & Pelley, 1966; Dugger, et. al., 1980).

A comparative analysis was conducted of these three bodies of work. While some unique perspectives emerged through the process, the analysis yielded remarkable consistency of views over the past decade. It is important to note that this time frame coincides roughly with the period during which the significant initiatives identified in section two of this paper occurred. Seven significant issues were identified in the analysis. The remaining pages of this paper will consist of a brief discussion of each of these issues.

Curriculum Development & Instructional Delivery Paradigms

A key outcome of the Sanders study (2001) was a distinct shift from the industrial arts emphasis on skill development to the development of problem solving. This emphasis was clearly present in the Savage and Sterry's *Conceptual Framework for Technology Education* (1990, p. 20) and has been further delineated along with a strong emphasis on design in the *Standards for Technological Literacy*. Even with this consistency, several significant issues remain to be addressed by technology education curriculum developers.

First, the concept of problem solving remains to be refined both theoretically and practically for technology education. Technological problem solving must be clearly distinguished as something distinct from more general forms of problem solving (i.e., personal, social, scientific, etc.). (Custer, 1995). Secondly, technology educators in the

U.S. disagree about the extent to which problem solving and design can be reduced to a set of general heuristics or steps, contrasted to the views of cognitive psychologists, who stress the importance of domain specific knowledge for problem solving and learning transfer. Yet another curriculum development issue (and one not necessarily resolved in the *Standards*) has to do with the relationship between design and problem solving. For some, design is the general category, whereas others view design as a subset of problem solving, along with trouble shooting, experimentation, invention, and research and development.

Another major issue that remains to be resolved by curriculum developers involves curriculum organizers. Since Jackson's Mill, much of the curriculum in the U.S. has been organized around systems, (e.g., communication, transportation, construction, production, etc.). The substantial broadening of contexts in the *Standards* to include agriculture, and medical technologies, as well as the distinct shift away from systems toward a focus on design and problem solving represent challenges that have not yet been addressed in depth by the profession (as illustrated in Sanders' study, pp. 49-50)

Additional curriculum and pedagogical issues include the widespread use of vendor developed, modular delivery systems, and the challenge of appropriately addressing the social science and scientific aspects of technology.

Content/Knowledge Base

Considerable progress has been made since the Wicklein (1994) study on clarifying the content base for technology education. The *Standards* represent the most comprehensive conceptual framework available to date. However, major work remains to be done along at least two fronts. First, technological knowledge is both procedural and conceptual. McCormick (1999) observes that "technologists are the doers, and the scientists are the researchers." One of the major challenges of the Technology for All Americans standards developers was to attempt to formalize what it is that technologists do (procedural knowledge) while also clarifying the core concepts of technology (i.e., tradeoffs, feedback, systems, resources, requirements, etc.). Technology educators in the U.S. have concentrated primarily on procedural knowledge, as the historic emphasis on skill development would indicate. We have focused much less on carefully thinking through the core, enduring concepts that are essential to understanding technology.

A second remaining challenge with the knowledge base is that it is still too general (Raizen, 1999; McCormick, 1999). The *Standards* represent a huge step forward, conceptualizing the "big ideas"; but these ideas have yet to be developed in sufficient detail for student learning and assessment purposes. What are the specifics that need to be taught if students are to be deemed technologically literate? What specific concepts must they know about particular technologies (e.g., food production, communications systems, etc.) to be able to make sense of larger core concepts?

Assessment/Measurable Outcomes

One of the most serious challenges facing the research team charged with making the case for technological literacy at the National Academy of Engineering (Pearson & Young, 2002) was a serious lack of assessment research. While the general consensus of the panel was that general levels of technological literacy are low, the data were simply not there to support the assertions. In addition to this large scale assessment concern, relatively little is known about specific student learning outcomes in technology education relative to the emerging content base for the field. For the most part, the case for technological literacy has been made rhetorically; that the study of technology is important in a technologically intensive world. There is growing realization that we know relatively little about such matters as how technology education classes are affecting student learning, both related to technology education learning content and when technology is used as a vehicle to promote learning transfer and content integration. Also, much remains to be learned about how to "tease" information about individual learning and performance from group imbedded learning activities.

In their work with "backward design", Wiggins and McTighe (1998) make the point that curriculum design must begin with clearly identified, robust essential concepts, followed by an articulation of the evidence needed to conclude that the concepts have been understood. Only AFTER these steps have been taken, is it appropriate to develop the student learning activities needed to deliver the content. There has been a distinct tendency for technology educators in the U.S. to BEGIN with the activities without a clear sense of the content they were designed to deliver. In the absence of clearly focused outcomes, student assessment is nearly impossible.

Cross Disciplinary/Interdisciplinary Issues

Lewis (1999) notes "if schooling is to have desired meaning for children, then the various elements of the curriculum must cohere." Technology educators in the U.S. have been actively involved in exploring the association of technology with related academic disciplines, particularly mathematics and science. Some integrated curriculum has been developed (e.g., IMAST) and limited empirical research has been conducted (e.g., Childress, 1996; Scarborough & White, 1994). Further, with the current interest in what cognitive scientists have to say about situated cognition, technology education would appear to be ideally equipped to contribute to interdisciplinary learning.

Several significant problems persist in this area however. At one level, the problem is political. Where the curricula in mathematics and science tend to be driven by high stakes testing of students, this is not the case in technology education. This situation tends to reinforce the separation of disciplines while reducing the perceived value of technology education. A second challenge is that, in spite of the strong interest in situated cognition, there are relatively few working models of successful curriculum integration, particularly at the secondary school level. In summary, the rhetoric of integration tends to be much better than its practice.

Public Awareness, Understanding and Status

Technology education in the U.S. faces several significant challenges related to identity. Perhaps the most serious is the persistent and growing association of technology with computers and other high tech electronics. In a recent national Gallup poll (Dugger & Rose, 2002), strong support was registered for the development of technological literacy. However, when asked to define technology, over seventy percent associated it with computers, electronics, or the Internet. While the same poll indicated strong support for including technological literacy in the schools, it is not at all clear that their understanding extends beyond computers.

A second point of confusion has to do with the confusion of technology education with vocational education and even, to some extent, industrial arts. The paradigm shift that has occurred since Jackson's Mill has attempted to place the emphasis of the field on technological literacy as a key component of the general education of all students. Significant progress has been made in this regard through the work of the profession's leadership, the *Standards*, and other initiatives. At the same time, considerable progress remains to be made in both public perception and, in a number of cases, actual practice in the nation's schools. While technology teachers have shifted their emphasis away from skill development to problem solving and general technological literacy, Sanders' (2001) study found that course categories have actually remained very stable since 1963 (e.g., woods, metals, drafting, and electricity/electronics).

One of the most important challenges for the profession during this period of paradigm shift is to find ways to effectively interpret the goals and focus of the field to the larger educational community and the public. Part of the solution will have to do with effective communicating and marketing. But, the need also exists for solid, empirical research that demonstrates the value of technology education content as well as its value for contextualized learning.

Research Base and Research Culture

Reviews of the status of technology education research in the U.S. have generally been critical, citing an overall lack of substantive research, diminishing numbers of researchers, and a reliance on survey research methods (Foster, 1999; Sanders; 1999; Zuga, 1999). Zuga (1999), after three such reviews extending back to 1987, concludes that "the research base of technology education in the United States is limited and weak" (p. 2).

This problem is generally acknowledged among technology education teacher education faculty, the vast majority of whom teach at regional universities, which emphasize teaching over research. The problem is multifaceted. As McCormick (1999) observes, part of the problem is cultural, where technologists tend to be the doers while scientists tend to focus on research. At a practical level, shrinking numbers of technology education faculty are stretched with increased expectations for teaching, research and service.

In spite of these problems, the fact is that expectations for research and grant writing are escalating in regional universities, which employ the vast majority of technology education faculty in the U.S. Tenure and promotion systems in these universities increasingly are requiring that faculty engage in research, often while retaining substantial teaching loads. The positive spin is that these are positive growing pains for the profession. Increased expectations for research coincide with an increased awareness of the value of research to fuel the maturity of the field. The profession needs to know much more about such things as how technology education facilitates cognitive development, how the gap between theory and practice can be bridged, how public perception can be influenced, and more.

Teacher Preparation and Professional Development Issues

As the field continues to evolve through the paradigm shift to technology education, technology teacher education programs are facing significant challenges, both at the pre-service and in-service levels. In a number of states, departments of education, policy makers, and teacher education programs are using the same mechanisms for preparing technology education teachers, vocational teachers, and industrial technologists. For many (if not most) programs, the practical necessity of delivering technical courses to both teacher education and industry-based students is a serious constraint to developing creative, standards-based models for educating new technology teachers.

Several factors are currently at work that signal potential for progress. Many technology teacher education programs are growing, at least partially in response to the strong demand for technology teachers. Standards driven initiatives, including the soon to be released Technology for All Americans *Professional Development Standards* and the standards-based NCATE accreditation guidelines (under development) will provide incentives and structure for teacher education program change. Technology teacher educators have always played a key leadership role in the U.S. and the present is no exception. Strong teacher education programs will remain vital to the future of the profession.

Concluding Comments

A key and ongoing task for the profession is to ascertain the extent to which the significant investment in initiatives and programs is addressing its needs and issues. Clearly, initiatives such as the development of the Standards, collaboration with the NSF and the National Academies, curriculum development work, etc. are serving to address, at least to some extent, the need to conceptualize and clarify the field's content and knowledge base. Significant work, however, remains to be done to address the need for research, to develop new models for teacher education, and to promote the value of technology for all students.

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Chapter Two

Technology, Education and Social Change

Technology Education and Social Change

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Questioning the nature of technology education within the context of social change

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Technology Education and Social Change

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Introduction

Technology is a driving force in society. It can be viewed as an oddity, feared and given unrealistic assumptions of power by the uninitiated, but in the end, it is a powerful force of change. Social institutions, values and cultures are forever altered as a result of the introduction of technology. One the other hand, society is the impetus for almost all new technological developments and adaptations. In that capacity, society is a driving force behind technological development. Without human demands for new technological products and systems that make life easier, technology would never have been granted power. Meanwhile, education provides the mechanism to study and understand the complex relationships between society and technology. There are thus important interactions between technology, education and social change. One of the basic lessons learned in studying these interactions is that technology can be used to solve social problems or to create new ones. Technology inevitably involves benefits, risks and tradeoffs. Intelligent decisions about technological development, proliferation and their impact on society must be made. In many ways, a careful understanding of the relationships between technology, society and education will help members of the technology education profession develop the vision that will shape our future in the public schools and assist us in preparing a generation of students who possess the knowledge and abilities necessary to be considered technologically literate.

Technology Shaping Society

For over 250 years, technology has been regarded by many in the New World as the hallmark of our culture—one of those things that defines our society and sets us apart from our European ancestors (Cowan, 1997). In the United States, technology has led to a standard of living inconceivable even a hundred years ago. Rhodes (2000) suggested that half the population of the United States is alive today due to technological changes in the 20th century, most of them in public health. Half the population of America would not be alive and a quarter would never have been born because another quarter would have died before they were old enough to reproduce. The same is true for most of the developed world. The paradox is that good technology is transparent. People walk through it and use it and don't realize it (Rhodes). Supporting this assertion, Pearson and Young (2002) contended that technology has become so user friendly it is largely invisible. People use technology with a minimal comprehension of how or why it works or the implications of its use or even where it comes from (Pearson and Young). Technological change and adaptation has become a pervasive element in our societies. The dynamic nature of technology makes it a unique human activity. Other human activities do not have this characteristic: We love old paintings, wine and cars, but yesterday's computer is a real drag. Technology has come to represent our dream of progress.

The technological revolution is however, not free of attached strings. By its very nature, technology brings about change in society and undermines existing cultures. It affects virtually every aspect of human activity: Private and public institutions, economic systems, political structures, international affiliations, social structure, and the condition of human lives. The effects are not one-way; just as technology changes society, so too do societal structures, attitudes, and customs affect technology (Pool, 1997). One hundred years ago, people in western nations generally saw technological development as a good thing. It brought prosperity and health; it represented "progress." But the past century has seen a dramatic change in western society, with a resulting shift in people's attitudes toward technology. As countries have become more prosperous and secure, their citizens have become less concerned about increasing their material wealth and more concerned with such considerations as maintaining a clean environment and safe neighborhoods. In many cases, this makes them less likely to accept new technologies without questions. At the same time, citizens of western nations have become more politically savvy and more active in challenging the system with lawsuits, special interest groups, campaigns to change public opinion, and other political tools. Subsequently, members of the public now exert a much greater influence on the development of technologies (Pool, 1997). Scholars now talk about the push and pull between technology and society, rather than just the push of technology on society (Pool). Pool stated that:

> Modern technology is like a Great Dane in a small apartment. It may be friendly, but you still want to make sure there's nothing breakable within reach. So to protect the china and crystal, government bodies, special interest groups, businesses, and even individuals are demanding an increasing say in how technologies are developed and applied (p. 8).

Even as people have come to rely on technology more and more, they have liked it less. They distrust and sometimes fear the machines that are supposedly their servants. Many worry about the nature of the world they are leaving to their children. Some of the long-term costs of technology have been higher than anyone expected: Air and water pollution, hazardous wastes, the threat to the Earth's ozone layer, the possibility of global warming. Meanwhile, the drumbeat of sudden technological disaster over the past twenty years is enough to give anyone pause: Three Mile Island, Bhopal, the Space Shuttle Challenger, Chernobyl, and the Exxon Valdez (Pool).

But the most important changes have come in the nature of technology itself. In the twentieth century, the power of our machines and devices has gown dramatically—along with their unanticipated consequences (Pool). Besides its power, modern technology has a second feature. In many cases, technology has reached the point where most in society can't comprehend how it works nor anticipate the possible consequences of the technology once it is put into motion. In a recently published International Technology Education Association/Gallup Poll, only 28% of the American public indicated that they understood most technologies to a great extent (Rose & Dugger, 2002). The increasing complexity of technology continues to alter the relationship between humans and the technology they use. Complexity creates complacency; uncertainty or fear and can limit the intellectual interaction between members of society and new technological developments. Consider the accident that destroyed the space shuttle Challenger. Although the cause was eventually established as the failure of O-rings at low temperatures, the real culprit was the complexity of the system (Pool). Pearson and Young (2002) proposed that:

> As technology has become more complex, society has become more specialized. As a result, all of us know more but about fewer things. We turn to plumbers, electricians, appliance repairmen, cable TV installers, telephone workers, and other specialists to service or repair our technological devices for the simple reason that we don't have time to learn everything we need to know to take care of them. (p. 49)

As the historian Thomas Hughes points out, technological problems generally demand technological solutions, of which the technical fix is one component—technological understanding the other.

Society Shaping Technology

Technological devices and systems do not bask in the glow of global acceptance or fade in the darkness of social rejection based solely on their intrinsic merits. Social, political, economic and other human factors play an extensive role. Humans are the central figure in all technological devices and systems. A wrench is not a wrench until someone picks it up and uses it to tighten a bolt and technology is of little value unless someone is willing to purchase or use the product. Technological proliferation is driven by the wants and needs of the consumer—the human. The nature of 20th Century human evolution has been external to our bodies. Instead of developing the eyes of a hawk, we develop binoculars and telescopes. Instead of becoming fleet of foot, we build automobiles and locomotives and airplanes. Instead of wings on our back, we have the wings of airplanes. Our characteristics are external to our physical being. We find ourselves at last at a point at which we do not adapt our human form, we build devices and systems that provide the advantage. Such capacity is unparalleled in nature (Alcorn, 2003). Volti (1988) remarked:

> "In considering the influence that technology in general or any single technology has over human affairs, it is therefore necessary to consider not only the technology and its presumed 'imperatives,' but also the key human agents of the technology, the organizations in which they operate, and how these influence the course of technological change." (p. 33)

With humans, the technology we choose to build and the manner in which we use it is totally a matter of choice. We have an infinite capacity to produce technology, and we can accept or reject a product or system as we choose. As members of various social orders, humans assess technologies based any number of priorities. These priorities might include ease of use, the advantage that the technology brings to the table, the social value of the device or system or the intrinsic value of the product. The assessment is not so much about the technology itself, or the elegance of the product, but rather, what can it actually do for me.

Human beings cannot help being creative and seem to be perennially prepared to adapt to new ideas. When the railroad came into being, some predicted the fundamental health and mental stability of humans would be severely altered. There were comparable commentaries about the impact of the telephone and the automobile. And since World War II, Americans have continuously and obsessively debated the role of television (Botstein, 2001). The fact that the railroad, the automobile and the telephone each had an enormous influence on history is not in dispute. However, the actual roles played by these widely disseminated technological changes were different from those predicted when the innovations first appeared. Without the automobile, there would most likely be no phenomenon quite like suburbia. And, without the railroad, it could be argued that the industrialization of the western world might not have occurred at the same rate and in the same fashion (Botstein). Nevertheless, humans and the social orders they reside within adapted and changed without any great upheavals.

The Risks and Benefits of Technological Proliferation

It really doesn't matter whether you like or dislike technology. One way or another, you're going to pay for it, even if you don't use it (Schneiderman, 2000). Each technology and each application of technology raises social issues with which we must deal. Each new device or system requires some consideration as to whether the use of that device will work for us or not. In many cases, we have no certainty as to whether the technology in question will benefit us or not. Alcorn (2003) asserted that, "Technology turns out to be a double-edged sword, with both costs and benefits in its use, and this in turn requires us to determine whether or not the benefits are worth the costs. And, that's assuming we can even actually determine the costs accurately in the first place." (p. 153)

Just as there is an increase in our dependence on technology, there is also the possibility of becoming more dependent on one another because of technological involvement. Alcorn (2003) stated that:

> The western world is highly dependent on Middle Eastern oil producers for the supplies of crude oil needed to run our economies. In a similar manner, much of the world depends on the western world for food. Because of technological innovations in agriculture, less than 5 percent of the population in the west is capable of feeding our own populations as well as millions and millions of others. Technology can both create and alleviate that dependency (p. 247).

So, the question becomes, are our societies better or worse by virtue of the technology we use? The answer is not a simple yes or no proposition. Technological innovation and change comes with risks and benefits for society. Depending on the use to which a technology is put, it can be either a benefit or a real danger, or both at the same time. Postman (1993) suggested that every technology is both a burden and a blessing; not either-or, but this-and-that.

As members of the human species, we are all, for good or ill, enmeshed in technological systems from which we cannot escape—and about which we need to be informed (Cowan, 1997). While technology has increased our ability to control our natural environment, we may now be unable to control the technology used to control our environment! This has been seen often in the past with sometimes devastating results. The practice of agriculture is an excellent example if we look at the relationship between climatic change and the extensive use of agriculture. Some of the most arid regions of the globe were once great forests or grasslands that were cleared for agriculture. Unfortunately, with the deforestation came a host of environmental changes that led to everything from soil erosion to changes in weather patterns. Other examples include the virtual lack of forests in Lebanon today, where once stood vast woodlands of cedar, a prized wood traded all over the Mediterranean (Alcorn).

To add a little perspective about the role technology plays in our society and the associated risks and benefits we could examine the automobile. Alcorn suggests that when the automobile was first introduced, it was hailed not only as a solution to transportation problems within cities, but also as a defense against growing pollution. That may seem quite strange from our current perspective, but a century ago, the pollution problems faced by industrial urban dwellers were quite different. At that time, at the birth of the automobile age, the chief means of transportation was the horse. Anyone who wasn't walking or traveling by train was traveling by horse. With the horses came horse dung, and it was everywhere. We do not think of horses and horse dung as being a major health hazard in our lives today, but 100 years ago, it was a major problem. Thus, the "horseless carriage" was hailed as the eliminator of the pollution problem of horse transportation. Less than a century later, we have come to view the automobile as a primary source of air pollution. The pollution solution became the pollution problem. Today, there is a great deal of public pressure on the transportation industry to begin producing more *non-polluting* electric vehicles. Since most electric cars do not utilize a combustion process to power the vehicle, they will not produce the same carbon monoxide pollutants as the petroleum-powered vehicles. And so, once again, the pollution solution has been located! However, should society not consider the other consequences (intended and unintended) that this new solution might bring? Currently, all electric automobiles utilize heavy lead-acid batteries as a power source. What will we happen to these batteries after they have been exhausted? Batteries are already seen as a pollution problem, with only one per car. What will happen when the number of batteries per vehicle rises to twenty? Could we once again be exchanging one form of pollution for another? (Alcorn, 2003). Although payment can be deferred for some length of time, any technological change or the adaptation of any new device or system brings associated costs. Alcorn suggests that there is never a free lunch--In the end, someone has to pay. Society must consider the idea that the use of technology will almost always benefit some while harming others. It is these technological changes and our responses to them that will ultimately determine what our future will be.

Social Change

Technological use changes society. It causes members of society to become more self-sufficient, self-centered, and more isolated. It causes a loss of traditions and rituals. The effects are often delayed and unintentional, but they occur nonetheless. In this capacity, technology has a tremendous ability to cause change in social values, norms, institutions and culture. Technological change can be a subversive process that results in the modification or destruction of established social roles, relationships and values (Volti, 1988). Alcorn proposed that our attitudes, opinions, approaches to problem solving, and psychological balance are all affected by changes in technology. Consider the impact that the automobile has had on eating habits, dating habits, family life and home construction just to name a few. The inventors of the automobile could not have seen the huge change it would have on how we work and play, how we build or neighborhoods, or how we base a large part of our economic strength on the sale of this product (Negroponte, 1998). If the introduction of a technology into a society changes the needs or wants of the population or alters the way the society functions, then society itself is altered, either by changing the nature of society or causing it to disappear. Technology is more than a device or system; it is also a catalyst for societal changes. Once technology is introduced, life, thinking, behavior, and social norms change. When automobiles—to name one technology—were introduced, life as we knew it drastically changed. Our point of reference changed, and our behaviors were altered. We changed our travel habits, the way we interacted with our families, our eating habits, the circle of friends that we accumulated over a lifetime and the location in which we elected to reside. With the advent of this technology, we make decisions to travel great distances on a moments notice, we arrive at our destinations more rapidly, move away from our families, commute great distances to work, and interact with people we might never have met without the technology in question.

As a whole, members of the public have an overwhelming appetite for technology and have become extremely dependent on the products and systems it produces. Consequently, most people have an unquestioning faith in technology to solve all of our problems. Even in the light of technological disasters like the Space Shuttle Challenger explosion, the public largely supports continued technological expansion. Unfortunately, we do not always possess technological understanding that equals our enthusiasm. In a 1997 survey sponsored by Ameritech, a Chicago-based wireless telephone operator, only eight percent of consumers had ever heard of TDMA, CDMA, or GSM, the primary technical standards for transmitting and receiving digital cellular phone calls. Most of the survey's respondents (69%) said they didn't care about the technology, as long as it worked (Schneiderman, 2000). The public's willingness to embrace new technologies as blessings without any measure of understanding is troubling to many in the educational community who argue that consumers of technology hold a responsibility to help society assess new developments so that these new products and systems will not mature into societal burdens. To many, it seems as if technology has become humanity's master and not the other way around. The inference here is that those things people never dreamed of having a few hundred years ago have become the things that people today couldn't dream of not having (Alcorn, 2003).

Unquestionably, technology causes change in any society. Little doubt exists that during the last 100 years the way we account for time has changed in the sense that we not only live longer but each hour seems capable of including more acts of communication, travel, pleasure and work. Our perception of time has been inalterably influenced by the ease of communication first initiated by rail travel and wireless telegraph (Botstein, 2001). At the same time, it can be argued that despite these momentous changes, the structure of our behavior and our attitudes toward birth, death, love, marriage and the meaning of life have remained quite stable (Botstein). He went on to suggest that it is therefore prudent to maintain a healthy skepticism about predictions concerning the influence and long-range significance of any given new technology. The debate about what the future will be like becomes neatly divided between enthusiasts who predict radical change and utopian outcomes and conservatives who fear that the end of civilization, culture and decency is suddenly at hand (Botstein). Volti (1988) implied that concern over technological proliferation has always been present. He suggested that when the railroads were first established many feared that they would provide an unnatural impetus to society, destroy all the relations that exist between humans, overthrow all mercantile regulations, and create all sorts of confusion and distress. In the long run perhaps, modern technologies like the Internet, cell phone and GPS will be more properly compared to the sewing machine, elevator and the adding machine. Future generations may easily look back at all the verbiage expended on the impact of the information age with the onset of the Internet as startling if not humorous. One would be embarrassed to have written a prediction about a new future based on the transformations that the elevator and the typewriter brought to civilization, important as these technologies were (Botstein).

Social Demands and the Educational Response

As we enter the 21st century, the technological landscape is changing. The United States is now only one of several technologically powerful nations. The global threat of terrorism has heightened the importance of technology in maintaining both economic and military security. In our daily lives we rely—whether we realize it or not—on a vast array of technologies. These new technologies increasingly depend on a public where everyone is technologically literate. Under these circumstances, members of the public and policy makers are beginning to place a higher value on the need for basic technological literacy, including an understanding of how technology is created (Pearson and Young, 2002). However, it is not altogether clear that the public is prepared to do anything with this newfound belief that technological literacy is important. In their recently published book entitled, *Technically Speaking*, Pearson and Young content that although the United States is increasingly defined by and dependent on technology and is adopting new technologies at a breathtaking pace, its citizens do not understand the tools they are using. They furthered this argument by proposing that "as a society, we are not even fully aware of or conversant with the technology we use every day. In short, we are not "technologically literate**."** (p. 1).

A recently published ITEA/Gallup Poll (Rose & Dugger, 2002) revealed that there is virtual consensus among members of the public that technological literacy is an important goal for people at all levels and that schools should include the study of technology in the curriculum. Despite the talk and enthusiasm, however, the reality in most classrooms remains strikingly different. The majority of schools offer little beyond basic computer classes in the way of technological instruction and most faculty members still rely primarily on lectures as their teaching method of choice (Hansen, 2000). Available evidence shows that American adults and children have a poor understanding of the essential characteristics of technology, how it influences society, and how people can and do affect its development. Having in many cases recognized the importance of technological literacy, neither the educational system nor the policy-making apparatus in the United States has done much about the dilemma (Pearson and Young, 2002).

Although members of the public or the policy making apparatus in the United States have not offered a great deal of support for including a course focused on the study of technological literacy in the public schools, they have been very critical of the status quo. Just as technology is only accepted when it meets human needs and wants, the curriculum offered in our public schools has been evaluated by members of the public and in many cases, the assessment has not yielded a positive response. Since the early 1980's, public support for the curriculum in American public schools has declined. Increasingly, the public sees the schools as out-of-touch and non-responsive to the needs and wants of society. This perception may be, in part, due to the need for quick answers usually found in our fast-paced technological world. Members of the public have become accustomed to the immediate response provided by technology. However, social problems, like public education, are fundamentally different from technological problems. While goals for technology are usually clear and unambiguous, goals for education are typically anything but clear.

Having said that, it should be noted that history reveals to us a simple truth. If a societies priorities and values are not reflected in the devices members of that society elect to purchase those technologies will vanish. The same is true of education. If a societies priorities and values are not reflected in the American public school curriculum, members of that society will go elsewhere. Currently, public schools in the United States are not preparing a student with the types of skills the business world finds most desirable and enrollments at private and parochial schools is at an all-time high. Roman (2001), suggested that Rip Van Winkle, having slept through the past few decades, would be lost with the computer, cash registers, ATM's, and the other technologies used daily by citizens. However, he would feel right at home in most public schools!

Since the beginning of school reform in the United States in the early 1980's, the public has demanded a return to *the basics*. Many have suggested that teaching students to use the latest technologies is only valuable if the students are well grounded in reading, writing and arithmetic. Members of the public seem to be suggesting that there are far too many graduating students who are not grounded in the basic skills. The results of such public pressure can be seen in increased high school graduation requirements (particularly in mathematics, science, and language arts), increased use of standardized tests, and the lack of emphasis in elective subjects like technology education. Meanwhile, technology education professionals argue that to be successful contributing members of a global society, all students must be technologically literate. The implication seems to be that people who stress back-to-the-basics at the expense of technological literacy are living in the past. Further, many of the strongest advocates for *getting back to the basics* are hard pressed to identify exactly what those basics are. Roman (2001) suggested that requiring students to complete additional mathematics, science, and language arts courses will not help the student who did not understand these classes the first time they took them. The lack of a clear message from political and educational leaders regarding the importance of technological literacy for all seems to be compounding this public perception problem. Generally speaking, parents understand that second grade students will be learning addition and subtraction of two-digit numbers, that fourth grade students will learn their multiplication factors, and that eighth grade students will learn essentially the same algebraic principles and processes regardless of the community or state within which they reside (Wright, 2002). However, the content and purpose of a curriculum focused on technological literacy remains a mystery to members of the public. In many cases, the technology education curriculum may be visualized by the public as a blue collar class that would be ideal for the neighbor's child.

In response to the public criticism initiated with the educational reform movement in the United States, many subject areas have developed standards and benchmarks that should be achieved by all public school children. Most state educational agencies have moved to mandate a core set of subjects (i.e., mathematics, science, history, reading) that all students are required to complete (Newberry, 2001). These national and state standards have resulted in a myriad of new required achievement tests at different grade levels. Perhaps, this new foci on standards and achievement tests is meant to demonstrate that schools are adequately preparing students for their future endeavors. Regardless, the process has negatively impacted many elective subjects like technology education as public school students have fewer opportunities to enroll in such classes (Newberry). In an effort to remain relevant in the future public schools, the technology education profession must develop a curriculum, based on the Standards for Technological literacy, that addresses the technological needs of all children. The profession must also form greater alliances with the accepted academic disciplines (i.e., mathematics and science), as well as the engineering community, and begin to address the misguided public perception of our field.

The Implications for Technology Education

One of the goals of technology education is to promote technological literacy in a broad and encompassing nature (ITEA, 2000). To achieve this goal, technology education must prepare students to understand, control and use technology. Students need to learn how to adapt to technological change and how to deal with forces that influence their lives and potentially control their future (Waetjen, 1985). Developing educational programs that deliver on the promise of *technological literacy for all* will require the insertion of comprehensive technology education programs into all elementary and secondary schools. Pearson and Young (2002) indicated that exposure to technological concepts and design-related activities in the elementary and secondary grades are the most likely ways to help young students acquire the kinds of knowledge and capabilities that are consistent with the demands of technological literacy. There are, of course, several obstacles that most be overcome in the immediate future to make this vision a reality. First, technological literacy and technology education have not been of primary interest to administrators in elementary and secondary schools throughout the United States. This is in stark contrast to the situation in some other industrialized nations, such as the Czech Republic, France, Italy, Japan, the Netherlands, Taiwan, and the United Kingdom, where technology education courses are required in middle school or high school (ITEA, unpublished). Because the local schools' performance and students' opportunities to enter college and university systems are based largely on standardized test scores, few administrators are interested in introducing a new subject that does not appear on the standardized tests into the curriculum (Pearson and Young, 2002). Zuga (1992) suggested that the solution to this dilemma might be found through connecting academic learning with *real-life* experiences that assist the learner in gaining a deeper understanding of course content and subsequently experiencing greater levels of success on those standardized tests. By using technology education content as a vehicle for addressing content in other academic disciplines, students go beyond just studying about abstract concepts and gain a deeper understanding through cognitive and psychomotor activity. The beauty of technology education lies in its ability to serve as a subject-matter integrator and harness the interfaces between subjects. To remain separate from our colleagues in other disciplines leaves us where we sit today with the public assuming that technology is taught in the computer labs and science classrooms while children are never introduced to technological literacy (Zuga, 2000). Recently formed relationships with the engineering community also hold the promise of developing closer relationships with post secondary degree programs, thereby easing the second concern of most public school administrators—Namely, will this course assist the student in being admitted to college.

The *Standards for Technological Literacy: Content for the Study of Technology*, published in 2000, represented the best thinking of some of the top scientists, engineers, mathematicians, technologists, designers, and technology education professionals (Wright, 2002). While these standards have already had a major impact on the profession and members of associated disciplines like engineering and science, they may also have the capacity to expose the promise that our profession holds for the education of all students. Some progress seems to have taken place since the publication of these standards. In a recent survey designed to ascertain the degree to which studies of technology education were included in state curriculum frameworks, Newberry (2001) found that a surprising number of those surveyed, 30 of 52 states and territories (57.7%), reported that technology education is in the state framework of education. An additional 11 states (22.4%) reported significant movement toward incorporating technology education more fully in the state curriculum frameworks (Newberry). Meanwhile, fourteen states (27%) reported that technology education is required in some form in their state. In six additional states (11.5%) where technology education is under local school district control, the requirement of technology education is left to the localities. Respondents from two states (3.8%) indicated that they are waiting for pending legislation regarding the status of technology education or are in the process of writing standards to meet a requirement. Of the 52 states and territories sampled, 16 states (30.8%) still consider technology education an elective subject.

If the technology education profession in the United States is to receive widespread acceptance in the elementary and secondary schools, two primary challenges must be addressed. Beyond the public perception problem, the foremost challenge facing the profession is the lack of a unified, standards-based curriculum. It is very difficult to sell school administrators on the idea that all students need to study technological literacy in the elementary and secondary school when we have no curriculum to offer. Albrecht (2000) supported this assertion when he implied that the future survival of technology education as a core discipline in our schools is dependent on the validity of the curriculum delivered in the classroom. Meanwhile, members of the technology education profession have had some difficulty in identifying exactly what the technology education curriculum should include. Often, the curriculum consists of new technologies inserted into an outdated laboratory and content delivered through extremely traditional methodologies. Welty (2000) suggested that one can not help but question if learning the commands and procedures associated with a given computer-aided drafting system will serve students in everyday life any better than knowing the types and sizes of wood screws and nails. Welty (2000) proposed that structuring the curriculum around contemporary topics like computer-aided manufacturing, alternative energy systems, and geodesic domes has resulted in teaching content that is just as removed from the everyday lives of students as woodworking and metalworking. He went on to suggest that in contrast to filling the curriculum full of technical details, the technology education community must develop curricula that uncovers profound understandings and empowering skills that capture the essence of technology and its relationship to society. Pearson and Young (2002) seemed to support this assertion when they suggested that one of the biggest obstacles to the delivery of technology education in all classrooms in the United States is the limited amount of high-quality instructional materials and curricula available. Although a number of National Science Foundation and other federally funded curriculum development projects are currently underway, members of the profession need to make the development of standards-based curriculum a high priority.

Another limiting factor is the small number of teachers trained to teach technology education. Starkweather (1999) suggested that the technology teacher shortage was an immediate problem that needed to be addressed. Daugherty (1998) asserted, "The greatest problem facing the technology education profession in the next decade will be the acute shortage of entering technology education teachers" (p. 24). Even though the total student enrollment at higher education institutions has continued to increase over recent years to about 15 million students (Gerald & Hussar, 2001), technology teacher education enrollment has continued to dwindle (Bell, 2001). Many technology teacher education preparatory institutions have closed their programs or significantly reduced the number of graduating technology teachers. For instance, in the 2000-2001 issue of the *Industrial Teacher Education Directory,* nine institutions in the United States and its territories closed their technology teacher education programs. During the same period of time, no institution added new technology teacher programs (Bell, 2001). To add to this dilemma, many states do not have a single technology teacher education preparation program and depend on other states for all of their technology teachers (Litowitz, 1998). Between 1997-2001, Weston (1997) projected there would be 13,089 secondary school technology teacher vacancies in the United States. Meanwhile, higher education institutions in the United States prepared only about 800 technology education students in 2000 (Bell). If this trend continues, the profession will be substantially short of qualified technology education teachers in the upcoming years.

Unquestionably, the technology education profession in the United States faces a number of challenges. Primary among these challenges is a chronic public perception problem, the lack of a unified curriculum for the profession, and severe shortages of qualified technology teachers. However, there are also a number of bright stops on the horizon. With the publication of the *Standards for Technological Literacy* and the soon to be published Companion Standards, professional support for technology education in the United States is reaching new plateaus. This newfound support comes from members of the engineering community, the National Science Foundation and other governmental agencies, political leaders and members of other associated disciplines. It is imperative that members of the technology education community capitalize on this unprecedented support for technological literacy by developing the vision, insight and mechanisms needed to deliver on the promise of technological literacy for all.

Summary

We live in a world controlled by technology. In many cases, that technology makes our lives more comfortable and satisfying, however, it brings with it risks as well as benefits. Social institutions, values and cultures are forever altered as a result of this technology. One the other hand, society is the impetus for almost all new technological developments and adaptations. The relationship between technology and society is a never-ending tug-of-war with neither technology nor society leaving the game unaffected. Constant change is the ultimate outcome of this power struggle between technology and society. The resulting societal changes introduce new public demands on the educational system as education provides the mechanism to study and understand these complex relationships. In many ways, a careful understanding of the relationships between technology, society and education will help members of the technology education profession develop the vision that will ultimately shape our future in the public schools and assist us in preparing a generation of students who possess the knowledge and abilities necessary to be considered technologically literate.

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Questioning the nature of technology education within the context of social change

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Introduction

To be a useful and authentic learning area, technology education should constantly put itself in question. The more perspectives used for this process, the better the results might be. This paper explores several facets of social change that can influence an understanding of the aims and nature of technology education and that can contribute to its development. Social change is a very complex and dynamic phenomenon that can be considered from a variety of perspectives and is reflected in a number of processes. In relation to the topic of this paper the following processes will be analyzed:

- The shift of emphasis from engaging society members primarily as producers to engaging society members primarily as consumers
- The colonisation of the cognitive and moral spheres of human life by the aesthetic sphere;
- The integration of people into the technological world
- The shift from the Welfare state to the Competition state

These processes had been identified on the basis of their potential influences on the development of technology education and students who study it. The approach chosen for this study corresponds with the level of macro theories that consider social forces that shape individuals, contrary to the micro level approaches that are concerned with how individuals operate within society.

To analyze the implications of the identified processes to technology education, the question: "whether education is designed to broaden minds and develop all pupils in creation of a better society or is really about reproducing economic and social inequalities by supporting existing power structures" (Bartlett, Burton & Peim, 2001, p.166), will be used. It was chosen because it summarizes the major issue that divides different social theories in their views on the role of education in society.

A shift of emphasis from engaging society members primarily as producers to engaging society members primarily as consumers

The shift of emphasis from the older type of modern society (that engaged its members *primarily* as producers) to its present late-modern, second-modern or post-modern stage (where society engages its members - again *primarily* - in their capacity as consumers) "does make an enormous difference to virtually every aspect of society, culture and individual life" (Bauman, 1998, p.24).

Disappearance of the work ethic

In post-traditional, modern societies work was the main factor determining social placement and identity for the majority of males. Work, as the main orientation point, was a phenomenon that planned and ordered all other aspects of life. Work was a search for daily meaning and was central to an individual's sense of identity and well-being. For that type of society, the work ethic was a crucial instrument in bringing all levels of the modern arrangements (individual motives, social integration and systematic reproduction) together. The work ethic was considered as "the moral duty, mission and vocation of all members (more exactly, all its male members)" (Bauman, 1998, p.19). In that society the work ethics called people to choose a life devoted to labour. It was an instrument to force working people in the name of the ethical nobility of working life.

According to Bauman (1998) the work ethic is a mainly European invention. He argues that in America the spirit of enterprise and the desire for upward mobility lubricated the wheels of American industry rather than the work ethic.

> Work, dedicated work, and ever more dedicated work, was seen almost from the beginning by both immigrant and the American-born workers as a means rather than a value in its own right, a way of life or a vocation: the means to get richer, and so more independent; the means to get rid of the repulsive necessity to work for other. (Bauman, 1998, p. 20)

In the struggle over a greater share of the surplus, wages began playing a central role in America. Gradually this tendency has spread throughout western countries. The fact that economic benefits became the only indicator of the ambitions for autonomy and self-assertion, has had a "profound influence on the whole course of development of modern, industrial society… as it moved from a society of producers to that of consumers" (Bauman, 1998, pp. 21- 22). Work is no longer considered as 'a road to a morally superior way of life', it became a means to earn more money.

Because of that change in contemporary society the work ethic is not playing its central role in the regulation of social order. It was "slowly demoted from its function of supreme regulatory principle" (Bauman, 1998, p.37). Work has lost its privileged position. It no longer serves as the basis for self-constitution and identity-building. Boring work provides a source of material comfort, the ability to consume. According to Rifkin (1995), more than 75 percent of the labor force in industrial nations engages in work that is little more than simple repetitive tasks that do not provide any gratifying and meaningful identity for the workers.

Another characteristic of work is its non-permanent nature. Currently, a continuous, logically coherent and tightly-structured working career is no longer a widely available option. The majority of new vacancies tend to be fixed term and part-time. Thus, only in relatively rare cases can a permanent identity be defined through the job performed.

In a society of consumers, identity is constructed on a different basis. The road to self-identity and meaningful existence now resides in the market place, with the individual now charged with the task of self-construction. Two fundamental elements of a consumer culture are the use of goods for both social positioning and as a symbolic means of self-expression (Gottdiener, 2000).

> Consumerism plays a significant role in the formation and realization of the self… The concepts of lifestyle, subculture, and neotribalism all capture the varied way in which people weave consumption activities into their daily lives… Consumerism is … an essential activity relating a conception of "action" for postmodern people with spaces that articulate with the most powerful cultural influences in society – TV, advertising, movies, fashion - - coupled with that powerful social force emanating from the status hierarchy of society that works through material symbols of prestige. (Gottdiener, 2000, p.25)

In a consumer society, the consumers have a right to enjoy, not a duty to suffer. It is "a wanting society, not a waiting society" (Bauman, 1998, p. 31). Consumption is an individual activity. The more freedom of choice one has the "higher up one is placed in the social hierarchy, the more public deference and self-esteem one can count on and the closer one comes to the 'good life' ideal… The prime significance of wealth and income is in the stretching of the range of consumer choice" (Bauman, 1998, p.31).

Peoples manipulation through cultivation of their desires

All images inside the consumer society are structured by the relevance of attractiveness, pleasure-potential, interest-arousal. In this world everything is representation, images are more real than reality. It is difficult to see the difference between representation and what is represented (Bauman, 1995). Advertising objects or commodities are frequently equated with ideas or values:

> …a brand of cigarettes with virility, beer with manhood and athletic prowess, a soft drink with being young and vigorous. Equal time and equal weight can be given and are given to the trivial and the profound. In this way, too, many of the increasing services and products of the consumer-oriented society fulfil artificially created rather than genuine need. (Shore, 1985, p.38)

Within the culture of consumption the creation of people's needs and wants is one of the important business areas to develop. In order to make people 'want' things they had never previously desired, business leaders had to create 'the dissatisfied consumer', they had to 'create the wants the business seeks to satisfy' (Rifkin, 1995). Consumerism is focusing on economic and productivity goals. The cultivation of desire is used as a way of manipulating people. This process of cultivation of the dissatisfied consumer is served as a rationale for designing new products and services. Advertising creates a fantasy world that is dependant on material means for personal self-expression.

Colonisation of cognitive and moral spheres of human life by the aesthetic realm

Historically, as argued by Habermas (1981) theoretical, practical, and aesthetic spheres of cultural modernity attained autonomy from one another from the end of the eighteenth century. Since then the process of gradual separation of the aesthetic dimension from society leads to the domination of this area over the other spheres. In the aesthetically spaced world the value of truth and justice is determined by judgments of taste and the " terror of the beautiful are capable of resisting capture by the deceiving world of science and morality" (Habermas, 1982, p.25). Habermas's concern is shared by a number of thinkers (Lash, 2001, Bauman, 1995, Lyotard, 1979/1984) who consider that the cognitive and moral spheres of human life have been colonised by the aesthetic sphere. This reflects deep changes in the nature of society and the meaning of Being. Bauman (1995), for example, argues that in the current era features that belong to aesthetic space tend to submerge and colonise social space, and become the principal tools of social spacing. He makes a clear distinction between a cognitively spaced world and an aesthetically spaced world. The cognitively spaced world:

> is the play of ends-and-means relevances, of matching means against appointed ends and ends against available means. The cognitively spaced world is the yield of goal-pursuit and attendant calculation, but it is also, though secondarily, the testing ground of the limits of the capacity to act, and to act effectively. (Bauman, 1995, p.123)

The aesthetically spaced world is the mosaic of experiences, of novel experiences, and more intense experiences than before. Thus, the modern individual has found himself in the position of goods-consumer, "lived as the role of a pleasures-collector - or, more exactly, a sensations-gatherer" (Bauman, 1995, p.115). In such a world the person keeps open all possibilities and has "no fixed identity that could be threatened by disappointment, humiliation or loss" (Dreyfus, 1998, p. 116). There is no distinction between the relevant and the irrelevant, the significant and the insignificant – everything becomes equally interesting and equally boring (Dreyfus, 1998). Interesting and boring are the only qualitative distinction between these experiences.

This shift from cognition to perception increases the importance of experiences and, as argued by Lash (2001), reduces the role of epistemology in the meaning of contemporary Being. Our knowledge is obtained not through the abstraction of judgment, but through experience. We are experiencing things, through being in the life-world with them. "Through being no longer above things, but in the world with things, we come to grips, not with epistemology and appearance, but deeper ontological structures" (Lash, 2001, p. 107)

We are making sense of the world through designed objects and systems. To some extent, in this world things became the measure of the human being. People's identities are constructed through products. They are not fixed. For, example, Nike spends millions of dollars each year to create brand consciousness and desire: "A pair of Nikes represents a competitive edge, glamour, rebellion, status, and the intricacies of coolness" (Petrina, 2000, p.219). Young men's identities are linked to Nike shoes via the images the company presents. Consumers are guided now by aesthetic interests and not ethical ones, with the aesthetics of consumption now ruling over the work ethic.

> It is aesthetics, not ethics, that is deployed to integrate the society of consumers, keep it on course, and time and again salvage it from crises. If ethics accord supreme value to duty well done, aesthetics put a premium on sublime experience. (Bauman,1998, p. 31)

Opportunity to experience does not have its inner, time-extensive logic, time structure. There is no reason to postpone experience, waste of opportunity may lead to delay (Bauman, 1998). Each moment is equally good for the purpose. The existence of the aesthetically spaced world provides deep changes in the meaning of Being for the people in it. The increasing role of design in our lives is closely connected to the appearance of the aesthetically spaced world. The role of design in the current era is to create this aesthetically spaced world.

Integration of people into the technological world

In contemporary society technology has become a social phenomenon (Beck, 1997; Wajcman, 1995; Mackay, 1991; Habermas 1968/1971). Traditionally, technology has been viewed as a cause or as an independent variable with social change as the consequence. Nowadays technology, as stated by Böhme (1992) has:

> penetrated the social structure, the forms of social action and normative expectations. More to the point, technology has itself become a social structure, a form of social action and a part of the norms of action ... It is no longer a question of technology as a cause or object but a question of the technological forms of social life. (p. 39)

Through technological forms of life people are integrated into a technological world, the world where everything depends on technology. In technological forms of life, we make sense of the world through technological systems (Lash, 2001). We live in a society that is totally made by technology and for technology (Ellul, 1990). In this type of society action oriented to success, a purposive-rational action, which is either instrumental or rational, or their conjunction (Habermas, 1968/1971) is the leading factor of being in the world. Although another area of human action - action oriented to reaching understanding, a communicative action (symbolic interaction, which depends on social norms) is shrinking, there is still a distinction between society (technological society) and the technical system (Ellul, 1990, Habermas, 1968/1971). However, there is a threat to the social lifeworld from the system. The technocratic ideology 'affects the human race's emancipatory interest as such' (Habermas, 1968/1971).

In the traditional society, the stock of accumulated technically exploitable knowledge, "never reached that measure of extension after which their 'rationality' would have become an open threat to the authority of the cultural traditions that legitimate political power" (Habermas, 1968/1971, p.95) and, in the modern society, the capitalist mode of production established the economic mechanism that permanently increase the expansion of subsystems of purposive-rational action (Habermas, 1968/1971). In this environment instrumental thinking which is a dominant way of thinking in the economy-oriented society, required:

> the trivialization of the person, the subordination of the human being to process and to order. The human was no longer the measure of all things. On the contrary, things became the measure of the human being. (Shore, 1985, p.37)

Integration of people into the technological world is also occurring through an increase in the adaptive behaviour that is considered by Habermas (1968/1971) as gradually absorbing communicative action: "The culturally defined self-understanding of a social lifeworld is replaced by the self-reification of men under categories of purposive-rational action and adaptive behavior" (pp.105-106).

Adaptive behaviour closely relates to performativity, that is defined as:

> a technology, a culture and a mode of regulation, or a system of 'terror' in Lyotard's words, that employs judgements, comparisons and displays as means of control, attrition and change. The performances (of individual subjects or organisations) serve as measures of productivity or output, or displays of 'quality', or 'moments' of promotion… or inspection. They stand for, encapsulate or represent the worth, quality or value of an individual or organisation within a field of judgement. (Ball, 1999, p.1)

Productivity and commodification are the main telos of performativity "An equation between wealth, efficiency, and truth is thus established" (Lyotard, 1984, p.46). People are treated in terms of performance. Everything is subordinated to effectiveness. The principle of performativity relates to the optimising of performance by maximising outputs (benefits) and minimising inputs (costs) (Ball, 1999). Together with the rational dimension, performativity incorporates an emotional dimension. Competition between groups through ratings and rankings influence individual feelings of pride, guilt, shame and envy. Integration of people into the technological world through the principle of performativity:

> dramatically close-down the possibilities for metaphysical discourses, for relating practice to philosophical principles like social justice and equity… Again the tension and conflict between 'essence' and 'calculation' and the role of the 'players' in taking responsibility for the rules of performance points to the inauthenticity of performances and relationships. (Ball, 1999, p.8)

A shift from the Welfare state to the Competition state

The changing role of education as a social institution is the last process considered in this paper. In the West due to the processes of globalization viewed politically there is a shift from the Welfare State to the Competition State (Cerny, 1997). The 'authority' no longer follows the 'domestic' pattern of the 'welfare' state, but rather is altered along the 'market' pattern of the 'competition' state. It means that the terms of reference in the 'Competition State' have changed and it can no longer be viewed as 'an end in itself', but rather as 'means' for competition in the global market. The above changes in 'authority' require the educational system to be re-oriented, from socialisation into the national culture as a form of developing common polity, to preparation of learners to live and work in the market oriented or 'competition' state. However, the 'Competition State' seeks talent and requires new skills (human capital). This means that the goals of public school education cannot be reduced to socialisation into the national culture alone. For the first time in modern history mass education in the West is expected intentionally to educate as well as to socialise.

The wave of recent educational reform movements all over the world, is evidence of the attempts to re-configure educational systems into a 'late-modern model' (Cowen, 1996). Analyses made by a number of authors (see for example, Ball, 1994, 1997, 1998; Taylor, Rizvi, Lingard, & Henry, 1997; O'Neill, 1995; Marginson, 1993) identify the increasing colonization of educational policy by economic policy imperatives.

> The central goal of the modern system of education, socialisation into the national culture, is replaced by the determination to create new patterns of labour force formation: economic dimension of education becomes more influential than the civic. The goal of equality of educational opportunity (albeit with meritocratic elements) is replaced by conceptions of the internal efficiency of educational institutions and their external effectiveness. (Cowen, 1996, p. 161)

Contemporary education policies "tie together individual, consumer choice in education markets with rhetoric and policies aimed at furthering national economic interests" (Ball, 1998, p. 122). O'Neill (1995) identifies 'the new orthodoxy' in the relationship between politics, government and education where two of the five main elements are the following:

- Developing national economics by connecting schooling tightly to employment, productivity and trade.
- Improving student outcomes in employment-related skills and competencies.

Education is considered as playing a key role in stimulating growth and restoring economic competitiveness and a socially acceptable level of employment together with developing the individual and promoting the values of citizenship (Commission of the European Communities, 1993).

The difference between modern and late-modern models of education can be summarized as follows:

Modern educational system	Late-modern educational system
• The dominant message - equality of educational opportunity	• The dominant message - the international economy
• The strongest ideological pairing is the link between citizen formation and equality of educational opportunity	• The strongest ideological pairing is between the international economy and the effort to gear the educational system to knowledge competition
• The economic motif (selection and training for occupation) is present, but the political and civic motifs remain paramount	• The political is displaced by economic and what is abandoned is the political promises of the varieties of the social contract promised in the French, American and even the Soviet revolution (after Cowen, 1996)

The shift from the 'Welfare State' to the market oriented or 'Competition State' is accompanied by a shift in social expectations when the person socialised into the national culture is being replaced by a person able to live and work in the market oriented state. The development of competitive qualities in students is closely related to the lifelong learning that should be provided by the Learning Society. Three key versions or models of the Learning Society are the human capital, the social capital and the social control models. The human capital model, which is essentially an economic version of the Learning Society has become the dominant approach in official educational policy (Riddell, Baron and Wilson,2001).

In the Learning Society the role of schooling is closely linked to developing the problem solving capabilities of students with the emphasis on problem solving capability related to market competition. The emphasis is on performance (performativity) that means the productive seizing of opportunities offered by the market, which is placed largely at the personal level. Schooling, therefore, has changed its focus in terms of youth expectations: youth consider school to be a means to develop their personal capabilities rather than viewing it as value being shared publicly (Arnett, 1997). This leads to a claim that, for individuals in the West, it is important to remain 'emotionally detached' and 'productive' in seizing the opportunities of the market. Thus, the emphasis is largely on individuals. Seizing opportunities in the market place demands being productive or being able (ready) to re-act. In the current era, however, when social complexity is on the increase, re-active thinking can be viewed as inadequate (Morakhovski and Pavlova, 2002) and closely related to the development of the adaptive behaviour criticized above in this paper.

Implications for technology education

Major aspects of social change that have been analysed in this paper strongly influenced social institutions (such as education) and individuals. The appearance of technology education as a learning area in the curriculum of comprehensive schools internationally, is one example of the responses for social change by the educational system. Technology education as a field of study was widely recognised by the end of the 1980s although the debate on including *Technology* in school curriculum started from the 1960s. The close association between education and the economy raised technology education as an important area for discussion in many reports undertaken by educational authorities in different countries. In particular, the assumptions were made about the goals of technology education - to be relevant to the economic needs of the nation to increase global competitiveness of the state and to prepare students for work and life in society. This assumption was drawn from human capital theory in which "human beings are measured in terms of their monetary value" (Marginson, 1993, p. 31). By the end of the 1980s education coupled with market reforms became the dominant position in educational policy. Technology education was seen as a means for developing knowledge, skills, attitudes and values that allow students to maximize their flexibility and adaptability for their future employment, mainly, and to other aspects of life as well.

In the UK the former Secretary of State for Education, Kenneth Baker, announced that Technology as a subject was considered to be "of great significance for the economic well-being of this country" (cited in Barnett, 1992, p. 85). In Australia, *A*

Statement on Technology for Australian Schools explained: "Technology programs prepare students for living and working in an increasingly technological world and equip them for innovative and productive activity"(Curriculum Corporation, 1997, p. 4). In the USA it was announced that technology education was "vital to human welfare and economic prosperity" (ITEA, 1996, p.1).

The liberal perspective on education as being unrelated to economics and being fundamentally concerned with learning and personal development has changed to align with economic rationalist ideas. That is, to produce identities and positions for students that are useful for economic development. Thus, within the economic rationalist approach technology education was established to increase economic competitiveness of the state.

However, to analyze the implications of the argument above, concerning social processes and the further development of the aims and directions of technology education, the question: "whether education is designed to broaden minds and develop all pupils in a creation of a better society or is really about reproducing economic and social inequalities by supporting existing power structures" (Bartlett, Burton & Peim, 2001, p.166), will be used. This question reflects the major issue that divides different social theories in their views on the role of education in society. The argument developed is based on a critical approach to the ideology of economic rationalism and on the idea that through education it is possible to influence the development of society.

Identity formation through technology education

Individual self-esteem and a sense of purpose and meaning in the world are at stake in our society. There is concern that while vocation provides a map to guide the individual throughout life's journey, changing work practices and identity formation, obsession with growth and profit, threaten vocational possibilities, leaving individuals without an escort on their life move. Repetitive, boring work can drain the human spirit and lead to a sense of uselessness at the endless repetition of daily life. Boredom and meaninglessness cannot be solved merely by the joy of material comfort that work may provide. Educators have to recognise the social and individual consequences when reliable and meaningful work, work as a vocation is becoming increasingly rare. What can be done in terms of identity formation via technology education?

Through technology education, the ideology of consumption should be challenged by the concepts of sustainable and appropriate life style. Technology education can encourage students to think about the limitations of consumer culture, for example, ecological issues that currently became the basic issues of survival and global security. Technological development should be analyzed with all its misfortunes as well as benefits. Solving technological problems is closely related to the demand for global justice. "Why should the 'less developed' societies now embarking upon large-scale industrialization processes limit their economic growth in order to help solve problems created by the rich?" (Giddens, 1994, p. 189). What are the possibilities to limit the 'bads' as far as possible but not at the cost of the 'less developed' countries?

In the aesthetically spaced world the aesthetics of self-representation, consumption, and experiences plays an important role, however, it is not enough for a meaningful life. It is necessary to develop the cognitive, moral as well as aesthetic potential of students. In terms of the cognitive sphere, it is essential not to marginalise "both hermeneutic knowledge (or the knowledge which arises from understanding of the self and of others) and critical knowledge (which purports to question conventional thinking in all its forms)" (Hartley, 1997, p.70) in favour of instrumental knowledge. To be able to have a critical understanding of the possibilities for work and life it is necessary to question quite a few assumptions about our present mode of life. We need to go beyond the single idea that "efficiency is a good thing regardless of what it might serve and what might be its side effects in terms of human suffering" (Bauman, 1998, p. 98). Construction of knowledge guided by these principles can help students to challenge the nature of the new economy, but not to be trained in response to its demands. A reactive attitude towards change that is reflected in the concept of problem-solving does not provide the basis for addressing structural change. To accomplish this coordinated activities are required that are pro-active in nature.

Moral values should be considered on a much larger scale. Modern technology opens a lot of opportunities that should be challenged by moral values. For example, modern reproductive technologies change what used to be 'naturally given'. Now it has become the matter of human decision-making. Thus, humans have to have the capacity for wise decision-making. "Wherever what used to be settled by 'nature', whether this be the 'environment' or tradition, becomes a matter of decision-making new ethical spaces are opened up and political perplexities created" (Giddens, 1994, pp. 189-190). Ethical problems cannot be reduced to technical decisions.

Application of the concept of performativity to the field of technology education provides a framework for a critical approach to the concept of competence. Conflict between truthfulness and effectiveness, 'essence' and 'calculation' (performing criteria) is important to consider during the analysis of technological competencies and their further development. Performance on the basis of established criteria does not directly relate to the individual sense of purpose or meaning in the world. Performativity puts a lot of constrains on a variety of relationships with and between students, school and society. Developing students who are staying 'emotionally detached' and 'productive' to seize the opportunities provided by the market should not be the aim of the technology education classroom. Technology education should provide a space for students to increase their understanding related to communicative action, to the broad issues such as social justice and equity.

The work ethic needs to be replaced by an ethic that restores to the human instinct the dignity and significance of every individual human. Technology education should argue for a recognition of the significance of every human individual, irrespective of one's work arrangements or general capabilities. Make students aware that there is a wide variety of ways (including moral tradition of communitarian principles) in constructing a self-identity and meaning of life. A collection of experiences does not provide a firm basis for this. Technology educators have to develop a balanced position in approaching the concept of flexibility and adaptability, as for the majority of people the flexible labour markets "embracing one's work as a vocation carries enormous risk and is a recipe for psychological and emotional disaster" (Bauman, 1998, p.35)

In terms of the Learning Society the human capital theory should be challenged. Some theorists claim that new types of social co-ordination such as 'social capital' (Putnam, 1993) without reference to common culture can serve a more positive role. 'Social capital … refers to features of social organization, such as trust, norms and networks, that can improve the efficiency of society by facilitating coordinated actions' (Putnam, 1993, p. 167). This more positive response as the 'construction of social capital on which social coordination ultimately rests" (Dale, 2000, p. 103) can be used in the classroom environment. Although it would not provide a radical solution, it will have a positive influence on students. As argued by Morakhovski and Pavlova (2002) the overall positive co-ordination of society, within nation state boundaries in the context of the shift from the 'Welfare State' to the 'Competition State', based on the unified common culture approach, is also problematic. The idea of the positive social co-ordination was based on traditional thinking when the nation state was largely viewed as an end in itself rather than means for competition in the global market.

Understanding of design and technology in technology education

As argued above, technology has become a social phenomenon in the contemporary world in a way that is not possible to concentrate its consideration on technical aspects only. Technology is closely related to the mode of consumption, which is proliferating and expanding desire. Government policies support industries that produce prosperity and dangers equally. They make large investments in development of new hazardous technologies to protect the international competitiveness of the national business (Beck, 1994). Technology currently rules everywhere with little awareness by most people and thus, no one is really in control. Technological development is a subject of profitability. "Enterprises invest not in order to benefit humanity or to protect it from problematic side-effects, but rather to open up markets and areas of expansion with promise to the future" (Beck, 1997, p. 117). What can be done in terms of increasing critical attitudes towards Technology in technology education?

A useful approach can be drawn from a slogan "Freedom for technology!" proposed by Beck (1997). He calls for the 'new technology' for late modernity - technology of doubt that could free itself from "one-dimensionality and linearity and open itself to the … developing, elaborating and internalizing other guiding principles besides economy and effectiveness" (p.117). This will help to replace a technology of side effects with technologies that would minimize them and reduce the risks in society. This type of technology would not follow its internal logic, but replace it with the ethics and practice of the objective alternative. This would require political, ethical and public decisions. Technology, like painting, could become "pure and abstract, discovering and trying out its 'agitations of the lines', its laws of point, surface, colours, and so forth" (Beck, 1997, p. 116). For this technology and engineering science have to divest themselves of the dogmatism of instrumental rationality and open themselves to uncertainty, ambivalence and the contextuality of their designs.

For technology education classrooms these mean the involvement of students in democratic debates on the future outlines of technological development; development of their social and ecological sensitivities; avoiding orienting their solutions to the standard of business efficiency and profitability criteria only; helping them to distinguish real needs from desires; discussing the role of designed objects in the life of contemporary society; putting more emphasis on other than the aesthetic aspects of life that can provide existential meaning for people; challenging the way people are manipulated through advertising and cultivation of their desires; developing an active/creative attitude towards problems (not just a re-active approach); teaching students to formulate problems (not only being involved in problem solving); challenging consumer oriented design; looking at design as one source of inspiration, not as a source of economic utility; and developing social responsibility.

To be able to do this the whole society needs to make some radical solutions. It was Castoriadis (cited in Bauman, 1998, p. 95) who suggested that the crisis for the western world "consists precisely in the fact that it stopped putting itself in question". Bauman (1998) argues that we:

> have found ourselves on the crossroads. Crossroads call for decisions about which way to go, but the first, crucial, and not at all obvious decision to be taken is to recognize the crossroads as a crossroads - to accept that more than one way leads from here into the future, and that sometimes pursuing the future - any future - may require sharp turns. (Bauman (1998, p. 97)

Conclusions

In this paper I have raised a number of issues associated with social change and how these issues can be addressed by technology education. Four major processes that represent the different aspects of social change that have been identified in this paper as closely related to the nature of technology education are:

- The shift of emphasis from engaging society members primarily as producers to engaging society members primarily as consumers
- The colonisation of cognitive and moral spheres of human life by the aesthetic sphere;
- The integration of people into the technological world
- The shift from the Welfare state to the Competition state

There are a variety of different views on the structure and functions of society and their relationship to education. In this paper the position that education is primarily concern with learning and personal development and that it can influence social structure, institutions and practices, is adopted.

Technology education is considered as a learning area that can incorporate a range of important issues extracted from the analysis of social change and can provide a rich environment for understanding Technology in society and the development of students' identities. Technology education has to teach students to challenge the new economy, not only to adjust to its demands.

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Chapter Three

Undergraduate Technology Teacher Education Programs

Australian Technology Teacher Education Programs: Their Structure and Marketing

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An Elusive Vision for Undergraduate Technology Teacher Education in the United States

Undergraduate Technology Teacher Education in the United States

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Their Structure and Marketing

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Introduction

This paper addresses a number of key issues in relation to Technology teacher education. It commences with an analysis of current trends in program provision within Australia both for the secondary and primary/elementary levels. Discussion follows regarding the elements of exemplary Technology teacher education programs and the manner in which these differ from other disciplines. Factors that encourage student participation in Technology teacher education are then discussed in the context of market research and the resultant successful practice undertaken at Griffith University as a guide to strategies that may be employed in other institutions.

Trends in Australian Technology Teacher Education

The trend in Australian Technology teacher education over the past two decades has seen the demise of fully integrated four-year undergraduate programs in favour of alternative options. Williams (2002) points out that a number of institutions have opted for a post-graduate model where an initial degree is undertaken prior to a Bachelor of Education. In some cases a trade qualification is being accepted while design degrees or technology degrees are accepted in others. The nature of the technology degree is in some cases problematic as any degree with technology in the title is at times accepted. Williams highlighted the difficulties of identifying a "relevant" initial degree in view of the fact that "quality in teacher education is dependent on a research based, practical study of a range of industries and technologies and a critical approach to the social and environmental contexts of technology, not a study of a narrow range of specific vocations (Williams 2002, p. 6)". In addition to the conventional Bachelor degree programs a number of retraining programs have arisen.

The existing retraining programs may be divided into two categories. Some attempts have been made, particularly in NSW to attract existing teachers into technology education through the provision of Graduate Certificate programs whereby qualified teachers were provided with 6 months full-time training followed by a 6 month mentoring program (Gibson & Barlow, 2000). Four such programs were run between 1996 and 1999. The second type of retraining program has arisen mainly through the political imperative of retraining workers made redundant through industry closure. This lead to the federal Department of Education and Training and Youth Affairs (DETYA) negotiating with the University of Newcastle for a program to retrain BHP workers made redundant through the closure of the Newcastle steel mill. The scheme provides credit for prior learning and an 18 month teacher education program which includes a 6 month internship. Since its inception in 1997 the scheme has been expanded to encompass redundant workers from the Port Kembla Broken Hill Proprietary Ltd facility through the University of Wollongong as well as other retrainees from trade backgrounds in both Sydney and Wagga Wagga. This program has continued in four centers throughout NSW with a total of 146 students due to graduate at the end of 2002 (Thompson, 2002). The advent of short retraining programs has the potential to affect the status of Technology Education within the teaching profession and the community as few, if any, other disciplines are having teachers trained in such short programs. The Technology Educators will need to monitor this trend carefully if they are to maintain their position within the teaching profession and not regress to the lower status of the past that they fought so hard to overcome.

Primary or Elementary Technology Teacher Education

Data relating to the provision of technology education courses within primary or elementary teacher education within Australia 1999-2000 provided by Williams (2002) found that only seven universities included it as a core study. A review of current course offerings in 39 universities indicates that in the 33 Primary education degrees all but 9 offered courses in technology as a compulsory part of their program. Of those offering courses 18 offered one course and six two courses. While this appears to be a dramatic improvement the figures need to be treated with caution. Investigation of the content of the technology course offerings found that technology was interpreted quite differently across the institutions. Two courses were restricted to Information Technology, 13 were designated as Science and Technology, one Science Technology and Society, one Technology and the Arts, one Science Technology and Numeracy and 11 referred specifically to the Technology Key Learning Area (KLA). The Technology KLA was however specifically referred to in 10 of the Science and Technology course outlines. Overall it would appear therefore that 33% of primary education degrees now have at least one course devoted specifically to the Technology KLA while a further 30% have at least a part of a course devoted to the Technology KLA. This represents a major shift in this area of teacher preparation over the past two years.

Program Changes

Data relating to a surge in enrolments, an influx of funds for program improvements, modernization of instructional laboratories, and expansion of program offerings is somewhat difficult to interpret. Surges in enrolments in programs over the past four years have been evident. In the main this seems to have occurred with the introduction of new programs whereas established programs have fluctuated with, for example the Australian Catholic University almost doubling its intake, Griffith University maintaining its high intake levels while the University of Sydney has closed its program. While some new programs have arisen as a result of pressure on universities from the profession and employing bodies, particularly in Victoria, others have been the result of government imperatives to prevent unemployment as a result of industry downturn. New programs have arisen in the main utilising existing facilities either within the Technical and Further Education (TAFE) sector or through the use of school based facilities. Gibson and Barlow (2000) suggest that this is a result of budgetary constraints rather than concern for curriculum delivery and caution the use of the TAFE sector for technology teacher education due to the "potential for a clash of technology teaching philosophies. TAFE teaching strategies are largely focussed on competency based learning which to some degree might conflict with the problem solving philosophy underpinning secondary school subjects such as design and technology (p. 14). Overall it would therefore be difficult to establish that there has been a real influx of funds for either the modernisation of laboratories or the expansion of program offerings. In fact, the reduction in funding to universities over the past eight years has been in the order of 26% and has meant that very little funding has been available for anything other than academic salaries. As a direct result staff student ratios in Australian universities have risen from 12.9:1 in 1990 to 18.8:1 in 2000 a fact that has major implications for Technology Education programs where laboratory based instruction necessitates small group sizes but academic teaching loads are calculated on the basis of overall student numbers taught.

Attributes of a Technology Teacher Education Graduate

In 1998 the Australian Council of Deans of Education (ACDE) published a report of the National Standards and Guidelines for Initial Teacher Education project. They suggest that graduates should possess a range of attributes including:

- "an appreciation of entering a profession of rich complexity, which is of profound value to society, and which carries great responsibility, challenge and satisfaction.
- understanding and commitment to maintain the highest professional and ethical standards.

- a coherent sense of themselves as professionals who ……… should be able to make judgements about their competence in particular circumstances, and know when and how to seek assistance.
- be committed to, and capable of, lifelong learning.
- be able to communicate effectively and appropriately to the range of audiences (students, colleagues, school administrators, parents, and others) and in the range of circumstances expected of a beginning teacher.
- have an active sense of themselves as part of the education research community. They should be practitioner-researchers for whom research is a normal part of teaching practice. They should be explicit and analytic about their practice. They should have the capacity to access, evaluate and incorporate research findings into their work.
- should have developed their individual talents and interests as they relate to teaching - fostered their critical and reflective capacities, aesthetic sensibilities, and creative and physical skills."

In relation to content studies ACDE maintain that graduates should have;

- "a broad general education as a framework for critically developing their understanding of their subject/learning areas, for developing understanding and capability in new areas, and for providing a basis for responding effectively to a range of issues which will arise in their professional work.
- understanding, at a level appropriate to higher education, of the areas they are prepared to teach: those areas' historical development, central concepts and language; relevant content knowledge, capabilities and appreciations; structures and characteristic modes of inquiry.
- the deep understanding of content and pedagogy which enables them to transform (organise, adapt, present) content in ways which are powerfully responsive to the particular characteristics of learners, curricula and teaching environments. They need to have such 'pedagogical content knowledge' thoroughly integrated with their other knowledge and capabilities."

Few would argue that all teachers need to possess these attributes, particularly those relating to the ability to be analytical or reflective about their practice, which is a common theme in teacher education. However, do these general attributes vary in relation to technology teachers? Banks and Barlex (2001) point out that whereas teachers of other disciplines come to the task of teaching with a vision of how they were taught and are therefore able to initially model their teaching on that memory, the short curriculum history of technology means that this memory is often not available. The teacher education of technology teachers is therefore faced with the challenge of creating a framework of practice within which graduates are able to operate. This includes subject content knowledge about technology, pedagogical knowledge and school subject knowledge about how to teach specific content. Furthermore Hansen (1993) proposes that technology teacher education programs should include the following aims; the development of reflective practice, the development of an understanding of the curriculum development process, the ability to link critical thinking, independent learning and other higher order learning outcomes to the classroom experience of undergraduates and the development in student teachers of a 'context' or philosophy for technology education. Burke (1999) supports these with the addition of abilities related to understanding technological systems, making ethical decisions about the use of technology, using practical based resources in teaching technology, and an understanding of technology-based careers.

Changes in curricula are particularly relevant to the technology educator at this time with the advent of new syllabi in the Technology key learning area. Changes in curriculum such as those occurring in the technology education field often require changes in the roles and relationships of teachers with the introduction of new teaching and learning methods. The new proposals generally advocate a change in pedagogy that will affect lesson organisation through the use of a design or problem solving approach and may necessitate a change in the individual role of the teacher as they move from a director to a facilitator of learning. Changes or increased role interaction with other teachers may also result from the introduction of team teaching, teaching across traditional subject boundaries, or increased subject integration. Familiarity with these pedagogical shifts therefore needs to be a key component of Technology teacher education programs. One contemporary change in technology education curriculum delivery is the shift to an outcomes or standards base. Recent research by the Technology Education Research Centre of Griffith University has identified this as a major area of concern for existing teachers, even recent graduates, suggesting that this needs to be a specific focus in future Technology teacher education programs. This will be of major importance if teachers are to gain an understanding of the process by which outcomes are interpreted and converted into work programs and valid student assessment planned and undertaken.

Wash, Lovedahl and Paige (1999) highlight the necessity of technology teachers to be receptive to change through their observation that there has been more change in the last two decades than in the entire history of the profession. Their research into receptivity to change among traditionally and alternatively certified technology found no significant differences, however they maintain that alternative certification in the USA usually involved rigorous candidature screening, a requirement for ongoing professional development and an initial degree of teaching qualification. This is unlike the Australia experience whereby retraining programs are often for ex-tradespersons who were found by Chester (1994) to be significantly less innovative than their colleagues. Further research into this area is therefore needed in order to identify the potential implications of the current trend in technology teacher education in Australia on the future of the profession.

Welty (1999) adds to the list of potential problems facing technology teacher education by pointing out that "it is becoming increasingly difficult to believe that preservice education programs can prepare a new generation of technology teachers who have mastery of a knowledge base that is expanding at an exponential rate" (p. 1). He goes on further to make the point that many administrators see the employment of technology education graduates as means of upgrading the existing program within their particular school. This is not a problem unique to America as there is a similar trend within Australia placing additional pressure on teacher educators to not only produce good teachers but innovative leaders as well.

It would appear therefore that while exemplary technology teacher education in Australia has much in common with other education disciplines there are a number of specific characteristics that need to be addressed. These include the need to understand and make ethical decisions about technological systems, and the ability to use practical based resources (Burke, 1999), the difficulties associated with an exponentially growing content base (Welty, 1999), the lack of an historical framework of practice (Banks and Barlex, 2001) and high receptivity to change (Wash et al, 1999). In addition there is the need to generate an understanding of outcomes based curricula. These factors, when combined, tend to point towards the need for the focus of undergraduate technology teacher education programs be on breadth and innovative practise rather than depth of curricular offerings.

Encouraging students into Technology Teacher Education

In trying to identify the factors that encourage students to enrol in an undergraduate technology teacher education program it is evident that little research has been undertaken in the Australian context. A longitudinal study currently underway at Griffith University does, however, provide some insight. The project commenced in 1998 and involves surveying all year one students at the commencement of their studies. It builds upon the 1995 initiative of the Faculty of Education that undertook a market research exercise using an external consulting company Market Facts. That report highlighted the following factors that needed to be included in any marketing/recruitment strategy;

- Highlight program strengths and uniqueness.
- Highlight the community and professional input into the course design.
- Include employment opportunities, range and success.
- Include staff qualifications, research, and their national profile.
- Tertiary entry score must be included. A high proportion of students make career choices on the basis of the programs they think they can get into.
- The need for a contact number for further information.
- Investigate the possibility of using the Internet as an information source.
- Include commencement and ongoing salary scales.
- Include pre-requisite subjects.

The market research also strongly suggested the use of alternative presentation methods for information as students are now very visually oriented. For example interactive computer programs or video might be worthwhile investigating. The Market

Facts report also included suggestions for an effective marketing program. It highlighted;

- The need for accurate information for students.
- Development a distribution process - Networking!
- Identification of the 200 key people who "needed to know".
- Investigation to find out whether these people visit Griffith?
- A plan to work out how to reach them?
- Deciding how much time academic staff were prepared to spend?

As an outcome of this research a specific marketing/recruitment strategy was developed for the Bachelor of Technology Education. The current research has helped to identify how students became aware of the Bachelor of Technology Education and the factors that lead to their choice of this degree. It supports the general findings of the Faculty-wide research indicating that the factors involved in the decision to undertake general teacher education and Technology Education are similar. Tables 1 & 2 present the data from this study in terms of both response percentages and rankings.

Table 1

How did you find out about the Bachelor of Technology Education Course?

	1998		1999		2000		2001		2002	
	%	R	%	R	%	R	%	R	%	R
Friends	8	5	15	3	19	3	32	3	23	3
Teachers	44	1	46	2	25	2	47	1	28	2
Parents	0	9	6	6	11	5	6	8	8	7
QTAC Guide	44	1	58	1	55	1	41	2	53	1
Tertiary Expo	3	6	4	7	4	9	5	11	8	7
University open day	10	4	7	5	7	8	11	5	10	5
Promotional video	3	6	1	9	0	13	1	13	0	12
Course brochure	3	6	3	8	9	6	6	8	8	7
School guidance officer	18	3	13	4	9	6	6	8	5	10
Direct Contact					13	4	8	7	10	5
Previous Student					2	11	21	4	5	10
Web					2	11	10	6	13	4
Other relatives					4	9	2	12	0	12

Of particular interest from Table 1 is the fact that teachers are consistently one of the major sources of information for students. It is for this reason that all correspondence has been directed to the technology teachers within the schools and not the guidance officers. The other major source of information is the tertiary entrance guide booklet (QTAC Guide). It appears that in many cases students make choices on the basis of the entrance score they achieve and therefore use the guide to find out what programs they can get into. The other factor of interest is the increase in the use of the internet as an information source. This supports the 1995 recommendation to investigate this as a potential information source.

Table 2

What were the factors that lead to your choice?

	1998		1999		2000		2001		2002	
	%	R	%	R	%	R	%	R	%	R
Had the necessary entry score	23	8	17	7	21	8	21	8	18	7
Good job prospects	82	1	74	1	76	1	79	1	75	1
Secure future	64	2	53	3	66	3	77	2	63	2
Opportunity to work with students	36	6	5	9	48	5	56	4	48	4
I liked this subject at school	64	2	72	2	73	2	61	3	55	3
Good working conditions	44	5	32	4	38	6	47	5	20	6
Looking for a change of career	46	4	29	6	54	4	46	6	42	5
Didn't know what else to do	5	9	6	8	4	9	10	9	2	9
Good salary	28	7	33	5	30	7	39	7	13	8

The factors leading to the choice of Technology teaching as a career strongly support the need to highlight job prospects and future security in any marketing/recruitment program. In addition it supports the strategy of directing marketing materials towards the teachers of technology who have a significant role in the student decision to follow this particular career path.

The research undertaken at Griffith University has enabled both the initial development and later refinement of the marketing of the Bachelor of Technology Education over a period of seven years which has resulted in higher student numbers, increased student quotas and the attraction of higher quality candidates to the program. This process has proceeded through a number of stages. The first stage was the development of a new program brochure. This included all of the information suggested by the initial Faculty market research. Academic staff then undertook personal visits to over 80 school guidance officers throughout the state, addressed teachers at professional development courses, attended school careers night, and addressed groups of students during which time the new program brochures were distributed. Following this process a mail out of brochures was undertaken to guidance officers in every Queensland school.

How effective was the strategy?

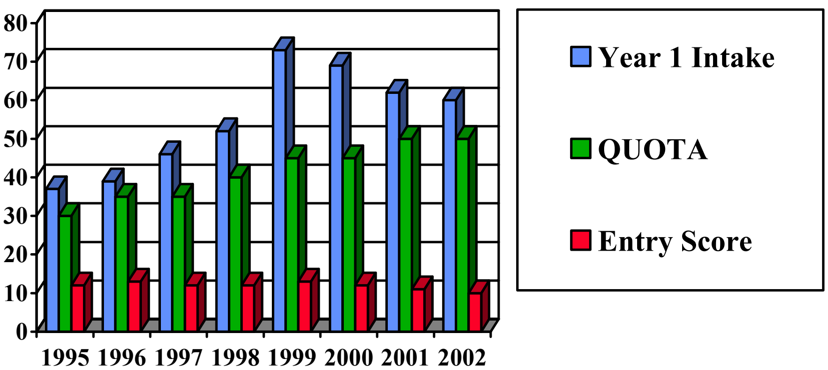

Figure 1.

Figure 1 displays a number of interesting trends. Firstly there was an increase in student intake progressively to a peak in 1999 after which there has been a slight decline. The decline however has been as a result of political factors within the university. As may be seen from the graph the difference between allocated places and intake increase dramatically up until 1999 after which there has been a closer match. The university is funded on allocated places and not actual enrolments thus numbers in addition to quota remain unfunded. Following 1999 the ratio of placement offers to allocated places has been reduced by the university in order to reduce the number of unfunded positions within the degree. However, it needs also to be noted that the quota has been steadily increasing over the whole period in recognition of the demand for places. Of interest also is the fact that while numbers have increased the entry score has changed also with students needing progressively better school results and/or prior qualifications in order to gain entry.

As a part of the ongoing marketing/recruitment strategy the Technology Education faculty now have a policy to accept all invites to talk about Technology Education at Griffith regardless of the location or the size of the audience. In addition a professional upgrade program was developed for existing teachers to gain degree status. This had the effect of meeting a market niche and also providing a forum for teachers to learn about the new degree. Of equal significance is the development of an alternative entry pathway for students who do not, for a variety of reasons, meet the normal entry requirements. These students may now undertake a one year Certificate in Technology Education. This program runs on a fee for service basis but uses four of the eight first year courses from within the degree. In this way the small numbers involved join existing classes thus only marginally increasing staff workload. At the end of the program success at the tertiary level elevates the student entry score to a point well above that required for entry the following year at which time students are given full credit for the four courses they have already completed. A number of very able students have entered the program via this process.

In line with the initial need a number of other marketing related strategies have been developed. The development of CDs of student work and the Presentation Night represent attempts to provide information visually and have proved particularly successful. These two activities relate to the Design and Technology Project students complete in the final semester of their program. During this time they work directly with a client to produce a product for which there is a particular need. These range from teaching aids for schools to aids for the handicapped and industry related products to improve production capacity. The CD was used to highlight the research testing and planning undertaken in the process of meeting the need and has now been replaced by similar Web-based materials. The Presentation Night, hosted by the Dean of Education, provides a public forum where key members of the university, state and private education and the community are invited to see presentations and static displays of the student work. The Presentation Night provides the opportunity to not only showcase the students' work but educate the invited guests regarding the nature of Technology Education. Since its inception there has been a noticeable increase in support for the program from within the university. In addition Griffith University has an ongoing process of Web site development that helps to inform our potential clientele of all of those pieces of information originally identified by the market research. New hard copy marketing materials are now directly related to the Web site.

Conclusion

Technology teacher education continues to face a number of significant issues for the future. The expansion of primary/elementary technology education course offerings provides a unique opportunity to increase the status and influence of the discipline and should be seen as a positive development. Teacher shortages and in particular the manner in which they are addressed provides a major challenge. Equally challenging is the nature of technology teacher education programs. The specific needs of the discipline outlined in this paper may provide a guide for future program developments and existing program evaluation. Having an exemplary program however means little if student recruitment is ineffective. The outcomes of the research outlined in this paper may provide a guide to future practice in this area.

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An Elusive Vision for Undergraduate Technology Teacher Education in the United States

Undergraduate Technology Teacher Education in the United States

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Introduction

Over the last twenty years the recommended curriculum for the study of technology in the United States has evolved dramatically in response to the emphasis on teaching design, the development of content standards, and recent insights into the teaching and learning process. In light of these advancements, technology teacher educators are being challenged to evaluate their technical curricula, to look beyond traditions in teacher education, to reflect on the nature of knowledge, and to update both technical and professional courses for undergraduate technology teacher education. This call for change is being spurred on by new paradigms for program accreditation and teacher licensure that focus on the outcomes of pre-service teacher education programs in contrast to their curricular composition.

The professional literature is teeming with recommendations for improving teacher education. The convergence of new standards, research, and policies have thrust many technology teacher education programs into a state of flux. Therefore, the following narrative will focus on a vision for an exemplary technology education program in contrast to looking at the conventions that have guided undergraduate teacher education programs for years. In contrast to reporting the literature on teacher education reform, this paper outlines some of the author's thoughts about restructuring and improving an undergraduate teacher education program. It will stress the importance of focusing on mission, scaffolding the study of technology, modeling best practices, and attending to the diverse needs of students.

Searching for Direction in a Fog

Given the changing nature of technology education, it is not unusual for teacher educators in the United States to be asked to be all things to all people all of the time. For example, classroom teachers and building administrators often ask technology teacher education programs to maintain or reinstate classes like woodworking and metalworking that they sincerely believe will enable new teachers to address the needs of students who have limited academic success. Similarly, business and industry representatives often lobby for classes like automobile servicing, building trades, and welding to help schools respond to their local labor market needs. Technical and community colleges often pressure teacher educators to offer courses that prepare the next generation of teachers to introduce high school students to specific career offerings at the post-secondary level. Lastly, technology teacher educators often need to negotiate the content in technical courses that are also serving the needs of industrial technology or industrial management majors. In response to diverse input and mounting political pressure both on and off campus, it is easy for teacher education programs to try to do too much for too many, and in the process, not really address the needs of any one group effectively.

Teaching Less Better

One of the important realizations that inspired the development of standards was the observation that teachers are being asked to cover an overwhelming amalgamation of facts, concepts, and skills at the expense of facilitating genuine understanding (AAAS, 1993). In contrast to trying to be attentive to special interests, especially those with antiquated or unduly specific demands, teacher education programs need to embrace a finely tuned mission. Instead of trying to cover all the content that life and work have to offer, teacher educators have to focus their energy and resources on teaching the essential concepts and skills that will enable the next generation of technology teachers to provide their students with a sound intellectual foundation for life-long learning.

The simple proposition that "less is more" can be used to guide the identification and development of the knowledge base for technology teacher education (AAAS, 1993, p. 320). Under this principle, the knowledge base would emphasize the essential concepts and intellectual tools necessary for building new understandings and skills throughout one's teaching career, without concentrating on unnecessary details. Developing and implementing coursework that is designed to target the concepts and skills that capture the essence of technology and apply to a wide range of technologies would be intrinsically attentive to the diverse groups that have a stake in the way technology education is taught in our public schools.

A variety of leaders and organizations have studied the basic skills required to participate in society as informed citizens and to gain meaningful employment in the world of work. The same themes have appeared year after year in these studies. For example, the United States Department of Labor (1991) challenged educators to prepare future citizens and employees who understand systems, can monitor and adjust the performance of systems, and improve or design systems. The American Association for the Advancement of Science (1993) took the concept of systems one step further by stating that all students, by the end of 8th grade, should know the following.

> Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole. (p. 265)

Similarly, the International Technology Education Association (2000) forwarded the proposition that, upon completion of 8th grade, students should understand "technological systems include inputs, processes, output, and, at times, feedback;" "systems thinking involves considering how every part relates to others;" and "technological systems can be connected to one another" (p. 38-39). Lastly, the National Academy of Engineers recommended all students should understand basic technological concepts like systems; more specifically, "components working together to provide a desired function" (Pearson & Young, 2002, p. 17).

Being committed to everything is not being committed to anything at all. The exemplary technology teacher education program needs to have a clearly defined mission. Once defined, that mission can be used to filter and prioritize the demands being placed on the program by diverse stakeholders. A review of the professional literature will uncover strong support for preparing teachers that can address, above all else, the technological literacy needs of young people in preparation for common life in a technologically sophisticated society. The development of standards has provided teacher educators with powerful sets of tools for focusing their work and preparing teachers that can address the technological literacy needs of young people.

Teaching Beads and Threads

The standards for technology education target a wide range of concepts that are subtly sophisticated (e.g., systems, tradeoffs, social control, risk). Teachers undergoing in-service training on implementing the standards have shown an initial inclination to develop specific lessons that target specific standards. Although this practice is a logical first step in addressing the standards, it falls short of tapping the full potential of the standards. Furthermore, it does not capitalize on the potential of the standards to facilitate genuine technology literacy.

Most of the standards, especially those recommended by the American Association for the Advancement of Science (1993), are essentially abstract generalizations about technology. As such, they are profound ideas that can be applied to a wide range of technologies. More importantly, these generalizations can be leveraged to understand a wide range of technologies, many of which will not be a formal part of the student's education. Therefore, the challenge facing teacher educators is to help teachers integrate the standards throughout their instruction. The ultimate goal is to provide students with multiple exposures to the profound ideas embedded in the standards across a variety of contexts. It is often useful to think about the standards as threads that run through a series of beads. The beads in this analogy are salient topics that provide meaningful contexts that illuminate the concepts embedded in one or more standards. For example, the concept of systems becomes a constant and repetitive theme, or thread, that students would encounter in the context of manufacturing, construction, communications, information processing, energy utilization, and transportation.

The purpose of this repetitive treatment of the concept of systems in diverse contexts is to encourage students to begin formulating generalizations about the nature of systems. Building valid generalizations about systems would provide students with a mental framework for analyzing systems in the future. The framework developed in one context would become part of the student's repertoire of knowledge for understanding the next context. Ultimately, the student would possess a coherent pattern of ideas about technological systems that can be used to understand the technology systems he or she will encounter in adult life.

Preparing Renaissance Technophiles

A review of technology teacher education programs in the United States will uncover a relatively flat collection of technical classes that provide students with a fairly comprehensive treatment of technology. Most of these programs tend to provide their students one or more courses in the study of materials and processes, design, manufacturing, communication, construction, transportation, and energy utilization. Due to the compartmentalization of knowledge across discrete topics, this pattern of coursework lacks the scaffolding needed to construct profound understandings about technology.

A more dynamic model would stratify technical coursework into at least four levels. The sequence would be designed to reflect a progression from concrete and fundamental details about technology to more abstract and encompassing understandings about the nature of technology. In addition to providing a framework for the technical core, stratifying technical courses across four articulated levels would enable faculty and students alike to leverage the understandings mastered at one level to study the salient concepts and skills at the next level.

Fundamental Elements of Technology

To better prepare pre-service teachers and to address the standards for the study of technology, teacher education programs need to include more courses that are designed specifically to empower aspiring teachers to teach a wide range of generalizable concepts and skills. One way to initiate the construction of knowledge is to begin with the basic building blocks of technology. Most technologies are essential collections of elements that work together to fulfill a purpose. More specifically, many technologies are essentially configurations of materials, structures, mechanisms, electronics, and fluidic systems. Furthermore, these configurations are the result of a pattern of thinking that we like to call design. Without a rich understanding of the way these building blocks work, the design process is limited to relatively uninformed series of trials and errors. Thus, when a viable solution emerges, it is often a by-product of perseverance more than it is the result of informed thought processes. Therefore, to establish an intellectual foundation for the study of technology, aspiring technology teachers need to master the fundamentals of materials, structures, mechanisms, electronics, and fluidic systems very early in their college education.

Technological Systems and Endeavors

The study of technology contains a wide range of intriguing stories about how the technological world works. These stories range from how raw materials are processed into useful products to the series of connections that are made across the globe when one dials a telephone. Young people preparing for life in a world inundated with technology need to study these stories to unravel the mysteries of technology and make sense of the human-made world. Without a fundamental understanding of our technological infrastructure, the technology that permeates and sustains society is an elusive and magical phenomenon that is easily taken for granted. Fortunately, a thoughtful and enlightened technology teacher can translate even the most sophisticated technologies into a simple series of ideas, actions, outcomes, and consequences that most young people can understand.

To prepare technologically literate citizens, technology teachers need to be competent storytellers who can engage young minds in the ways technological organizations, systems, and devices work. Therefore, aspiring technology teachers need to study and experience the salient stories related to the production of industrial and consumer products within a facility; the erection of structures, buildings, and pathways on the landscape; the movement of people and goods from one location to another; the processing of data and the exchange of information between people; and the conversion, distribution, and utilization of energy resources.

Technological Innovation and Design

The third level of coursework would target the thought process and skills associated with problem solving, design, and engineering. The study of design can play two roles in the preparation of technology teachers. One role would be to address standards related to the design process and the nature of technology. The central focus would be to introduce students to design as an important human activity and to help students develop their design capability. More specifically, one or more courses would be implemented to develop their ability to analyze problems, gather information, visualize ideas, work cooperatively in groups, engage in brainstorming activities, evaluate ideas based on criteria, build models, and evaluate prototypes.

In addition to using the design process to engage students in first-hand problem solving activities, aspiring teachers would study the designs of others (e.g., Sydney Opera House, Brooklyn Bridge, Boeing 777). Examining the designs of others can help our future teachers understand and appreciate the role of design in our culture. The insights gained by looking at design from a different perspective can enrich the students' knowledge base for doing design. Inversely, doing design can provide students a framework for studying the designs of others.

Another role design should play in the preparation of future teachers is to uncover how design can be used as a pedagogical strategy to address other standards. The thought processes required to design a working device are parallel to those required to learning something new (Kimbell, Stables, Wheeler, Wosniak, & Kelly, 1991). Engaging in design intrinsically requires students to think deeply about the problem that they need to solve. They must tap existing knowledge to begin formulating potential solutions to the problem, and then seek answers to the questions that emerge during the design process. Furthermore, as designers, students must use their new knowledge to develop their ideas into products or processes that can be tested. The results of the testing process validate the knowledge that the students used to solve the problem and inspire the need to refine or revise one's thinking even further. In short, design activities require students to activate prior knowledge, seek new knowledge, integrate new knowledge with existing knowledge, use new knowledge in conjunction with existing knowledge, and reflect upon their learning experience.

Foundations of Technology

To serve the technological literacy needs of young people, aspiring technology teachers also need to synthesize across content areas and discover the interrelationships among the technological concepts introduced in their course work. Unfortunately, the technical core in many programs places the burden of synthesis upon the student. Strategies need to be created to help students develop a broad understanding of technology and attain a sense of closure prior to student teaching. Therefore, this author would like to endorse the popular notion that the technical core should culminate in a seminar that addresses the Foundations of Technology. More specifically, the aspiring technology teachers will engage in the reflective study of the nature of technology as outlined in the national standards (AAAS, 1993; ITEA, 2000; Pearson & Young, 2002). Major topics would include the history of technology, its relationship with society, and its impact on the environment.

Talking the Talk and Walking the Walk

One of the classic axioms about teacher education that seems to have stood the test of time is the notion that teachers teach the way they were taught. Similarly, technology teacher educators are often criticized for talking the talk, but not walking the walk. If the study of technology in technology teacher education programs falls short of the goals outlined for the profession, one should not be surprised if the next generation of technology teachers implements incomplete, superficial, and fragmented curricula in the public schools. Similarly, if those teaching professional and technical classes utilize simplistic teaching techniques, one should not be surprised if graduates utilize the same modest methods to cover their content in public school classrooms and laboratories. Therefore, it is essential that technology teacher education programs model the content and pedagogical techniques that it wants its graduates to be able to emulate in public school classrooms.

Facilitating Journeys with Destinations

A common practice in technology education is to engage students in rich activities that are grounded in time-honored practices. Collegial discussions about the nature of the teaching and learning process often incite testimonials about the merits of hands-on activities, solving real-world problems, learning how to work in a team, and developing creative thinking skills. Unfortunately, specific details about what the pre-service teacher will know and be able to do as a direct result of instruction are extremely rare. Without a clear sense of direction, a technology teacher program can be dominated by adventures in technology education.

For the purposes of this discussion, adventures in technology education are exciting trips into the unknown without any specific expectations other than having a rich and engaging experience. For a learning activity to be a genuine adventure, it needs to be relatively open-ended in order to provide students the greatest latitude for discovering something new and unexpected. Burdening the activity with specific concepts and skills in the interest of achieving predetermined outcomes adds a formality to the experience that many practitioners believe tempers the quality of the adventure.

Teachers employing this popular approach to the study of technology strive to engage their students in activities that conventional wisdom suggests will be meaningful in the lives of students. Due to the richness of these learning activities, it is easy for teachers and observers alike to believe that the students will take something valuable away from these experiences. For some, the potential for students to have a new and enjoyable experience is more than enough justification for the time, energy, and resources needed to implement these activities. For others, a more tangible outcome is the students' ability to replicate the experience if a need should arise. Lastly, others defend these learning activities by sharing anecdotes and critical incidents that suggest these experiences had positive effects on students in the past. In the final analysis, determining the merits of this approach is dependant on hindsight.

An alternative, and potentially more efficient approach would be to initiate both classroom practice and scholarly inquiry with important concepts and skills that both scholars and teachers alike have endorsed as an integral part of becoming technologically literate. Fortunately, several initiatives have provided the profession with standards for the study of technology (AAAS, 1983; ITEA, 2000; National Research Council, 1996). Although they are not perfect, these standards do provide teacher educators as well as classroom practitioners an operational taxonomy of desirable outcomes (or destinations) for the study of technology.

In contrast to conducting adventures in technology, the need to address standards and facilitate student learning suggests engaging students in journeys might be a more appropriate symbolism. For the purposes of this discussion, a journey is an informed trip that is designed to reach a specific and predetermined destination. Unlike an adventure, a journey is a trek with a specific destination in mind. The destination in this analogy is a valuable piece of new knowledge that is thought to be essential to technological literacy. This new knowledge could be in the form of a profound understanding or an essential capability. The purpose of the journey is to engage students in activities that encourage and support the construction of new knowledge in ways that are personally meaningful to the student. Therefore, the emphasis in this paradigm is on how students learn technology instead of how teachers teach technology.

Modeling the Art and Science of Teaching and Learning

When faced with perplexing questions about how we should educate the next generation, it is both natural and appropriate for us all to reflect back on the teachers who had the greatest impact on our understanding of the world and our ability to solve problems. At some point in our education, we have all had at least one special teacher that stands out from all the others. For most of us, these teachers occupy a unique place in our hearts because it was in their classrooms that we experienced the intrinsic joy and satisfaction of mastering important ideas and developing powerful ways of thinking. While most of our teachers asked us to simply absorb large bodies of knowledge in anticipation of the inevitable test and subsequent grade, our real heroes shaped our thinking by focusing on ideas that transcended the minutiae that dominated public school experience. These teachers made a profound difference in our lives because they possessed a special kind of wisdom about the nature of knowledge and learning and they provided us with insights that have served us well in adult life.

Most of the understandings outlined in national standards cannot be transferred from teachers to students by language alone (Donovan, Bransford, & Pellegrino, 1999). For example, asking students to read fundamental truths about systems, to discuss them in class, to commit them to memory, and to reproduce them on a test will not result in genuine understanding. For genuine learning to occur, students have to attach personal meaning to the language of systems by engaging in worthwhile experiences with systems.

Human beings have a built-in aversion to disorderly thinking. When we encounter new ideas we try to find something about them that is familiar and fits into our way of thinking. Once a connection is made between old knowledge and new knowledge the anxiety associated with learning is reduced, the ambiguity of the new ideas is lessened, and the process of making sense of new ideas begins. The learning process continues with the formulation of tentative thoughts about new ideas and efforts to test them out in situations that we find meaningful and relevant to our lives (Brooks & Brooks, 1993; Donovan, Bransford, & Pellegrino, 1999). If we have positive experiences with our newly formed understanding it becomes an integral part of our knowledge base. If our experiences are less than satisfactory, we tend to modify our patterns of thinking and put these new "constructs" to another test. The process of formulating, testing, refining, and validating patterns of thinking continues until we are satisfied with our new insights.

Attracting, Retaining, and Serving Aspiring Teachers

Aspiring technology teachers have already begun constructing notions about what it means to be a technology teacher before they enroll in a program. For instance, a recent survey of 77 new technology education majors at the University of Wisconsin-Stout uncovered a strong desire to help young people learn and grow while using tools and materials to help them make sense of the technology around them. These students also expressed a strong desire to pursue an occupation that would provide them a respectable salary, good benefits, lasting job security, and lengthy summer vacations. Furthermore, they reported a need to be associated with a trade without having to practice it for a living and have a career that is consistent with their interest and hobbies. Consistent with their experiences in public education, they are looking forward to teaching classes that follow the themes of woodworking, metalworking, drafting, carpentry, and automotive servicing.

The three most important factors that shaped these students decisions to attend UW-Stout as a technology teacher education major were prior experience working with young people in a teaching capacity, the encouragement of their high school teachers, and visiting campus and talking to faculty about the program. Ironically, attending college with a close friend, enrolling in a college that is close to home, and talking to high school guidance counselors played a modest role, if any, in the selection of a college and major.

These findings, along with those found in the professional literature, suggest the recruitment process begins in technology education programs in the public schools with teachers that can identify talented students, provide them with opportunities to experience first-hand the intrinsic rewards of being a technology teacher, and encourage them to visit a university with a strong technology teacher education program. Once on campus, technology teacher educators have to take the time needed to help the prospective student see him or herself as a successful technology education major, and subsequently, an effective technology teacher. If technology teacher educators want their message to be enduring and effective, it needs to be composed for parents and directed toward the student.

Casting a Bigger Net

Teacher education programs need to abandon the dubious assumption that high school graduates possess the experience and maturity needed to make an informed decision about pursuing a career in education. More attention needs to be given to recruiting non-traditional students into teacher education programs. (e.g., people entertaining a career change, displaced workers, people who have been released from the military, recent community college graduates). Furthermore, teacher education programs need to make course work more accessible to non-traditional students (e.g., evening courses, weekend programs).

The development of information and telecommunication technologies has created unprecedented opportunities to reach untapped populations. Unfortunately, access to easy to use distance education technologies has resulted in simplistic forms of instruction that are akin to the correspondence courses of the past. However, with significant investments of time and technology, distance education has the potential to expand the boundaries of technology teacher education programs, attract more non-traditional students, and ultimately, reduce the shortage of technology teachers.

Non-negotiable Outcomes for Competence

The current shortage of technology teachers is putting pressure on teacher education programs to consider alternative paths to teacher licensure. Many of the models for alternative certification are fraught with compromises. Ironically, these compromises are being entertained at a time when teacher education programs are being challenged to increase their standards. Fortunately, the prospect of granting teacher certification based on the achievement of predefined outcomes instead of the completion of approved classes has shed a new light on alternative certification. The path an aspiring teacher follows to meet certification requirements is relatively inconsequential as long as the standards are the same for all future technology teachers and the evidence used to demonstrate competence has integrity. The profession should be extremely cautious of alternative certification scenarios that abbreviate the standards or evidence for technical and professional competence in order to staff classrooms. Such scenarios suggest the study of technology does not warrant the same academic preparation as teachers in other disciplines.

Closing Thoughts

It is very easy to be critical of technology teacher education at a time when the field is supporting diverse curriculum paradigms, the demand for new teachers is overwhelming, teacher certification and program accreditation requirements are undergoing revision, and the number of teacher educators available to address these new challenges is shrinking dramatically. Ironically, the state of flux in which technology education finds itself is also opening numerous doors of opportunity for teacher educators to facilitate the curriculum reforms they have been aspiring to implement for more than twenty years.

The dramatic turnover in technology teachers at the secondary level has put unprecedented pressure on teacher education to prepare a new generation of teachers that can implement recent recommendations for the study of technology. A wide range of stakeholders are challenging technology teacher education programs to deliver a viable knowledge base that defines our unique contribution to the public school curriculum and captures the skills and understandings that will empower future teachers to address the technological literacy needs of young people.

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Chapter Four

Technology Education, Science and Science Education

ENGINEERING IN THE K-12 CURRICULUM

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TECHNOLOGY EDUCATION, SCIENCE, AND SCIENCE EDUCATION: EXPLORING THE RELATIONSHIP

Beverley Jane and Russell Tytler

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Engineering in the K-12 Curriculum

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Introduction

This paper explores the interaction of science education and technology education in the K-12 schools in the United States. The economic engine of the United States is based upon technical leadership. In elementary and secondary schools, students are exposed to science and are expected to achieve some measure of science literacy; yet, despite its importance, much less attention is paid to technological literacy. As technology education has replaced industrial arts and home economics in an already overcrowded curriculum, it may be appropriate to think about the effect of a curriculum connection to science education. One idea might be to provide a more academic base for the technology curriculum while at the same time providing a more concrete context for the science curriculum. The similarity between design and inquiry may provide a cognitive basis for the connection. Describing this curriculum as engineering may have both intellectual and political advantages. The increased emphasis on educational accountability in the US, for better or for worse, has concentrated on reading and mathematics. Science testing is to become important in five years or so. Thus, there may be a window of opportunity to make some changes. The consequence for technology education would be a broader role for technology teacher educators in the education of all teachers. There would also be a need for teachers who also understand science content and the uses to which society puts that information.

Standards

In the United States, education for grades Kindergarten through twelfth grade (5 to 18 years of age) is under control of each locality with some oversight and support by each state. The funding of K-12 education is mostly state and local taxes. Federal funding contributes about 7%. Much of the federal funding is capitated - "pass-through" - funding for various social causes. In addition, the Federal government (and also state governments) is known to make rules about education, which local districts must meet, but are not funded (unfunded mandates). In the latest attempt, the Federal government is mandating testing every year in reading and mathematics in grades 3-8. The form of the tests is left up to the states.

The majority of textbooks used in schools are developed by commercial publishers, who determine what teachers want. They are particularly sensitive to the curriculum frameworks of the large states that adopt a list of textbooks for which the state will provide funding for local purchase. Thus the textbooks are large and amazingly similar. If the book is not on the "adoption list school districts must pay for the texts with local funding unless a waiver can be obtained. A little more than half of the states adopt textbooks.

A number of studies in the 1980s demonstrated that students were not being educated with the knowledge and skills needed to maintain the intellectual and economic position of the US in the world market. (AAAS 1990, Appendix B) A few national, non-governmental, professional organizations began to consider what students should know and be able to do when they leave high school. In 1989, the American Association for the Advancement of Science (AAAS), in its Project 2061, published Science for All Americans (AAAS 1990). Despite the title, the monograph also describes what all Americans should know about mathematics and technology education to understand the scientific endeavor, which is more than literacy about science. The need for science literacy is based upon the need to solve many complex environmental, physical and social problems - engineering. In fact, it is interesting to note that the gist of the argument of this paper is pre-saged in Science for All Americans.

The National Council of Teachers of Mathematics published the Content Standards for School Mathematics. (NCTM 1989) This volume not only describes the goals at the school leaving age, but provides standards for grade bands - now K-2, 3-5, 6-8 and 9-12. The mathematics standards are written mainly by mathematics educators. The standards emphasize the connections between branches of mathematics and less the need for mathematics that is useful in daily life and in the workplace. There is, however, much more emphasis on understanding mathematical operations and mathematical reasoning and less on algorithmic manipulation. There is now a reaction to these standards by a few mathematicians.

The mathematics standards gave rise to the development of other national standards in social sciences, humanities and the arts developed mostly by non-governmental organizations. In general, the standards limit the number of concepts students should learn and stress understanding of concepts over coverage. Mathematics perhaps has succeeded better than science. In part, this is due to that fact that science is not a discipline the way mathematics is. Each of biology, chemistry, Earth science, and physics have their own set of important goals and the number of science standards is far in excess of what can be learned with deep understanding in the time allotted. In addition, other science fields - e.g. astronomy, environmental science, computer science - want to be included.

In science, the National Research Council, the implementation arm of the National Academy of Sciences, was requested to develop standards for grade bands and the

National Science Education Standards (NSES) were published in 1996 (NSES 1996). The NSES includes standards for teaching, professional development, assessment, science content, science programs and science education systems. The eight content standards are about physical science, life science and Earth/space science, inquiry, science and technology, personal and social perspectives and history and nature of science. The standards for technology provide goals of increasing sophistication at each grade band for abilities of technical design and understandings about technology and society. The verbs used at all levels are identify, propose, implement, evaluate, communicate and understand; but the depth of understanding expected increases.

However, Project 2061, continued to develop the Benchmarks for Science Literacy (AAAS 1993). Fortunately, the two "flavors" of science standards are largely the same. The Benchmarks provide more detail, so that they are judged to be more useful for instructional materials development. Whereas Science for All Americans describes the understandings one needs to be considered scientifically literate, the Benchmarks describe the understandings at grade bands of K-2, 3-5, 6-8 and 9-12. Technology education figures prominently. The Section on the Nature of Technology describes the relation between science and technology, the principles of technology - design and systems, and the interaction between technology and society, including trade-offs, risk analysis and safety. The Designed World describes the understandings students should have about agriculture, manufacturing, energy sources and use, communication, information processing and health technology. In manufacturing, for example, at K-2, students should learn about properties of materials and tools; at 3-5 the difference between natural and human-made materials and also about waste disposal and mass production. At grades 6-8, the issues become tailoring materials for the job, design and sequencing, and use of technology to obtain uniform parts inexpensively and automation. At grades 9-12, manufacturing connects to basic understandings of manufacturing processes and control of waste. The molecular structure of materials provides insight into new materials with properties needed to do the job. The role of ethics and values in technological decisions is addressed.

The International Technology Education Association (ITEA), with funding from the National Science Foundation and NASA, developed *Standards for Technological Literacy: Content Standards for the Study of Technology* (ITEA 2000). The Standards received input from science educators. A committee of the National Academy of Engineering (NAE) reviewed these Standards and made many suggestions that were followed. The President of the NAE wrote the forward to the Standards. The twenty Standards are grouped into 5 topics: the nature of technology; the relation between technology and society; understanding the design process; applying the design process and assessing, using and maintaining technology; and understanding of medical, bio-related, energy and power, information and communication, transportation, manufacturing and construction technologies. The standards emphasize understanding and ability to do. For each standard, there are benchmarks for grades K-2, 3-5, 6-8 and 9-12. Some ideas are repeated with increasing complexity and some ideas are introduced at later ages. The standards contain more than can be learned, but there is some overlap with other standards. ITEA also has funding to develop assessment, professional development and program standards, which should be released in the spring of 2003. Again, these standards are informed by similar standards in other disciplines.

Each of the fifty states has developed standards/curriculum frameworks for that state. These tend to be more detailed than national standards. Many are based on the national standards, but pay less attention to "less is more." The state standards are important because state tests are based upon them. With the rise of the accountability movement in the US, the state tests are truly high stakes in terms of federal funding for student programs and local control of schools. In a survey of state technology supervisors in 2001, almost 60% of the states reported that technology education was part of the state frameworks. However in less than 40% of the states is technology education either a state or local requirement; but it is an elective in another 30%. (Newberry 2001) The publication of Standards for Technological Literacy seems to be increasing the attention paid to technology education. Several states, particularly in the East, have science and technology standards - Pennsylvania, New York, Vermont. In Maryland, a technical course is a graduation requirement; but there is some latitude in what constitutes a technical course.

Massachusetts has developed a Science and Technology/Engineering Curriculum Framework. (MA DoEd 2001) (This has the advantage that it may engage engineers in the education of K-12 students.) In grades K-5, the technology standards are suggested extensions to the science standards; e.g. the technology extension to grade 3-5 standard on adaptation of living things is to brain storm and sketch things in the home that are designed to help humans survive. The technology standards are organized around materials and tools and engineering design. However the verbs for each standard are identify, describe, and compare. At the middle school and at grades 9 and 10, the curriculum framework for the technology standards suggests a separate course for technology. Major categories of standards are Materials, Tools and Machines, Engineering Design, Technologies of Communications, Manufacturing, Transportation, and Bioengineering at the middle schools. These are augmented by Energy and Power Technologies - Fluid systems, Thermal Systems and Electrical Systems. The verbs continue to be identify, describe, explain with occasional uses of design, calculate, and construct.

In a recent talk at the 89^{th} Mississippi Valley Technology Teacher Conference, Ted Lewis chronicled the history of "the continuing struggle of technology education for legitimization as a school subject." For that talk, he asked nineteen State Supervisors of Technology about how widespread is "pre-engineering" in technology education. In all but two states, pre-engineering had made some inroads. There are a few college programs in which engineering students who have become disillusioned with the practice of engineering can study to become science or technology teachers.

Thus the national standards, state frame works and state practices encourage the development of curricula that apply knowledge to concrete situations or, conversely, use concrete situations to motivate the learning of abstract concepts. Since all of the standards documents promote literacy, it is useful to ask what that term means. I favor Howard Gardner's definition: "Having sufficient grasp of concepts, principles or skills so that one can bring them to bear on new problems and situations, deciding in which ways ones present competencies can suffice and in which way one may require new skills or knowledge." (Gardner 1991) The various standards described provide a consensus of the knowledge it takes to be literate in science, mathematics and technology education.

Relation between Science and Technology

Mathematics is about relationships between abstract entities that may or may not connect to the natural world. Science is particular ways of connecting observations about the natural world - the use of evidence to verify hypotheses. Technology extends our ability to modify the natural world to meet human needs and wants. There is a continuum from abstract to concrete in going from mathematics to science to technology education. Whereas the center of any of these areas may be well defined, the boundaries are increasing blurred. As one goes along this continuum, there is logic, pure mathematics, applied mathematics, theoretical science, experimental science, engineering science, engineering, tinkering and crafts. In the past, much of technology has been developed by tinkering and following best practices. However, increasingly engineering practice furthers technology. Engineering can be considered to be the application of knowledge to the design of practical solutions of perceived problems. First a general approach is worked out and then applied to solve the technical details of a particular problem. The processes of engineering are closely allied to scientific inquiry and mathematical modeling. (AAAS 1990)

It is interesting to note that American education has moved along this continuum as well. Philosophy, religion, literature, other languages including Greek and Latin and mathematics were elements of a classical education. Science is a latecomer, entering the curriculum in the late 1800s. At that time manual arts were not learned in school, but on the farm and in apprenticeships. With some strong advocates, the subject matter slowly entered schools as vocational education - with the stigma of a second-class education for other people's kids. The emphasis is on doing rather than understanding. In more recent times, the jobs that require only manual skills are being replaced by computers or being sent to countries with low wage scales. It is now very difficult for a family to be supported in the US with a job that only requires manual skills. The world has become more technological and the need for workers who can understand and reason has increased. In the US this also means at least some post-secondary education. The move from industrial arts to technology education follows this trend. Technology education in the US has undergone many definitions - the latest is the Standards for Technological Literacy described above. This incarnation with its emphasis on design is really the basis for engineering education.

It is also interesting to follow the course of engineering in the US. Up until the 1950's, engineering education was handbook engineering. Engineers were taught to use handbooks of tables. However during World War II, most of the large engineering jobs went to physicists and chemists. The engineers then concentrated their education and research on engineering science - the science necessary to understand the application. In this period of time, colleges recruited students proficient in mathematics and science from high schools. In the last ten years, industry is pointing out that the newly minted engineers are of little use to them. It takes too long to re-educate them. As a result, engineering education is emphasizing design and process control. In the K-12 system, this, if taught at all, is done by technology education. Thus engineering education in K-12 is technology education. (Prados 1995)

K-12 Engineering Education

The transition from industrial arts to technology education first made use of the existing work force of industrial arts teachers. The implementation of the standards is complicated by the number of teachers being produced. There are about 40,000 teachers who consider themselves technology teachers; but in 1999 the 105 institutions that have programs in technology teacher education produced only 1100 graduates. Technology education is almost non-existent in the education of elementary school teachers. (Newberry 2001) Thus frameworks such as those in Massachusetts, which require extensions of science learning to technology, will not be easily implemented unless there is a change in teacher preparation.

A few experiments demonstrate that this may feasible. Burghardt and Hacker (Burghardt in press) have a five year grant to "enhance the pedagogical abilities, mathematics, science and technological education content knowledge and leadership expertise of to three-person MSTE leadership teams in New York as teachers begin to address national and New York State MST Learning Standards." The first two years of the grant concentrated on the professional development of the leadership teams, including clinical practice, peer coaching, follow-up classroom visitations, development of a resource guide, and assessing student work. In the second two years these teachers conducted 100 hours of summer workshops and ongoing academic year meetings for 1200 'second wave' elementary school teachers. The professional development helped teachers integrate their mathematics, science and technology lessons and include language arts and social studies. By working with several teachers from a school and their administrators, change is supported and continued. Teachers work together to develop new integrated lessons. Students and their parents become more engaged. Results show that about 85% of the classes score above the school and state averages on statewide mathematics and science tests. The teachers are asked to serve on district wide committees that establish curriculum and adopt texts. The students who learn in integrated classes are easily distinguished in science fairs.

Gary Benenson, at the City College of New York, has produced *City Technology* - materials for elementary school teachers to support technology education at the elementary grades (Benenson in press and Benenson 2002). These materials, co-developed with elementary school teachers, use common, easily available examples of technology to illustrate fundamental concepts and processes. For example, "by testing shopping bags and analyzing how they fail, you can learn a great deal about how structures work." Students gather artifacts, analyze quantitatively their behavior under some conditions, and determine how to make them work better. There are real problems with many solutions; each solution is evaluated to begin redesign. The teacher workshops model the classroom practice desired. The four curriculum guides are mapping, mechanisms, structures and use of space. Teachers have found that these activities help students ask questions that can be answered with careful tests. The students enjoy the materials; they realize their potential; and girls actively participate.

Janet Kolodner, at Georgia Institute of Technology, is developing a middle science and technology school curriculum - *Learning by Design* (Kolodner in press). A "design culture" is established by having groups of students build a device from 3x5 cards and paper clips to support a book above a table. This takes students about ten minutes. All of the devices are displayed so that students can see other students' ideas. They then redesign their device. After the second or third redesign, some students complain that other students are stealing their ideas. The concepts of attribution and patents are discussed and student contributions are celebrated by attribution. In "gallery walks" students describe their work to each other and answer questions. Design "rules of thumb" are introduced; e.g. the larger the coffee filter the slower the parachute falls. After establishing the design culture in the class, the class studies force and motion by building a car that starts at the top on hill and goes over a couple of smaller bumps before running out on a flat surface. In physical science the emphasis is on design and build. In the study of Earth Science it is design and test models. Graphing and quantitative calculations bring in mathematical ideas. Again, the students who have participated in the field tests later distinguish themselves in science fairs.

Similar types of developments have been done in projects for elementary and middle school. (Sanders and Binderup 2000). An entire middle school curriculum that coordinates the study of mathematics, science, and technology education has been developed by Franzie Loepp at Illinois State. (Satchwell in press) Teachers who are interested in reform have successfully taught this curriculum and student test scores demonstrate their increased learning

The Advanced Technological Education Program at the National Science Foundation is a Congressionally mandated program to strengthen technician education at the nation's two-year colleges and strengthen the preparation for that in secondary schools. The Program funds the development of curricula, educational materials, program improvement, professional development of faculty and teachers, and recruitment, retention and placement of students. A major emphasis is to strengthen the mathematics, scientific and technical content of the courses as well as to inculcate employability skills - allocating resources, interpersonal skills, accessing and assessing data, understanding social, organizational and technological systems, and selecting and maintaining technology. (US Department of Labor 1991). Almost all of the more than 200 projects and 19 centers have strong partnerships with business and industry and interactions with K-12 programs with similar goals. Although the goal is to educate the technician workforce needed by the high performance workplace, articulation partnerships to four-year degree institutions are also funded. One component of the program is to provide education of teachers in mathematics, science and technology who have some familiarity with the workplace.

Educational Issues

In the last 40 years, cognitive science has changed our understanding about how people learn. Knowing has shifted from being able to remember and repeat information to being able to find out and use it. (NRC 2000) Experts' knowledge is connected and organized around important concepts; it is made specific to the context in which it is applied and supports transfer to other contexts. The aim of schooling should be to help students achieve this kind of understanding. The shift to an engineering context for learning both technology and science is consistent with this idea. Engineering design can provide the context for learning both the content and processes of science and engineering. This does not mean that all learning is in the context of application. Once having established that a certain scientific concept is important in the real world, one can explore the ramifications of the concept per se. Although some students can learn without context, it is generally agreed that the context can provide the rationale and motivation for the learning that the majority of students need. Such learning is active and usually done in group settings. Thus engineering contexts can be knowledge centered and learner centered. They also can be assessment centered. Carefully designed modules can elicit student preconceptions. The student can use the feedback group settings and the redesign to assess their learning. (Kolodner, in press)

The Benchmarks for Science Literacy and the National Science Education Standards differ on the role for inquiry in science. In the NSES, inquiry is a standard; and the Benchmarks, inquiry is a tool to obtain understanding. In either event, design experiments can foster inquiry. The end result of a scientific inquiry and an engineering design are quite different. In the first the process is to obtain knowledge about the natural world; in the second, it is to modify that world for perceived needs. Yet the day-to-day processes used in the two are not that different. Students ask questions that can be tested by evidence. For school problems, learning inquiry in design may have an advantage. The science of all school problems is known; so that students are inquiring about something already known. Whereas in design, there may be many solutions to the problem under the constraints posed, not all of them are known. There is an additional inquiry about optimal solutions. Thus, the use of carefully constructed design problems may facilitate the learning of science. If this conjecture is true, it provides another incentive for science teachers to want to teach with design.

There is much careful research on how students learn science. (AAAS 1993; NRC 2000) Particularly in physics, the research has elucidated the misconceptions that students hold and how the misconceptions hinder learning. There is almost no research on how students learn engineering concepts and processes - either by technology educators or by engineers in research universities. There are a number of models but very little cognitive research at either K-12 or post-secondary engineering education. However, the Center for Engineering Learning and Teaching (CELT) at the University of Washington has been funded to perform, collect and disseminate research on engineering education. (http://www.engr.washington.edu/ celt/about.html) Since the science educators know the research methodology and the technology educators/engineers have the problems, there is fertile ground for cooperation. In 1999 and 2001, Project 2061 held conferences on Research in Technology Education that brought technology educators together with those who have experience in educational research. http://www.project2061.org/

An active, careful research program can help garner technology education a stronger position for being in schools. One model is to recruit technology teachers/engineers who want more schooling to work with science educators on issues related to the teaching of engineering/ technology. The graduates of this program can then establish their own research programs at other institutions. In physics, it is becoming more common to find research in physics education being part of the disciplinary department.

Political Issues

Thus, there exist models for instructional materials and for teacher professional development for engineering education K-12. The political will is also building.

The National Academy of Engineering (NAE) in the Untied States released the report, *Technically Speaking: Why All Americans Should Know More About Technology* (NAE 2002). The report makes the case that technology has become so user friendly that is has become invisible. The benefits of technological literacy include better consumers, better recognition of the trade-offs involved in technological choices, increased informed citizen participation in policy decisions and a more abundant supply of workers who have the knowledge and abilities for the high performance workplace. The literacy needed is the ability to know how to ask questions and understand when the answers are evidence based - an engineering approach. Obtaining this goal requires the work of K-12 schools, two-year colleges, four-year colleges and informal learning institutions.

The Institute for Electrical and Electronics Engineers held a conference at which Deans of Education and Engineering must come in pairs. (IEEE 2000) As result the Engineering Directorate together with the Education Directorate at the National Science Foundation solicited proposals for planning to put more engineering into the education of all teachers and to help engineers think about the pedagogy of their courses. About twenty planning grants of $100,000 each were funded. Most of these did not reference the Standards for Technological Literacy despite the fact that the reference was part of the solicitation. At the Grantees Conference, the Standards were described. Hopefully out of these planning grants will come some models for having all teachers learn more about engineering education and/or have engineering faculty learn more about pedagogy.

Changing the title of technology education to something involving engineering can have several good effects. First it would begin to separate technology education from educational technology. Secondly, with some careful spadework, it could bring the engineering community into meaningful interactions with K-12 education. The engineers would benefit as well.

Conclusions

The case I have tried to make is that a joint technology science program has a chance to be successful. Design and inquiry can be mutually supportive. The increase of the science content of technology programs makes them more acceptable in the academic tradition of high schools. There are rewarding careers for those who understand both science and technology. Strong backgrounds in both can also lead to long-term, rewarding careers as technicians. Both science and technology are necessary for an informed citizenry. Except that the education will not look the way that education looked for successful scientists, I believe that the mixture of science and technology will increase the access and interest in technical careers for a greater variety of students. If the state assessments emphasize repetition of facts, there may be some problem with joint teaching of science and technology. However, joint teaching of science and technology- engineering - should engage students to think about what they are learning and understand concepts.

At issue will be teacher education. I have long thought that a high school teacher who had a good background in physics or chemistry and technology education would teach both subjects better than teachers who had been educated in one or the other. There would be more concrete examples in the physics class and more science in the technology class. Further, since many schools cannot afford a teacher to teach only physics, this combination would ensure good jobs. Engineers who want a change of profession would also be accommodated. More technology education teacher educators would be needed to educate the elementary school teachers.

What would be given up? One issue would be education about careers. The academic teachers and probably many technology teachers are not terribly concerned with career education. There is good evidence that students need information about careers. The other issue would be one of numbers. Would the science teachers overwhelm the technology teachers and try to teach the steps of the "design cycle" and have students explore processes? The technology teachers would have to be more forceful about the importance of their style of learning than I have seen heretofore.

Going toward engineering education is an idea that is already discussed in Science for All Americans. In the last decade or so, technology education has reinvented itself to look more like engineering education. Maybe now is the time to make the break. I would hope that in doing so one could still look at Technology for All Americans and include those who want to go into move into careers as technicians.

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Technology Education, Science, and Science Education:

Exploring the Relationship

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Introduction

In this paper the nature of technology education in relation to science and science education is explored. Ways forward are indicated for both technology and science in the curriculum so that the two areas can be mutually supportive. In the 1990s, when curriculum writers were attempting to provide technology a unique place in the curriculum, they tended to downplay the relationship between technology and science. One reason for this tendency derives from a perception that science is an academic and elitist discipline and technology is well served by emphasizing the distance between the two. The other reason is perhaps political, that science, by virtue of its status in the community, and the status of its special type of knowledge, would be in a position, if allowed, to subsume the new subject. There are philosophical and historical precedents that justify such a concern. In tracing the historical relationships between science and technology, in professional practice, in philosophical positioning, and in school curriculum, we inevitably need to deal with the politics of school subjects.

The position taken in this paper is that science and technology are different, both in their epistemological foundations, and in the nature of the professional communities and the concerns of individual practitioners within the two areas. In clarifying these differences the essential nature of technology and of science are illuminated. The paper also explores ways in which the two areas can benefit from each other's existence in the curriculum, and ways of approaching teaching that both clarifies the special nature of each type of knowledge, and allows them to be mutually supportive. This may necessitate a reconstruction of the nature of school science.

Science in the curriculum: an historical perspective

In 19th century Australia, as in the UK, the curriculum of public schools was dominated by classics, seen as cultural pursuits to serve the ruling elite by virtue of their value for the training of the intellect, and the acquisition of cultural graces. Science, by contrast, was available in popular writings and was not seen to conform to the ideals of the classical curriculum by virtue of its accessibility to the burgeoning middle classes, and its utilitarian nature. Its initial inclusion into the public school curriculum was opposed by those who argued that it did not represent the mind-training qualities of the classical curriculum, and was better seen as the province of men of practical minds, artisans. Only by emphasizing its academic rigor and structural qualities, and by being represented by a growing acceptance of the pursuit of such studies within universities, did science gain a foothold. For science, the price of admission into the public school system was that it recast itself as concerned with universal principles and mind-training qualities. The type of knowledge that was valued in science was thus changing "... an emphasis on science in its applications to practical affairs was slowly yielding to one in which science was pursued for its own sake" (Layton 1973, p. 22).

The nature of science in the curriculum has changed considerably over the last 50 years, largely due to the wider social forces that impact on schools and determine the shape of the curriculum. In the 1950s and early 1960s, science curricula included many technological details, about how things work, and contained a myriad of facts and applications. Technology was mostly presented in these curricula as applied science, included as examples to enhance students' interest in science and to illustrate science in action. Sometimes courses began with a technological context from which science principles were developed. In both cases technology was subservient to science. At the upper levels of schooling the curriculum was essentially seen as a preparation for a career in professional science. Very few students remained at school beyond the compulsory years, and many of these pursued a technical education from the beginning of secondary school, quite separate from the general education meant for those whose preferences lay in mental rather than manual work.

With the sputnik 'scare' in the USA (in the late 1950s), when Russia was suddenly seen as technologically advanced, and in the context of the cold war therefore a threat, there was a re-evaluation of the USA upper level science courses. Large curriculum projects, such as BSCS biology and PSSC physics were produced. Both of these courses, which found their way into Australia, had been structured by teams of professional science academics (the government had looked to the 'experts') who emphasized within them the structure and essential nature of the discipline, throwing out many of the detailed applications that had characterized previous courses. Science was thus driven further toward higher level abstractions as epitomizing the science way of knowing. For example, in the PSSC physics, the way scientists use models as ways of understanding the world was a core idea around which the content was structured, and many of the engineering applications which had grown up within previous courses disappeared. In primary schools, science had been mainly associated with studies of nature, and it was not until the 1960s that serious attempts were made to define appropriate subject matter in the area of physical science.

Science has always had an impact on society. In recent decades the rate of scientific knowledge production has increased dramatically. New scientific knowledge has been associated with technological advances that may improve the quality of life or threaten it.

Demands for science/technology to solve many of the world's problems have fuelled the development of technologies that can advance medical science, space science, organic chemistry, and engineering science. Advances in electronic media have vastly increased the capacity to bring news of scientific discoveries and problems to world attention. When technology fills the marketplace with inventions, gadgets, and sophisticated hardware, consumers face bewildering decisions about what to purchase and how to intelligently use these innovations. When scientific investigation foresees difficulties in the availability of future energy sources, pollution, or environmental degradation, the impact of these findings ripples through the very fabric of society affecting economics, politics, lifestyles, and the quality of living for all citizens. When there is a rapid growth of technology-dependent industry, there are increased demands for a technologically literate work force. When scientific research suggests new and daring possibilities in areas of nuclear energy, genetic engineering, pesticide development, and artificial life support, people must deal with moral and ethical value questions that have never previously been part of society's concerns. The quality of life and the welfare of people are closely linked to science, technology, and the politics of society. Future decisions demand that people in society recognize the interdependence between scientific and technological developments and the quality of society and environment.

During the 1970s it was increasingly argued that science teachers must assume an important role in fostering this understanding by developing student understanding of science and technology within the context of social progress and environmental quality. Science education is still grappling with the challenges associated with educating young people so that they can function effectively in a rapid-paced scientific and technological-driven society. But it took a crisis in classroom science teaching to gain the attention of the educational community. Large-scale studies in several countries including the UK, USA and Canada have highlighted similar program inadequacies ranging from narrowly-conceived and implemented goals to over-reliance on texts as curricula and overuse of the lecture as a teaching strategy. Yager and Penick (1984) found that science was very negatively viewed by the bulk of school students. Other studies also found that on the whole, students become increasingly disenchanted with science as they progress through the secondary school years. It is argued that the crisis in science education is the failure to respond to changes in society and an avoidance of an orientation toward public understanding of science and technology. There is wide agreement among science educators, if not among teachers, that science programs must present basic concepts and processes within the context of personal and social applications and issues (Bybee 1985; Hurd 1986).

The growth of the Science-Technology-Society movement

'Science-Technology-Society' (STS) is the descriptor that characterizes a major reform movement in science education that began in the 1970s and was increasingly active through the 1980s (Aikenhead 1985; Bybee 1985; McFadden 1991; Ziman 1980). Convinced of the inadequacy of current programs and teaching methods, reformers of science education aimed to completely reconceptualize the entire discipline. STS proponents put forward a series of recommendations for reform in science education which ask teachers of science to encourage students to become both capable and motivated to actively participate in a science and technology oriented society (Hurd 1986). To accomplish this goal, teachers must rethink their beliefs concerning what is worth knowing about modern science and technology to enable students to respond appropriately to the demands of social change. The essential skills to be developed in science teaching are those necessary for accessing, processing, and using information in the contexts of thinking critically, making decisions, and forming ethical judgments.

One of the driving forces behind the STS movement was the increasing 'Science for All' argument that science education must cater for all citizens, rather than simply an elite of students intending to pursue careers in science related fields. One difficulty that has always beset the STS movement is its challenge to the nature of science as a body of knowledge, as a discipline that is structured around generalisable, abstract knowledge. STS thus runs hard up against the discourse established in the 19th century to legitimate science as a school subject. By their nature, the more radical STS formulations largely emphasize local, conditional aspects of science knowledge as it applies in context, rather than pushing for universal and mathematically formulated abstractions. The question of status thus becomes critical.

Apart from a conservative academic resistance to STS ideas, there have been criticisms (e.g. Hart & Robottom 1990) from a methodological perspective concerning the process by which STS courses have been implemented. From a technology perspective, criticisms of the mainstream of STS formulations include:

- Technology is treated as an object of study, often theoretically presented (Layton 1991, 1993) rather than as a set of knowledge and skills in its own right. STS courses traditionally have not been concerned with educating technologists.
- The relationship between science and technology is often seen as unproblematic, with technology treated as the application of science and subservient to it.
- Value positions have not been taken as seriously as they should (Cross 1990).

During the latter half of the 1980s the emergence of technology as a key learning area, separate from science, forced science to reconsider its position. The comfortable notion that technology could be encompassed within science to represent its interface with the real world of artifacts, a product of the scientific method, was no longer tenable either philosophically, or in a curriculum sense. Therefore, work needed to be done to clarify the essential differences, or demarcation line, between science and technology, and in doing so to clarify the essential nature of both. This process has had political as well as philosophical overtones, in that interested parties, and champions within the academic community, inevitably exert their influence on the course of curriculum events.

Science and technology: epistemological issues

David Layton (1991) has been a staunch opponent of the view that technology is a derivative of science. He contends that technology has its own unique community of practice, different in important ways to science, and that the essence of technology lies in the notion of praxis. In science there are limited opportunities for students to engage practically in the design and construction of technological inventions in 'real-world' situations. The notion that our understandings of phenomena are inherently context bound is a fundamental aspect of the theoretical position of the situated cognition school (see, for example, Resnick et al. 1991). Rogoff and Lave (1984) argue that context is an integral aspect of cognitive events, and that one cannot hope to divorce thinking from the social and other contextual elements of a problem-solving situation. Rahm (2002) highlights that studies of the everyday practice of scientists have helped change the view of school science to one that now emphasizes the 'doing' of science and its embeddedness in people's daily lives. Science principles, which have a high level of abstraction, cannot be used directly for the practical action required in technological tasks. Layton (1988) argues for a redefinition of technology that is independent of science, an argument that lent support to the growing impetus during the 1980s in the UK to formulate technology as an area of study in its own right.

Technology as Applied Science (TAS view)

The media, public and politicians regularly use the phrase 'science and technology' and always in that same order. This practice stems from the common perception of Technology as Applied Science (TAS) and fails to acknowledge the complexity of the relationship between science and technology. Proponents of a TAS view believe that technologists rely on scientific knowledge in order to create their artifacts. The TAS perception holds that science is the generator of ideas which technology then utilizes to produce artifacts. Examples from history that illustrate such a belief include the electrical and nuclear power industries that have science foundations.

Technology influences the development of ideas and perceptions of the world (materialist view)

Another perception holds that technology actually influences ideas and mediates perceptions of the world, and in this role is not subservient to science but rather a foundation for scientific thought. Numerous historical examples show that technology is not necessarily subservient to science. The light microscope is one technological development that led to scientific discoveries. Improved techniques and the invention of better instruments have enabled scientists to refine scientific descriptions and explanations. Examples of technological inventions made by craftsmen prior to the scientific theory can be found in Gardner (1994). More fundamentally, Ihde (1983, p. 29) sees technology as a way of revealing the world: “It is a certain way of experiencing, relating to and organizing the way humans relate to the natural world”. For example, in the mid-fourteenth century, the invention of clock technology (the clock's movements represented the heavenly bodies) changed the way western society perceived space and time. In cultures without clocks time was perceived differently. Furthermore, in the Renaissance period, technological developments such as systems of warfare and mechanical power in agriculture formed the foundation of modern science.

A symbiotic science-technology relationship (interactionist view)

Proponents of an interactionist view regard the science-technology relationship as a two-way interaction. Jobling and Jane (1996) use the term ‘symbiotic’ to describe the position where science and technology interact in a mutually beneficial way. Science often provides a purpose for technology, whilst products designed and made by technologists can enable scientists to carry out their investigations. In the past scientists and technologists worked together to produce the steam engine, Bell's telephone, pneumatic pistons and energy-efficient machines (Fensham & Gardner 1994). These are only some examples of new discoveries in science that have influenced the developments of products and vice versa.

Science and technology are independent (demarcationist view)

Not all writers accept the view of science and technology as being related. Historically, most philosophers of technology recognized the craft phase of technology and believed that technology was a unique way of thinking and an autonomous realm of knowledge (Lewis & Gagel 1992). Scriven puts the case for developing technology curricula independently from science by arguing that technology has its own knowledge, skills and equipment.

> Science is defined as the process and publicly accessible product of our attempts to describe, explain and predict natural phenomena. Technology is the systematic process, and the product, of designing, developing and maintaining and producing artifacts. (Scriven 1985 cited in Rennie 1987, p. 122)

Such a definition shows that science and technology are independent, and have different goals, methods and outcomes (Gardner 1994). Other proponents of this view include Cross and Price (1992, p. 27) who perceive both science and technology to be human endeavors but each has its own purpose. “Science is the process of explanation, answering the question 'why' in its various meanings and Technology is the process of knowledge, answering the question 'how' to make or do something”. Scientists are driven to seek knowledge and understanding, whereas technologists search for practical solutions to personal or social problems.

How does engineering compare to science and to technology? Goldman (1990) argues that engineers view engineering as a way of knowing separate from science. Engineers generate their own knowledge by selecting appropriate scientific knowledge and transforming it. Design has a central place in engineering problem solving, but this is not the case in science. Gunstone (1994) examined technology education and science education by discussing engineering as a case study of relationships. He argued that engineering is a unique way of knowing, different from science and not equivalent to technology.

Solutions to engineering problems involve contextually bound issues as Goldman (1990) explains.

> The objects of engineering reasoning are far more complex than the objects of scientific reasoning; the former, unlike the latter, never lose their particularity and are explicitly inseparable from the intentional, contingent, willful, and value-laden contexts of their formulation. (Goldman 1990, p. 129)

Solomon (1993, p. 9) contrasts science and technology in the following way.

Science is concerned with	Technology is concerned with
Identifying questions.	Identifying needs.
Explaining and predicting.	Producing successful products.
Discovering.	Inventing.
Theorizing about causes.	Theorizing about processes.
Analyzing.	Designing.
Making distinctions between concepts and isolating phenomena by controlling variables in experiments.	Bringing many different factors to bear on complex design problems.
Searching for causes.	Searching for solutions.
Research for its own sake.	Research for practical purposes.
Pursuit of accuracy.	Pursuit of only as much accuracy as is necessary for success.
Reaching correct solutions based on accurate data.	Reaching good decisions based on available data.

Technology in the curriculum

The creation of a new subject inevitably raises a number of issues. These include the need for interested groups with some stake in the curriculum, around which practice can be built and support provided for teaching and curriculum development. The other issue, which involves the status of the subject and its legitimacy within a system that requires a coherent assessment program, is the development of an agreement about the fundamental purpose and nature of the subject (Layton 1994). In the search for fundamentals, technology is laying claim to greater academic weight than would be accorded to that collection of skills which was the central feature of the craft subjects that were in many respects the forerunners of technology. Another argument for focusing on generalisable knowledge that has been a feature of arguments for a technology curriculum, has related to the need for citizens to have knowledge and skills that will provide them with the flexibility to contribute in a society that is increasingly marked by rapid technological change. Particular skills outlive their usefulness very quickly in such an environment. Even outside a workplace situation, the prospect of developing in students a transferable technological capability is an attractive prospect.

With the emergence of technology as a new curriculum area on the international scene, the particular form the subject has taken has varied considerably from country to country, depending on particular histories and other circumstances that have led up to its introduction. In the context of the Western European situation, de Vries (1994) developed a taxonomy of approaches to technology curricula that identified eight different possible approaches to technology education. These approaches are the craft-oriented approach, industrial production-oriented approach, high-tech approach, applied science approach, general technological concepts approach, design approach, key competencies approach, and the Science/Technology/Society (STS) approach. Each approach fosters a particular view of technology.

Approach to Technology Education	Concept of Technology students will acquire
Craft-oriented approach.	technology is a way of making things.
Industrial production-orientation approach	technology is product oriented.
High-tech approach	technology is very product-oriented.
Applied science approach	technology is a cognitive activity that depends on science.
General technological concepts approach	technology is a cognitive, analytical activity.
Design approach	technology involves creativity, designing skills and making skills.
Key competencies approach	technology has innovation as a key issue.
Science/Technology/Society (STS)	technology is broad, includes human/social and scientific aspects, and downplays role of design.

For some time now, particularly since Australia has closely followed developments in the UK, the emphasis on design has been an essential part of Australian technology curricula. With an autonomous education system in each state, there was bound to be differences in the way technology curricula were framed. The development of an Australian Technology Statement and Profile provided an overarching commonality (to a certain extent) for the introduction of a Technology Key Learning Area. However, particularly in the upper secondary school level, the relationship of the technology subjects with certification courses and vocational education has been quite varied across the states (Gardner, Penna & Brass 1996).

Science and technology in the curriculum

The issue of the relationship between science and technology in the curriculum is linked to the historical and 'real world' relationship, but has its own dimensions. How science and technology relate to each other in the curriculum has a lot to do with the politics of school subjects and the realities of school organization, and not just the relationship between science and technology as ways of thinking and acting. Science may have argued its place in the school curriculum on the basis of technological advances that do not necessarily owe their existence to science, and has adopted a very formal view of knowledge in response to pressures from academics. However, science and technology are closely linked in many contexts, and the curriculum should reflect this situation. Curricula should also reflect the complexity of the relationship between technology and science. Science curricula need to retain technological thinking and purposes within the Key Learning Area if they are to truly represent the nature of science as it is practiced, just as technology curricula need to acknowledge the importance of science knowledge and processes. How the two curriculum areas relate will be different for primary and secondary schools. In secondary schools the subjects are necessarily demarcated to a larger extent. The organization of curriculum in primary schools provides the flexibility to explore the different ways in which science and technology can interact.

The challenge for Science Education

Roth (1998) defines the field of science education as being concerned with understanding the learning and teaching of science. Technology has posed a serious challenge for science educators that led to considerable activity in the literature, and in schools, during the 1990s. Until recently, science occupied a position of comfortable dominance in which it was assumed that science knowledge was the engine that drove both the industrial and technological revolution by providing the core intellectual content that was then applied by technologists as artisans. This view had implications for the status of science within the curriculum, and the reputation and funding of scientists and their research. The opposing view is that in most respects technology is prior to science in generating innovations, and indeed in an important sense is ontologically prior in defining the cultural and intellectual framework that underpins the science program. Layton (1993) uses the metaphor of 'science as cathedral, or quarry, or company store' to draw attention to the competing notions of science as a self-contained and impressive edifice, compared to a resource ('a charwoman serving technological progress'; Smolimowski 1996, p. 373) for the use of technology studies. A reasonable perspective would have it that science education must serve both functions, but the questions What is the main priority? How is the curriculum to be structured to do this effectively? are important questions that will occupy the minds of science educators over the next decade. Some time ago Fensham (1990) highlighted the difficulties that science as a curriculum area faces with technology established as a separate curriculum area. The difficulties he identified are still with us.

In many respects science is seen as being in competition with technology. With the subject still in its infancy, some technology educators tend to distance themselves from science as they struggle to carve out a unique place for the subject within the curriculum. While this is understandable, and probably necessary, too severe a de-linking of the two areas does a grave injustice to the way they relate historically and philosophically, and to possibilities for fruitful interaction within the curriculum. Many science educators have been important advocates of the new technology subject, and have played key roles in defining the area in the UK, in New Zealand, in Australia and elsewhere. In primary schools there are many opportunities for a fruitful linking of the two areas, and in secondary schools there are an increasing number of interesting models being developed that explore the relationship within the curriculum. With the growth of the science and technology studies movement it has become evident that there is potential for interdisciplinary work between the two domains science and technology studies and science education. Roth (1989, p. 5) identifies: "At this time, there appears to exist only few in either science education or science and technology studies interested to straddle the boundaries in their work" and he hopes that more collaborations will occur between members of the both sides.

Earlier in this paper we foreshadowed the necessity for a reconstruction of the nature of school science. One reason for such a change is the shift away from the traditional view of science that regards the universe as a machine ruled by linear cause and effect, to a systems view that emphasizes integration, context and relationships (Capra 1996; Jane 2001; Hogan 2002). Consistent with this view, science in schools could be taught in a contextual way integrating with technology. How might technology educators respond to such close links with science? Jones (1997) highlights the influence subject sub-cultures have on students' expectations of classroom practice. His New Zealand studies show that when technological problems are solved in science classrooms the students played by the 'rules' of the science classroom and focused on the collecting of information to present to the class. The wider social issues were often not explored by students because they did not perceive these to be relevant to their science understandings.

The challenge for Technology Education

One difficulty facing technology education is the varied perceptions of the nature of technology. Many pre-service teachers continue to associate technology with recent high tech products such as computers, microwave ovens, lasers (Fleer & Jane 1999). Recent research studies by science educators recognize the need to teach the nature of science in schools (Jane 2002; Schwartz & Lederman 2002). Is there a similar push by technology educators to teach about the nature of technology? The USA *Standards for Technological Literacy: Content for the Study of Technology* devotes a whole chapter to The Nature of Technology (Dugger 2000). We argue that the nature of science should be included in all primary teacher education programs, together with opportunities for students to engage in authentic technological tasks that help to develop an understanding of technological concepts. Links with science can be fruitful, and indeed are essential, in certain areas such as materials testing and machines. However the differences between science and technology should be made explicit. If technology educators choose not to work with the science education profession they will fail to capitalize on the benefits that can be gained by linking science and technology in mutually supportive ways. For primary school teachers confronted with an overcrowded curriculum (with an emphasis on numeracy and literacy programs), planning units of work that link science with technology can be productive. When teachers set technological tasks and make the links with other curriculum areas this practice can foster connected learning. Authentic tasks, often devised by students as they recognize a need or a problem to be solved, can encourage students to view technology as a real life enterprise. Anne Marie Hill (1997, p. 137) argues for reconstructionism (attending to the action that realizes the invention) "with its holistic approach, allows for connections between the humanities, the sciences and technology". She also reminds us that it is important to include values and environmental concerns when students design and create products.

Bencze (2001) argues very strongly against the status quo for science and technology, and calls for 'technoscience' education, a combined technology and science program that would treat technology and science as equals. Such a framework (developed by science teachers engaged in collaborative action research) is inclusive, explicit, authentic, contextual, personal, problem-focused and involves apprenticeship. However, there are two possible limitations associated with this program. Firstly, the differences between science and technology may be blurred. Secondly as the status of science is generally perceived to be higher than technology, technology may be consumed under the science banner. The question becomes should the technology education profession be lobbying for technology education to become a science subject on par with biology, chemistry, earth science, and physics? We contend that the notion of technology coming under the science education umbrella would be a backward step and is an idea that should be resisted. Such an amalgamation could result in a loss for technology education, because it may be difficult to argue a place for woodwork and food technology in a science program. In this paper we have argued for technology as a subject in its own right because technology has a different way of thinking, involves a different process and philosophy. If technology education became amalgamated with science education this would result in less flexibility, and that runs against the trends happening in the Australian State of Victoria. The Victorian Certificate of Applied Learning (VCAL) is providing flexible and challenging options for students in years 11 and 12. Technology should be taking the initiative to feed into these programs and it cannot do so if it is under the umbrella of science.

Ways forward for technology education and science education

Can science education and technology education co-exist in a school's curriculum? In this section we put forward several different approaches to implementing technology education and science education in the classroom. Firstly, John Williams (1997) examined a collaborative problem-based learning (PBL) approach to teaching technology in teacher education. He concluded that PBL was appropriate to achieve the goals for technology education and should be one of several methodologies made available in technology education. This approach may or may not include science.

Secondly, reform efforts in science education have led to a project-based science

(PBS) approach being implemented in classrooms. PBS involves extensive use of student-directed scientific inquiry supported by technology and collaboration. The performance of students in classrooms using PBS has been monitored and the findings show that these students outscored the national sample (Schneider, Krajcik, Marx & Soloway 2002). The study recommends that educators should endeavor to use PBS to implement reform in school science. In PBS the questions students investigate relate to their community or their own lives. PBS involves design activities that help students understand important science concepts. Students investigate a real-life question or problem that drives activities and organizes concepts and principles. Students use cognitive skills to develop a series of artifacts in response to the question/problem through collaboration with students, teachers and community members. Although students design and produce artifacts, the investigation focus aligns this approach strongly with science and not technology.

Thirdly, for several years a community project approach (CPA) has been successfully implemented in Primary Technology Education, a core unit in a primary teacher education course in Victoria. This approach encourages students to identify needs or problems that are relevant to people in their local community. In CPA the students write their own design briefs and use their design drawings as a basis for communication with their clients. Students engage in interviews, investigations, and the testing and purchasing of materials. On a need-to-know basis they learn to use tools and equipment safely. There is on going dialogue with the client as the product is being devised and produced. An important feature of the CPA is the student and client evaluation of the product in terms of its durability, appearance and effectiveness. Students incorporate a range of Information Communication Technologies (ICTs) when they present their product to their peers. Many students tell their 'CPA stories' by preparing PowerPoint presentations on CDs which incorporate digital photographs and music, while others show videos of themselves interviewing clients and making the products. Many students use recycled materials to minimize the cost, but also for ecological reasons. Although students were not required to illuminate the science concepts underpinning their products, their science understandings were often revealed in their narratives (Jane 2002).

These three approaches (PBL, PBS and CPA) are different ways to incorporate technology in the curriculum that are not isolated one-off technological tasks which are often set in science classes. By embedding the design task within a framework of helping people in their community to make a better world, brings in the important value component that is frequently missing from technology curricula. When technology education is recognized as a real-life enterprise the technological process can be the organizing process that integrates other subject areas such as science.

Conclusion

As a technology educator and science educator we are interested in examining the boundaries between science education and technology education from both sides. In this paper we began by exploring the historical relationship between technology and science, and then investigated ways of linking the two areas fruitfully in the school curriculum. We argued against placing technology education under the umbrella of science on the grounds that the two areas are unique ways of knowing and have different processes and content. We strongly contend that technology education and science education can be implemented in the curricula in mutually supportive ways.

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Chapter Five

Technological Literacy

It's technological literacy…but not as we know it

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Technological Literacy

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It's technological literacy…but not as we know it

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Introduction

One of the surest things in the world of technology education, is that every time you utter the word technology, you can be sure that there are as many meanings conjured in listeners' minds, as there are pairs of ears present. I'm certain that one of the first (if not *the* first) notion to be conjured will involve a computer of one shape or form.

Pair this with the ubiquitous notion of literacy and the reaction is immediate. Everyone knows that it is essential to be literate, and nowadays it's even more essential to be technologically literate.

Technological literacy - what might it suggest?

- the 'literacy' of technology domains or subjects (put simply, knowing the nature and form of language of technological activity), **or**
- the more holistic idea of a person being competent in the technology domain, exhibiting expertise in initiating and completing technological activities (being able to make design and production decisions, find solutions and create technological products), **or**
- being sufficiently capable to participate in our technological society (and which societies aren't technological??) where the complexities of technological activity and speed of technological change are ever-increasing, bringing new and increasingly significant impacts on the lives of individuals and communities. Technological capability here, may suggest the ability to engage in community debate, consider ethical, as well as aesthetic, as well as practical and functional issues, with an understanding of how decisions are made, and the capacity to evaluate impacts at a personal as well as societal level, in order to make judgements and take action.

It is important to spell out each one of these, giving each a place in our formulation of what technology education can be, particularly if we are serious about assuming a significant place in the education of students. I do not intend to explore this further here, as it forms the basis of much of the technology education in Australia and will be well discussed in other papers.

I do, however, want to challenge the use of the term 'literacy', which is definitionally to do with language, in order to find a more useful term with which to conduct this discussion.

In an attempt to find a better way of representing the expertise required by participants in contemporary society, I suggest we refer to technological 'capability' (hence, a technologically capable person), in preference to 'literacy'. Capability suggests the wider variety of elements involved: understanding how the world is constructed and works, being able to perform technologically and be a critically aware agent of technological development and change, rather than the object of it.

This is necessarily a broad notion of technological capability, one that I believe is essential to promoting the value in Technology Education as an area of learning. It is the view underpinning the various technology education frameworks or syllabuses, each reflecting the national curriculum statement on technology (Australian Education Council 1994) in one way or another. However, I would also suggest that it is a specialist's view; one shared almost uniquely amongst technology educators, and perhaps only a small group even of them.

The more populist concept of 'technological literacy' refers, narrowly, to the ability to use that subset of technologies that involve computers - frequently used interchangeably with 'computer literacy'. When technological literacy is referred to by our friends, the parents of children in our classes, in the media or amongst our colleagues, few of us could assume that they were referring to that broad set of capabilities that we are aiming at in our teaching - no matter how much we would like to. Even teachers who are working within the Technology learning area commonly use the term 'technological literacy'[1] to describe their own expertise (or lack thereof) in computing.

This computer-based technological literacy is the focus of study at tertiary and school level; it drives investment by governments in vast (IT) infrastructure projects and, in Australia at least, has often hijacked the language and meaning of technology education as a whole.

There is variation in usage within state systems and certainly ambiguity in use when referring to the technological activities that occur beyond the learning area.

I don't want to get bogged down in this definitional quagmire. Rather, I need to establish that, for the purposes of this discussion, I will refer to 'technological capability' as concerned with the broadly-defined ability to be an active, critical participant in a designed world, and 'computer-based capability' as related to the use and appraisal of computer-based technologies. This paper focuses on opportunities that must be provided for students to become technologically capable, in its broadest sense, which necessarily involves an increasing place for computing, in ***its*** broadest sense.

Throughout this paper I will use the situation of NSW to exemplify patterns and issues familiar to teachers in all Australian states and territories, making links, in particular to national directions and trends.

The challenge for technology educators in Australia is to carve out a place within a curriculum that privileges measurable 'basic skills' of literacy and numeracy, and is rapidly

[1] The looseness of use of the term is evident as we hear people flexibly include a variety of other machines in their references, especially to their own ineptitude; being technologically illiterate if unable to operate video recorders, timer switches, or in my own case, the microwave oven. Interestingly, one probably wouldn't describe an inability to use or fix the car or washing machine as being technologically illiterate.

adding 'technology' or computing skills to this list. The introduction of the *Computing Skills Assessment* in NSW and the requirement to report on technology achievements at a national level, in terms of computer-based technologies, are indicative of the conceptual position of many educational leaders and government policy makers.

This dichotomy between the Technology Education domain and the world of computing is both paradoxical and problematic. We have, on the one hand, the possibility of utilising a range of computer-based technologies in our teaching and learning practice, an opportunity shared with teachers of all disciplinary persuasions. Simultaneously, we are confronted with the very fabric of the learning area being transformed. As the technological activity in our world becomes increasingly computerised, so too must we reflect these changes and embed computer-based practices into our learning construct.

Learning to use computer-based technologies

Personal computers have been used in Australian schools since the early 1980s, with major advances in computer-based learning occurring from the mid 1990s. The major boost in NSW arrived with the Government's *Computers in Schools Policy 1995-99* (NSW Department of School Education, 1995), with an initial focus on 'using computers to improve learning in all curriculum areas'. The normalisation of computers as an 'educational tool' was the primary aim.

The work of researching and developing this approach soon revealed the need to identify computer-based capabilities that would be essential if students were to be active participants in a technologically convergent world (Curriculum Support Directorate 1998), resulting in a set of parallel aims presented to teachers:

- to utilise computer-based learning strategies to enhance students' experiences in all curriculum areas;
- to provide opportunities for students to develop capabilities in the use of computer-based technologies.

This is a cross-curriculum agenda that involves more than just the development of skills to 'use' computer hardware and software. It moves beyond other skills-based sets of 'literacies' which are linked to particular applications or functions of computer use. Often these are developed at a local level and tend to take a functionalist view, even though they might be described in terms of being 'learning-enhancing' competencies (for example, Ballantyne 2000; Daly 2000).

The NSW capabilities represent a relationship between attitudes, knowledge and skills, that includes an understanding of the cultural and social relevance and impacts of technological activities and change. The intention is to promote methods of thinking and working in new ways, with a developing critical view that is progressively refined throughout a student's school education, from the earliest years.

Various sets of competencies, outcomes or characteristics have been developed across the country. In NSW five capabilities were defined. In short, students in NSW schools should participate in activities, each year, that assist in the development of their ability to:

- use computer-based technologies to locate, access, evaluate, manipulate, create, store and retrieve information
- express ideas and communicate with others, using computer-based technologies
- develop an awareness of the range of applications of computer-based technologies in society
- discriminate in the choice and use of computer-based technologies for a given purpose
- develop the confidence to explore, adapt and shape technological understandings and skills in response to challenges now and in the future.

There is equally, a nationwide commitment to the development of computer-based capabilities amongst students, as a major part of the current National Goals for Schooling (MCEETYA 1999) – agreed to by all Ministers of Education, applicable to all students, across systems and sectors. Students are expected to develop a range of skills, knowledge and the confidence to continue to change, so that they can be full participants in this rapidly changing world.

These (NSW) capabilities provide one articulation of an approach to computer-based learning that is reflected in other Australian states and territories and is consistent with international trends. It contends that computer-based activities developed through a wide range of contexts maximise students' ability to apply and adapt their learning to various situations. It aims to build understanding of the uses and impacts of computer-based technologies across the breadth of human activity, including in the home, workplace and wider community.

A common approach is taken in all learning areas, emphasising the use of appropriate technologies driven by the learning needs of the subject or learning area. The role of teachers is to design and implement learning activities that encourage the purposeful use of computer-based technologies to enhance achievement of syllabus-specific outcomes *and* enable the development of computer-based capabilities; such capability being developed within the context of activities and knowledge systems relevant to each area.

Just as the range of relevant software, applications and uses of computer-based technologies will vary from learning area to learning area, issues of societal applications unique to each subject or area, should also be highlighted and explored. These may include changing vocational opportunities, new or different ways of undertaking discipline-based study (e.g. new ways of gathering data, accessing reference materials or communicating) or challenges to, and extensions of accepted knowledge.

It is this computer-based interpretation of technological capability that is of relevance to teachers in all learning areas. It is the clearly-stated position of NSW education authorities (Board of Studies, NSW and the Department of Education and Training) that all teachers are teachers of technological capability - a stance reflected in the practices of other states and territories. Accordingly, there is an expectation of computer-based technology use in student learning, in all learning areas, and some level of focus on technological changes to the learning area itself.

Variations in uptake and implementation occur across and between learning area delineations, as well as from teacher to teacher within subjects. This is consistent with the growing body of evidence within the literature, questioning the ability of current ICT initiatives to deliver promised learning improvements (Schacter 1999; Cuban, Kirkpatrick et al. 2001).

The NSW Department of Education and Training is currently participating in the three year, Commonwealth funded *effects project* [2] focusing on student learning in schools and classes where computer-based activities are being used. Preliminary evidence suggests that a majority of teachers, in all learning areas, increasingly recognise (and are supportive of) the need for students to develop competencies in the use of computers and related technologies; the demands of society, careers and 'the future' being the dominant rationale.

Several general trends are emerging from systemic documentation of practice, as well as from limited local research (Meredyth, Russell et al. 1999; Audit Office 2000; Hayes, Schuck et al. 2001):

- use of computer-based technologies across subject or learning areas is not yet consistent, nor widespread. Computer-based activity in schools is characterised by pockets of innovation and a growing number of teachers who report 'some use'. The learning areas in which computer use occurs varies from school to school and is still most frequently a product of individual teacher interest or expertise;
- there is a wide range of motivations for teachers to incorporate the use of computer-based technologies. Equipping students for their future (to be technologically capable) is the most commonly stated driver of activities. Other motivations for teachers include the motivational effects of computer use that they observe amongst their students, and the desire to find different or novel ways of achieving existing outcomes;
- computer-use reflects the teacher's existing teaching strategies and is most frequently presented as alternative ways of achieving familiar learning outcomes;
- the majority of activities are intended to develop students' skill in use of particular applications and software products. Most frequently, students are using a narrow range of applications, predominantly word-processing, publishing, Internet searching and content-specific games or drill activities.

Approaches taken in learning areas other that technology are largely focused on teaching students how to use the hardware/software, albeit in subject specific ways, (predominantly) in the context of conventional tasks - finding information, representing ideas in written form, making presentations, gathering data, graphing results. There is little focus on appraisal of technological activity or impacts, or on the development of

[2] The *effects project* is a three-year research project (2001-3) funded by the Australian Research Council and the NSW Department of Education and Training in association with the University of Technology Sydney.

critical views.

Extending use of computer-based technologies into new and more complex ways of doing and knowing does not feature strongly, to date. This may be a product of the 'place in time' in which we find ourselves, and the pace of change that can be expected.

Threat or opportunity?

To a large degree computer-based capability concerns students developing skills and knowledge in a generic sense - in all subjects and in all learning areas.

However, I am not prepared to give away the role of the technology learning area in providing a critical, pivotal role in the development of students' computer-based capabilities.

The analogy can be made to the approach used in promoting literacy (real literacy - the ability to read, write and use language effectively). NSW has had great success in promoting literacy learning through a dual approach: a combination of cross-curricula emphasis on subject-specific literacy development, to complement a primary, formal foundation provided through the English learning area[3]. Literacy demands, unique to each learning area or knowledge domain are part of the fabric of the subject, they are the way students make or negotiate the meanings of the learning area.

So too, this dual approach can work for the development of computer-based capabilities. Students use computer-based technologies in all sorts of learning contexts, for all sorts of purposes. They learn about the roles of computer-based technologies in industry, in work, in changing the very knowledge base of various disciplines. They learn about and use electronic texts, tools and software, across the range of learning areas.

If students are to participate in the difficult technological and social questions of our time, they need to be able to do more that just use computer-based technologies. They also need to understand the debates that surround innovation, to appraise, be critical, assess consequences, and continue to change as the technologies do. We cannot afford to produce another generation of people who 'cannot program the video recorder'.

With the rapid expansion in the use of computer-based technologies and their permeation into every aspect of life, the place of technological capability should be seen as important beyond its role as a tool for learning.

Computer-based technologies are the key technologies of today and tomorrow, transforming every aspect of our traditional areas of work. Technology teachers should be providing a consolidated, broad-ranging approach to the use of computer-based technologies as a major part of our learning area content. We must take responsibility for the development of students with well-rounded, comprehensive skills and understandings of the changing nature and place of computer-based technologies, the diversity of applications, and the social and ethical impacts and questions that are

[3] A similar model is now used for numeracy development also, both across the curriculum and focused through the mathematics learning area.

presented.

Technology teachers need to be at the forefront of learning about, and with, computer-based technologies.

This presents a huge opportunity, rather than a threat; the opportunity to establish a dedicated place and responsibility for assisting students to focus on the nature and role of computer-based technologies in shaping society, as well practising computer-based skills in purposeful ways. The only threat posed by current events is if teachers in other learning areas take up the challenge with greater enthusiasm and with greater relevance to students. If the Technology Education profession doesn't embrace this change, we seriously risk falling by the educational wayside.

In fact, the opportunity offered may be to establish an even more prominent place in the curriculum - one that brings together the two notions of technological capability.

Technological capability is for all

Discussion of the place of the technology learning area needs to set in the context of the wider demands on education systems everywhere. Much has been written about the challenge of shifting all educational practice to reflect the demands of contemporary society, resulting in suggestions of new skills, and new understands of how such education can be achieved. Some camps advocate reform of current practices, others argue for the more radical "total restructuring" of schooling; all focus on a set of expectations for education - publicly declared, consistently attributed with great importance, and consistently described.

A variety of researchers and educationalists (individuals and groups)[4], describe variations on a range of desirable attributes. Students need to be able to motivate and direct their own learning, engage in creative, productive activities that are relevant beyond the classroom. They need to be well-equipped to think critically, make decisions and be sensitive to multiple cultural and world views.

If students are to develop these abilities, then educational experiences need to be practical and issue-oriented, providing environments where students are challenged to identify questions of significance and complexity, develop solutions and present results, working both independently and in collaboration with others. This sounds remarkably like technological capability, to me.

Such approaches are variously referred to as problem-based, project-based or design-oriented learning, but are extended to reflect and prepare students for a world that now uses knowledge and information differently. Dede (2000) suggests we need to include the ability to "thrive on chaos", the ability to make rapid decisions based on incomplete information, to resolve novel situations.

An imperative accompanying these expectations is that they must be accessible to,

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[4] Learning theorists, practitioners and commercial think tanks including, for example, Fiske 1998; Goldman, Williams et al. 1999; Papert 1999; Bertelsmann Foundation 2002; George Lucas Educational Foundation; Centre for Educational Research and Innovation (CERI) 2001; ILO 2002; Resnick 2002.

and expected from **all students** not just a select few (Fiske, 1998; Goldman, Williams et al., 1999; Dede, 2000).

Such expectations are increasingly reflected in the public policy positions taken by governments worldwide (UK Department for Education and Skills, 2001; European Union, 2001; U.S. Government, 2001).

In Australia, successive declarations of 'Common and Agreed Goals of Schooling' have set both national and state-based education agendas since 1989 (AEC, 1989). The initial goals were reviewed in 1997, in order to "take account of the significant social, economic and technological changes which have occurred over the last decade and because …there are new challenges which will face schools in the near future." (MCEETYA, 1997) The resultant *Adelaide Declaration on National Goals for Schooling in the Twenty-first Century* (MCEETYA, 1999) focuses more closely on students and their learning outcomes, with the major addition to the goals being a specific emphasis on "emerging priority areas of the curriculum" including information technology at the top of the list.

Further direction setting is articulated in the Commonwealth's strategic action plans: *Learning for the knowledge society: An education and training action plan for the information economy* (DETYA, 2000) and its school sector subsidiary *Learning in an online world: School education action plan for the information economy* (EdNA, 2000). These reflect the extreme expectations placed on educational uptake of (online) technologies. "Harnessing these technologies for learning is vital. Australia's future as an equitable, imaginative and economically strong knowledge society depends upon it."

Most recently, the Australian Council of Deans of Education (2001) has set out its charter for change, arguing that in all sectors "Australian education institutions need to foster new learning" if we are to succeed economically and "preserve social cohesion and democracy". The major propositions again reflect the need to be concerned with "*creating a kind of person*, with kinds of dispositions and orientations to the world, rather than simply commanding a body of knowledge."

The other aspect that distinguishes recent discussion of the role and nature of schooling, is the place of computer-based technologies. Increasingly the suggestion is that achievement of the stated expectations can not only be assisted by the use of computer-based technologies, especially the Internet, but rather is reliant on their use.

The Deans' charter postulates that "Technology Will Become Central to All Learning" (op cit., 2001, p.3), challenging teachers to harness the potential of the technologies to transform learning relationships and to position technological expertise as one of the "main things that learning is about - a message as well as a medium".

These sets of expectations suggest that education should be even more forward looking - extending beyond a "knowledge society" that is somewhat predefined, to a creative, action-based approach where students learn to use their knowledge for a purpose. Michael Resnick (2002) ups the ante, describing this as a 'Creative Society' where "…success in the future will be based not on how much we know, but on our ability to think and act creatively." (p.36)

This is something that students need to learn, and be taught; the role of schools and teachers being to create the environments and experiences that allow students to develop these capabilities. Our opportunity, as technology teachers, is to offer to students a means to these ends - something that is valuable in its own right and clearly useful to the student. In this way we can bring together our two notions of technological capability - the broad based idea that encompasses ways of working in the designed world, a growing part of which involves computer-based technologies.

The Technology learning area is the ideal place to provide this realistic and relevant context or reason for learning (if we allow it) - and shift the focus of computer-based capabilities from being competent users of computer-based technologies, to a situation where students use them as creative "construction materials" rather than merely information transfer tools. Resnick describes this as moving from being competent users of computer-based technology to a more empowering notion of "digital fluency". Fluency in working digitally, as in working in a language, involves being able to be able to "construct things of significance" (ibid, p.33) rather than being merely technically competent. This is where Resnick sees the catalyst for all learning. Critical to this shift is providing a design orientation to activities, in order to promote purposeful and relevant learning structures.

There has been no better time for technology educators to lay claim to this vision for learning, one that reflects changing work practices, the processes of technology in industry and society as a whole, the expectations and demands on students as they leave school, to say nothing of reflecting the interests and experiences of our students. Where else in a school career are students challenged to identify real issues and problems, to undertake real and tangible projects, to consider environmental, social and ethical questions that are directly related to the real technological world of which they are an important part?

Teaching for change

The technologies that surround us, more than anything else in our experience, are always changing. By the very nature of the activity, as one need is satisfied, one problem solved, new ways of doing things are developed, new needs and new ideas merge, and so on.

The major change required in Technology Education is one that does not to tinker around with some of our content, nor attempts to 'add in the new bits' while trying to hold onto the 'best of the old'. It is actually to reconceptualise and shift our thinking about what it is to be Technology Educators - to shift from a fixed knowledge content or discipline approach, to one characterised by the use of technological processes. We need to reflect the processes of a changing technological world.

By choosing to ground our practice in a design-based learning process we can provide a 'constant' in a changing world. If our foundational content is an approach to engaging with, working in and finding out about the world, then we can provide learning experiences that will be adapted to the rapid changes that will take place within the school lifetime of a single child.

The 'subject' of the process may change, the object of critical enquiry and appraisal may evolve or be altered, but if we utilise a learning approach that values the development of capabilities that are applicable to a wide range of contexts and situations. The content or materials of design activities become a matter of choice, to the point where making the choice is, in itself, evidence of being technologically capable.

Working together to achieve change

If the profession is to capitalise on the opportunity being presented, we can only do it as a united and strong group, determined to design our own preferred future: all players, in all layers of education working with a shared purpose, moving in a common direction.

The richness of the learning area comes from the diversity of these players. There is no need to put aside our individual interests or strengths. There **is** an urgent need to find our common ground, form partnerships that will move us forward and publicly declare our united intention to take the leading role in developing technologically capable students.

The invitation has already been extended, through the agendas set at a national level. Given the federal/federated system in Australia, national initiatives have two major roles:

- *articulating requirements* set by the Commonwealth on which state systems must report, often linked to continued funding. The importance here is for Technology Educators to participate in the events and debates that form and influence national policy and priorities. Generally this is achieved through participation in local, state-based forums that provide representation at national level;
- *providing policy or position support* that may lend weight at a local level and can be used to provide direction for professional development activities, resource development or even the baseline definition of the learning area.

The frameworks developed to reflect national agendas are created by state curriculum authorities that bring together all levels of the profession - academics, policy makers, expert practitioners. It is at this level that an image of technology education is created in the minds of parents, students and the wider community. It is in this arena where a united and innovative profession is most critical. In our multifaceted learning area we need to build a forward-looking, constructive (rather than obstructionist) approach that promotes the features of technology education that have currency for the future, through evidence of innovative student activity.

State-based mandatory syllabuses provide the basis of school curriculum. The translation into class-based practice is the responsibility of the teacher and the school community. This places the teacher at the centre of the decision making (curriculum design) process. The responsibility of class teachers, from K-12, includes:

- expanding the range of technologies, views of technology and variety of technological experiences that are valued and reflected in class activities;
- reflecting the technological world in which we live, and that is particularly relevant to the needs and interests of students. This necessarily involves the use and exploration of computer-based technologies as means of designing and the focus of production;

- updating the focus of class-activities and pedagogical approaches, to work beyond a materials definition of activities and to provide students with options and choices, as an essential part of developing capability
- set high, but well-articulated expectations of creative activity for all students, where excellence in process is as importance as excellence of product;
- maintain personal professional standards that critically evaluate current practices and are informed by ongoing research.

The role of the teacher is to focus the nature of technology learning activities on those aspects that will be valued by students, parents and the wider community.

Teachers must be assisted in making these significant changes through a variety of professional activities.

The role of teacher education and the higher education sector in general, is twofold. First, to better prepare teachers entering the profession, there needs to be an increased emphasis on changing practices, reflecting the real world and taking on pedagogies that foster student decision making and participation in realistic technological processes.

Second, and equally important, is the benefit to be derived by the entire profession from a growth in research activity that:

- makes accessible the changing pedagogical practices that may provide renewed direction to technology educators
- reveals the nature of successful practice that fulfils the requirements of students to develop capabilities beyond traditional modes of manufacture.

Professional development initiatives need to be grounded in research, but translated into practical, meaningful experiences for teachers. Professional development should first focus on the business of teaching and learning - the pedagogical practices that will shift the profession, and second must support the role of computer-based activities in all aspects of technology learning.

The success of these strategies is reliant on the complementary roles of the various players. Teachers need to reflect on and update their practice in response to changing demands. They need to be responsive to research and encourage and support new practitioners. Policy makers and departmental officers need to provide tangible support for the changes demanded of teachers, including negotiation of directions, provision of professional development and recognition of industrial and career path issues. The tertiary sector needs to provide a foundation of sound theory and research that is useful in informing practice and takes into account the realistic constraints of schools.

Professional associations have roles to play in all of the above, and more. They need to lead and support simultaneously, initiating change while assisting members through the ongoing process of updating and extending their practice. They need to position teachers as players in the development of policy and the negotiation of new directions.

Most of all, they need to truly represent the profession. The most successful associations are those that consolidate their role through widespread representation, at all levels. The role of a new (and different) professional organisation in Australia, must be to build on the past and to act as an independent and authoritative body to present a new, united future for Technology Education .

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Technological Literacy

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Introduction

Technology is a very important and powerful force in human life. It provides us with the means to better feed ourselves, become more mobile, shelter ourselves, improve our health, communicate more effectively, develop a knowledge and information infrastructure, and harness energy into many forms of power. These developments have created a world of technological products and systems - roadways, buildings and hospitals, and data communications. Technology has provided us with a complex world of constant change in which human innovation is a dominant force in our lives.

We can reasonably assume that humans will continue to modify the world in which they live through technology. We as individuals cannot make the choice to stop technological advancement. We can, however, choose whether we will march into our future with our eyes open, deciding for ourselves how we want it to be, or whether we will be pushed along, ignorant and helpless to understand where we're going or why. Technological literacy can empower individuals to understand and make choices about our evolving technological world.

What Is Technology?

The International Technology Education Association (ITEA) defines technology in the publication, *Standards for Technological Literacy: Content for the Study of Technology* (*STL*), as the modification of the natural environment in order to satisfy perceived human needs and wants" (ITEA, 2000a, p. 7). This is compatible with the definition provided in the *National Science Education Standards* produced by the National Research Council (NRC), which states, "…the goal of technology is to make modifications in the world to meet human needs" (NRC, 1996, p. 24). Parallel to these definitions, the American Association for the Advancement of Science's (AAAS) *Benchmarks for Science Literacy* presents the following: "In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach farther with our hands, voices, and senses" (1993, p. 41). In the National Academy of Engineering (NAE) and the National Research Council (NRC) publication, *Technically Speaking*, technology is described as "…the process by which humans modify nature to meet their needs and wants" (NAE & NRC, 2002, p. 2). All four of these definitions of technology are very similar and reinforce each other. Most markedly common among the definitions is the concept that technology is a result of human innovation.

What Is Technological Literacy?

The International Technology Education Association (ITEA) defines technological literacy as the ability to manage, assess, and understand technology (ITEA, 2000a, p. 7). In its most basic sense, technological literacy is what every person needs to know and be able to do with respect to technology. A technologically literate person understands, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, how it shapes society, and technology, in turn, is shaped by society.

In the publication, *Technically Speaking: Why All Americans Need to Know More About Technology*, which was prepared by the NAE and NRC, it states that "Technological literacy is described as having three interdependent dimensions - knowledge, ways of thinking and acting, and capabilities" (NAE & NRC, 2002, p. 3). These three dimensions are provided in more detail in Figure 1.

Characteristics of a Technologically Literate Citizen

Knowledge

- Recognizes the pervasiveness of technology in everyday life.
- Understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.
- Is familiar with the nature and limitations of the engineering design process.
- Knows some of the ways technology shapes human history and people shape technology.
- Knows that all technologies entail risk, some that can be anticipated and some that cannot.
- Appreciates that the development and use of technology involves trade-offs and a balance of costs and benefits.
- Understands that technology reflects the values and culture of society.

Ways of Thinking and Acting

- Asks pertinent questions, of self and others, regarding the benefits and risks of technologies.
- Seeks information about new technologies.

- Participates, when appropriate, in decisions about the development and use of technology.

Capabilities

- Has a range of hands-on skills, such as using a computer for word processing and surfing the Internet and operating a variety of home and office appliances.
- Can identify and fix simple mechanical or technological problems at home or work.
- Can apply basic mathematical concepts related to probability, scale, and estimation to make informed judgments about technological risks and benefits (NAE & NRC, 2002, p. 4).

In the ITEA's Council on Technology Teacher Education 40th Yearbook titled, *Technological Literacy*, M. Dyrenfurth and M. Kozak provide the following definition of technological literacy:

> Technological literacy is a multi-dimensional term that necessarily includes the ability to use technology (practical dimension), the ability to understand the issues raised by or use of technology (civic dimension), and the appreciation for the significance of technology (cultural dimension). (Dyrenfurth & Kozak, 1991, p. 7)

The concept of technological literacy is still in its infancy, just as such terms as scientific literacy and geographical literacy are. This is important to realize since educational efforts worldwide are still in the formative stages of offering the study of technology as a school subject for all children.

What Are The Characteristics Of A Technologically Literate Person?

Technologically literate persons are comfortable with and objective about technology, neither scared of it nor infatuated with it. They are capable problem solvers who consider technological issues from different points of view and in a variety of contexts. They acknowledge that the solution to one problem often creates other issues and problems. They also understand that solutions often involve trade-offs, which necessitate accepting less of one quality in order to gain more of another. They appreciate the interrelationships between technology and individuals, society, and the environment.

Technologically literate persons understand that technology involves systems, which are groups of interrelated components designed to collectively achieve a desired goal or goals. No single component or device can be considered without understanding its relationships to all other components, devices, and processes in the system. Those who are technologically literate have the ability to use concepts from science, math, social studies, and the humanities as tools for understanding and managing technological systems. Therefore, technologically literate people use a strong systems-oriented approach to thinking about and solving technological problems. Technologically literate persons incorporate various characteristics from engineers, artists, designers, craftspersons, technicians, mechanics, and sociologists. These characteristics involve systems-oriented thinking, the creative process, the aspect of producing, and the consideration of impacts and consequences.

Technologically literate persons can identify appropriate solutions, and assess and forecast the results of implementing the chosen solution. As managers of technology, they consider the impacts of each alternative and determine which is the most appropriate course of action for the situation. Technologically literate persons understand the major technological concepts behind the current issues. They also are skilled in the safe use of the technological processes that are life-long prerequisites for their careers, health, and enjoyment.

Technologically literate persons understand and appreciate the importance of fundamental technological developments. They have the ability to use decision-making tools in all aspects of their lives. Most importantly, they understand that technology is the result of human activity. It is the result of combining ingenuity and resources to meet human needs and wants.

Is There Confusion Today Surrounding Technological Literacy?

A November 2002 search on the World Wide Web revealed approximately 242,000 references on technological literacy. Some of these were related to ITEA's *Standards for Technological Literacy: Content for the Study of Technology* (*STL*), while others were associated with educational technology. Unfortunately, there is widespread confusion today between *technology education* and *educational technology*.

Technological literacy is achieved through *technology education*. Sometimes referred to as technological studies, technology education is "a study of technology which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human potential" (ITEA, 2000a, p. 242). In other words, technology education is a school subject specifically designed to help students achieve technological literacy.

Educational technology, sometimes referred to as instructional technology or informational technology, both teaches skills and facilitates learning in all school subject areas. A very careful analysis of words and terms related to educational technology gives one a better understanding of the differences between it and technology education. Educational technology is concerned with the technology in education. It presents technology as a "tool" to enhance the teaching and learning process across all subject areas. Educational technology is concerned about teaching and learning with technology. In the International Society for Technology in Education's (ISTE) *National Educational Technology Standards for Students* (*NETS•S*), it is stated that their standards describe,

"…what students should know about technology and be able to do with technology" (ISTE, 2000, p. XI). Also the *NETS•S* provides "…curriculum examples of effective use of technology in teaching and learning" (ISTE, 2000, p. XI).

Educational technology is involved with a more narrowed spectrum of technology than technology education, dealing primarily with information and communication technology centered around the didactic practice of using technology to improve the teaching and learning process. Key words and phrases found in *National Educational Technology Standards for Students* related to educational technology include: use of technology; media; multimedia; hardware and software; information; telecommunications; web environments; communicate; process data; use technological resources for solving problems; locate, evaluate, and collect information; and other instructional technology terms. In the 14 standards listed in *National Educational Technology Standards for Students*, all have terms that encompass the words of "use(s)," "demonstrate," "select," or "employ" with respect to technology, which implies that educational technology is primarily concerned with "using" technology.

Further elaboration about technological literacy was revealed in the ITEA-Gallup Poll which was published in January 2002. (This report can be viewed at the ITEA website, www.iteawww.org.)

> The major purpose of this research was to determine how the public views technological literacy and the importance of technology in their lives. As stated earlier, another purpose of this study was to determine the public's perceptions of technology and how this is congruent with the opinions of national experts in the fields of technology, engineering, and science. The findings support three major conclusions. The first is that the public views developing technological literacy as a matter of great importance and considers technology to be an extremely important factor in everyday life. The second is that the public's definition of technology is a narrow one that is likely to encompass mostly computers and the Internet. This narrow definition is a factor that may be influencing other responses in the poll. The definitional difference may, in fact, be important because of the opportunity for change it offers to those in the field. The third major conclusion is the overwhelming agreement that schools should be including the study of technology in the curriculum. The importance the public places on technology and technological literacy is reflected in a number of findings. There is virtual consensus that technological literacy is an important goal for people at all levels. There is near consensus in the belief that technology is a major factor in the innovations developed within a country. The public sees technology as having a great effect on our society, greater even than its effect on the individual or the environment. There is near consensus that schools should include the study of technology in the curriculum. The public believes technological literacy should be evaluated in high school graduation requirements. And, possibly most important of all, the public has a strong desire to be involved in decisions that affect their lives, decisions that require a high degree of technological literacy. (Rose & Dugger, 2001)

Should Everyone Be Technologically Literate?

A major consequence of accelerating technological change is a difference in levels of technological ability and understanding. There is a widening gap between the knowledge, capability, and confidence of the average citizen and that of the inventors, researchers, and implementers who continually revolutionize the technological world. While it is logical and necessary for the developers to have advanced technological capability, it is senseless for the general public to be technologically illiterate.

George Bugliarello, Chancellor of Polytechnic University, New York, takes a broad view of technological literacy when he states:

> The issues of our everyday life for which we need technological literacy go beyond knowing how to use computers and other technological devices, essential as that knowing is. They are issues that affect how we go about making personal decisions as well as community decisions…They are issues of risk, safety, cost/effectiveness, standards, and tradeoffs; all interwoven. None of these concepts is emphasized in the teaching of the sciences. (Bugliarello, 1999)

Technological literacy is vital to individual, community, and national economic prosperity. Beyond economic vitality is the realization that how people develop and apply technology has become critical to future generations, society, and even the Earth's continued ability to sustain life.

Because of the power of today's technological processes, society and individuals need to decide what, how, and when to develop or use various technological systems. Since technological issues and problems have more than one viable solution, decision making should reflect the values of the people and help them reach their goals. Such decision making depends upon all citizens acquiring a basic level of technological literacy - the ability to use, manage, assess, and understand technology.

In the United States, several groups, organizations, and agencies have made the case for technological literacy. These include ITEA (ITEA, 1996 and 2000a) and the National Academy of Engineering (NAE & NRC, 2002). A detailed report from the United States Commission on National Security/21st Century states that, "…It is not good enough that we produce a sufficient elite corps of science, math, and engineering professionals. We must raise levels of math, science, and technology literacy throughout our society" (2001, p. 45).

Understanding of and capability in technology traditionally have been ignored, except for those pursuing education and training in technological fields. For most people, technological literacy has been left for individuals to gain through their daily activities. However, technological processes and systems have become so complex that the happenstance approach has clearly failed most people.

How Can Technological Literacy Be Guided By Nationally Developed Standards?

ITEA's *STL* was developed by the Technology for All Americans Project (TfAAP), with a vision that everyone can be technologically literate. These standards were conceived to be significant, timeless, and able to be implemented in all schools. They are meant to be used in an articulated educational program from kindergarten through Grade 12.

ITEA and TfAAP have conducted over 40 workshops from 2000-2003 to provide in-service education to existing teachers on *STL*. In the summer of 2000, 11 workshops were conducted at NASA centers nationwide. Approximately 250 leaders attended these workshops from 38 states. The workshops were conducted in a "train-the-trainer" format so that the leaders could return to their states to provide in-service to other educators. Additionally, ITEA has developed a cadre of six Standards Specialists who have conducted over 30 workshops and presentations nationally, providing in-service to approximately 2,000 people on *STL* as of 2002. Their efforts will continue into the foreseeable future.

ITEA and its Center to Advance the Teaching of Technology and Science (CATTS) have developed a number of publications that provide support to *STL*. These include

- A Guide to Develop Standards-Based Curriculum for K-12 Technology Education (1999),
- Teaching Technology: Middle School Strategies for Standards-Based Instruction (2000),
- Teaching Technology: High School Strategies for Standards-Based Instruction (2001),
- Measuring Progress: A Guide to Assessing Students for Technological Literacy (2002), and
- Technology Starters: A Standards-Based Guide (2002).

In addition to STL, ITEA's TfAAP is currently developing additional companion standards that are titled, *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*. This document will be available from ITEA in the first quarter of 2003.

Who Will Deliver Technological Literacy?

Suppose we could hypothesize about the future and project what would be happening if technological literacy could be developed for all citizens. We would have a technologically literate society that could make informed decisions rather than making them from fear or emotion. How can this take place?

Visualize a laboratory-classroom where students are engaged in the study of technology. The standards described in Standards for Technological Literacy: Content for the Study of Technology (STL) (ITEA, 2000a) are reflected in the learning activities. Imagine all of the students with varied prior experiences and abilities working collectively, in pairs, and individually to learn about the technological world in which they live. Students are actively engaged, trying out solutions to technological problems. They revisit prior solutions and retest ideas using new information. They are curious, ask questions, and accept the responsibility for developing technological literacy. Student assessment is varied, providing information for students to adjust their learning and for teachers to adjust their instruction. It is an active environment full of enthusiasm for learning.

Picture teachers seeking professional development opportunities to remain current in the study of technology and confident about utilizing *Advancing Excellence in Technological Literacy* (*AETL*) and *STL* in the laboratory-classroom. Schools across the country support the study of technology and have facilities that work together to empower students. Elementary teachers, technology teachers, and other subject teachers at the middle and high school levels work together to integrate content and educational activities for learning that is more interesting and meaningful.

Imagine administrators, policymakers, parents, business/industry, and the community at large working together to create environments that promote the study of technology and support teacher and student growth. Time and resources are provided, enabling teachers to educate and students to learn. Institutions of higher education support teacher preparation and professional development in compliance with professional development standards. Professional and student organizations provide leadership, resources, professional development, and opportunities for teachers and students that improve the teaching of technology and the development of technological literacy for all. (ITEA, 2003)

The deliverers of technological literacy in the future must be teachers, supervisors, administrators, teacher educators, and all other stakeholders who are responsible for the study of technology. This will take a concerted effort across all levels of education. Other informal education agencies, such as museums and science/technology centers, can also play a significant role in this implementation process.

Summary

The idea of providing technological literacy to everyone through a formal education is a powerful concept. William Wulf, President of the National Academy of Engineering stated that:

> We are a nation increasingly dependent on technology. Yet, in spite of this dependence, U.S. society is largely ignorant of the history and fundamental nature of the technology that sustains it. The result is a public that is disengaged from the decisions that are helping shape its technological future. In a country founded on democratic principles, this is a dangerous situation. (ITEA, 2000a, p. v)

Much work needs to be accomplished in the future if we are to have all people who are technologically literate. In order to do this, technological literacy must become a new fundamental in the educational systems in the world.

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Chapter Six

Ethics, Values and Technology Education

Ethics and Values: Essential Components of Technology Education in the United States

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Ethics and Technology Education: another ac-prac trap or an education for humanity?

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Ethics and Values: Essential Components of Technology Education in the United States

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Introduction

The events that dominated the news media in the United States during the spring and summer of 2002 provided evidence of significant lapses in ethical behavior by managers in several major corporations. News reports cited the unethical behavior on the part of corporate executives in first one company and then another. Even the accounting firms responsible for oversight of financial integrity were found to be lacking. Although angst about ethics and ethical behavior in the United States was already evident, the corporate scandals of 2002 heightened awareness of the need to address ethics and values as a societal concern.

Ethics and values were already receiving attention in the United States prior to the events of 2002. One facet of this has been concern about a decline in work ethic as employers reported increasing difficulty in the 1990's finding employees who were dependable, showed initiative, and had appropriate interpersonal skills (Applebaum, 1992; Bernstein, 1988; Hill, 1997, Hill & Womble, 1997). There was also a growing trend toward including character education as a component of school instruction (Vincent & Meche, 2001) and increased emphasis on identifying common shared values in a world that is now globally interdependent (Kidder, 1994).

What Are Ethics and Values?

Merriam-Webster's Collegiate Dictionary defines ethics as (a) "a set of moral principles or values," (b) "a theory or system of moral values," (c) "the principles of conduct governing an individual or a group," or (d) "a guiding philosophy" (1998). Webster defines values as "something (as a principle or quality) intrinsically valuable or desirable." In practice, ethics guide the process of choosing a right course of action within the context of interactions with other people and institutions. Values influence this process as they reflect internal beliefs and desires.

Ethical perspectives can vary considerably from person to person. One way of explaining why people differ with respect to ethical decision making is provided by the work of Kohlberg (1975). He has described six stages of moral development grouped into three levels. Active thinking about moral issues and decisions stimulates movement through these moral stages. Kohlberg also noted that people at different levels of development respond to ethical issues in different ways.

Kohlberg's *preconventional level* describes people who can identify "right" and "wrong" but interpret these labels based on external forces. Decisions involving ethical issues are based on avoiding punishment or obtaining some type of reward from those in positions of power. Fairness and reciprocity are recognized on a superficial level but this *quid pro quo* is not based on loyalty or gratitude.

Kohlberg's *conventional level* represents stages of moral development involving loyalty to family and support for social order. Ethical decisions would be based on pleasing or helping others and conformity to majority behavior would be valued. This level also encompasses a law and order orientation where authority is respected and the importance of maintaining social order is recognized.

The *postconventional level* includes Kohlberg's most sophisticated stages of moral development. For people at this level, choices involving ethics take into account the perspectives and needs of all persons involved. Individual rights and standards that have been critically examined and approved by the society through democratic processes influence right action. The relativism of personal values and opinions is recognized, but emphasis is placed on procedural rules and consensus. This level of moral development also embraces universal principles of justice, reciprocity and equality of human rights, and the value and dignity of all people.

Gilligan (1982) identified several weaknesses in the application of Kohlberg's model to the moral development of women. Sometimes referred to as an ethic of care, as compared to Kohlberg's ethic of justice, Gilligan described the moral development of women as being heavily influenced by the value they tend to place on relationships. Women tend to focus on developing intimacy and relationships, but men focus more on autonomy, competition, and fairness.

Definitions of ethics and higher levels of moral development include references to moral principles. One of the issues that is relevant to any discussion of ethics is whether or not there are universal ethical principles that all people accept. The values clarification movement of the 1970's encouraged people to discover their own values without providing an endorsement of any universal principles, but it failed to provide an effective strategy for encouraging ethical behavior. The values clarification movement was built on the premise that it would not be appropriate for those in positions of power to indoctrinate others to adopt currently fashionable values (Kinnier, Dautheribes, & Therese, 2000). Moral relativism was a popular philosophy in the United States during this period of the twentieth century and the values clarification movement was compatible with this perspective.

The decline of ethical behavior in the workplace, entertainment, politics and government, and numerous other societal contexts in the United States resulted in several initiatives to identify a set of universal ethical principles (Kidder, 1994; Kinnier, Dautheribes, & Therese, 2000; Nish 1996). School reform recommendations such as the SCANS Report for America 2000 (Secretary's Commission on Achieving Necessary Skills, 1992) included personal qualities (individual responsibility, self-esteem, sociability, self-management, and integrity) in the list of outcomes educational programs should seek to achieve.

Kidder (1994) developed a list of eight common values that transcended international borders and cultural traditions. Based on interviews with 24 individuals in 16 nations, he identified love, truthfulness, fairness, freedom, unity, tolerance, responsibility, and respect for life as values people in all cultures espouse. He founded the Institute for Global Ethics (IGE) in 1990 to promote ethical behavior in individual, institutions, and nations through research, public discourse, and practical action (IGE, 2002).

Another initiative to identify a list of shared values was undertaken by the Josephson Institute of Ethics when in 1992 they assembled a diverse group of education and youth service leaders in Aspen, Colorado (Nish, 1996). The task of this group was to find consensus on values that all Americans could agree on regardless of political persuasion, religious views, race, ethnicity, or socioeconomic status. The outcome was a list that included trustworthiness, respect, responsibility, fairness, caring, and citizenship. A coalition was formed in 1993 for the purpose of systematically teaching and advocating these shared values through the *Character Counts! Coalition*. Materials to support this movement have been developed and published by the Josephson Institute and *Character Counts!* programs have been implemented by schools in many communities across the United States.

Unlike the values clarification movement of the 1970's, *Character Counts!* and similar initiatives make clear distinctions between right and wrong and what Kidder refers to as right vs. right (1996). Moral principles are distinguished from personal opinions. A character education framework is built on endorsing those values that civilized people agree on and encouraging thoughtfulness about how to approach ethical decisions with no clear right answer. Cheating on payment of taxes, being dishonest about children's ages to receive a lower admission cost, stealing supplies from work, violating traffic laws, and any number of other actions can and should be clearly identified as wrong. Tough decisions occur when choices involve truth vs. loyalty, individual vs. community, short-term vs. long-term, or justice vs. mercy and options being considered do not violate one of the universal values.

The case for ethics based on a universal set of moral values is not new; the values being identified have existed for 2,000 years as a part of Christian belief systems. C. S. Lewis (1952), a prominent twentieth-century Christian theologian, described the moral law or law of human nature and presented a strong case for recognition of this law by human beings everywhere. He distinguished this law from conventions such as which side of the road one should drive on. Lewis presented a compelling argument that universal moral laws were established by God, and humans were created with an inherent understanding of these ethical principles.

Religion and Christian belief systems have significantly shaped and influenced the history of the United States. Attributes associated with success in the work place provide an example of this. Work ethic, historically associated with the Protestant Ethic, is a construct that is closely related to ethics. Consisting of initiative, interpersonal skills, and dependability, work ethic encompasses providing an honest return for wages earned (Hill & Petty, 1995). The Protestant Ethic was a term coined by Max Weber (1904, 1905) in describing a trait of the hard-working protestant people groups who were early settlers in the United States. Weber ascribed much of the success of capitalism to the work ethic of those pioneers. He also associated their work attitudes with their religious belief systems.

Teaching Ethics

Kohlberg (1975) attributed the first fully developed theoretical basis for moral education to John Dewey. Jean Piaget had earlier defined stages of moral development in children based on studies of cognitive developmental stages. Dewey stated that the goal of education was intellectual and moral development, and he postulated three levels of moral development similar to those described by Kohlberg. Ethical and psychological principles provided a basis for character development, according to Dewey, and an understanding of these was viewed as essential to success in developing character in students.

The ideas that moral values are taught and that ethical behavior is learned are underlying assumptions in much of the criticism acknowledging a breakdown in ethics. Diminished influence of families, churches, and other institutions that tend to support traditional values has been identified as a reason for a perceived decline in ethical standards (Vincent & Meche, 2001). If ethics and related values could not be taught, such observations would be meaningless.

Schools have been engaged to provide opportunities for character development as well as acquisition of knowledge and skills. As institutions such as the nuclear family unit have become less permanent, society has transferred greater and greater expectations on schools. Meeting the challenge to teach ethics has been difficult for most educators because of lack of formal preparation and the potential for criticism from agents within local communities who are concerned about the source of ethical principles that might be taught (Tucker & Stout, 1991).

Technology Education and Ethics

Ethics and ethical decision-making have become increasingly important as technology has permeated the work place (Hill & Womble, 1997). Technology has created an environment where many people work in an autonomous environment, using wireless communications networks and portable equipment to transact business. If these people lack ethical principles and a strong work ethic, management often has little opportunity to identify problems and take corrective action until significant damage has already occurred within a business or organization.

One of the distinguishing features of technology education is the extent to which it has encompassed a study of the impact of technology on society and culture, extending well beyond technical knowledge and skills. Technology education has provided a scholarly context for inquiry into the development of technology and the ways people interact with and are influenced by technology.

Ethics have been a part of the study of technology from its inception. Character development was an integral part of many of the educational activities found in the historical movements that were precursors of technology education. John Locke, in 1697, emphasized the importance of virtue, wisdom, and manners as components of manual arts education (Bennett, 1926). Pestalozzi, Froebel, Saloman, Della Vos, and other philosophers and educators who contributed to the historical roots of technology education all gave considerable attention to character building and moral development (Scott & Sarkees-Wircenski, 2001).

In more recent years the prominence of ethics and promulgating ethical behavior in technology education has varied in emphasis. Maley (1973) did not include ethics as an explicit component of what was then called industrial arts. His focus was on including a study of industry in general education, understanding the interrelationship between technology and culture, providing opportunities for student to reach their full potential, and encouraging literate citizenship in an increasingly technological world.

The *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) had a significant role in shaping technology education in its present form. The Human Adaptive Systems model presented in that document clearly recognized the interrelationship between ideological, sociological, and technological systems. Technology education content was organized around communication, construction, manufacturing, and transportation but a holistic approach to study of these areas was endorsed. Particularly in the areas of technological impacts on individuals, society, and the environment, opportunities to consider ethical issues were to be an integral part of technology education programs.

The International Technology Education Association (ITEA) published the *Standards for Technological Literacy: Content for the Study of Technology* in 2000. This document, intended to guide and shape the future course of technology education, specifically included ethics as a component of technological literacy. Particularly in the area of technology and society, ethical considerations were specified as an important component of development, selection, and use of technologies. The recognition that technology could have both good and bad outcomes was described as a desirable outcome for technology education.

Technology education is a study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities (ITEA, 2002). In almost every instance, one or more ethical issues can be identified in any situation where technology is used to solve problems or extend human capabilities. Whether dealing with topics related to resources and the environment or deciding how a new medical technology should be implemented, ethical issues are often an important element in the technology education curriculum.

Two key factors in teaching ethics and values in technology education are being certain students understand the significance of ethics in a technological world and that they develop ethical decision-making skills. Technology education content should include integrity, responsibility, fairness, caring and work ethic attributes of initiative, interpersonal skills, and dependability. This list represents core values that have been identified and widely endorsed as universally acceptable. It also includes characteristics relevant to success in a technological workplace identified through extensive research related to work in a technological world (Hill & Petty, 1995).

According to Kohlberg (1975), effective instruction related to ethics requires an approach that stimulates active thinking. Kohlberg identified this principle as a part of the cognitive-developmental approach described by Dewey. Hill and Womble (1997) identified an effective instructional design for teaching work ethic that provided an active role for learners, and included several case studies, numerous small group discussions, and guided students to examine and reflect on their own attitudes toward work. Research has shown that ethics and related topics are not adequately addressed by lecture or other approaches that do not use active learning.

Technology education provides an ideal context for ethics instruction. The field has a long history of providing learning experiences involving engaged, hands-on instructional approaches. By incorporating ethical issues with content related to technological problem solving and development, students are provided opportunities to develop understanding that moves beyond technical skills and superficial knowledge of technical systems. Technology education that is consistent with the philosophical foundation expressed in the Standards (ITEA, 2000) and other seminal works must include these kinds of experiences.

The extent to which ethics instruction is incorporated in technology education varies depending on the instructor and the curriculum materials being used. Although developing character and encouraging ethical behavior is listed as an overall objective by most school systems, the approach to teaching ethics is often haphazard and not well designed. Ethical issues are often embedded as a component of discussion points in technology education materials, but clear, focused strategies for including ethics in instruction is missing in many technology education programs.

Ethics and Technology Teacher Education

The extent to which practitioners teaching technology education incorporate ethics instruction in coursework is heavily influenced by the preparation provided by teacher education programs. Although professional ethics has been included in most technology teacher preparation programs, strategies for teaching ethics to students have not been included as a central theme of most technology teacher education programs. There are several reasons for this.

In most United States colleges and universities, postpositivist philosophies have had a significant influence during the past decades within disciplines related to teacher education. This resulted in a pervasive view that truth was relative, that objectivity and universal values were fantasies, and decision-making was a subjective process (Kinnier, Dautheribes, & Therese,2000). Promotion of certain values as universal was viewed as the disguised promotion of the dominant culture's values. The multicultural movement, by virtue of its idealization of diversity, also opposed promulgation of a universal set of values. In summary, the dominant position evidenced by most teacher preparation programs with respect to ethics has been that no individual or group of individuals is qualified to determine what is good or correct for all people. Therefore, ethics instruction has been almost entirely omitted from the curriculum.

One of the ironies of the stance that all standards are ultimately arbitrary is that such an absolute statement is self-contradicting. As pointed out earlier, unethical behavior by numerous prominent people during the past decade has caused some to reexamine whether a stance against core values was in the best interest of society. Technology teacher educators have endorsed the importance of ethics within the profession by commissioning a *Council on Technology Teacher Education* 2004 yearbook on the topic of *Ethics for Citizenship in a Technological World*. This edited work will provide a philosophical base for preparing technology teachers to address ethics as a component of technology education and will also provide practical resources for doing so.

Baker (1997) has provided a framework for using Kidder's ethical decision-making model in media instruction that could be adapted for use in technology education. Overlaying the revised Kidder model on a 5-stage problem-solving process familiar to technology educators yields the model shown in Figure 1.

Figure1

Revised Kidder Model for Ethical Decision Making in Technology Education (Baker, 1997; Kidder 1996)

Define the problem	Id concepts and ideas	Perform relevant tests	Develop/test prototypes	Produce solution
Recognize that there is a moral issue. Determine who has the power to act.	Gather the relevant facts. Identify all possible options	Is this a right vs. wrong issue? *Is one of the choices illegal?* *Is one of the choices intuitively wrong?* *Is there a choice that would be embarrassing if made public?* *Is there a choice that a very good person would not choose?* If an affirmative answer is given on one or more, make the right decision and move on. Identify paradigm for right vs. right issue. *Honesty* vs. loyalty* *Individual vs. community** *Short-term vs. long-term** *Justice vs. compassion**	Apply resolution principals. Ends-based decision. Rules-based decision. Care-based decision.	Make the decision and implement respective action. Ethical evaluation and reflection

Whether the model proposed here or some other model is used, a systematic approach for making ethical decisions is needed as a component of technology education teacher preparation. While in-service and professional development strategies could be used to equip practicing teachers with a functional knowledge of such strategies, the intensity of pre-service teacher education would provide a more appropriate climate for considering the underlying literature base and philosophical perspectives.

Along with an ethical decision-making model, technology teachers should be equipped to address stages of moral development. Familiarity with Kohlberg's model (1975) and awareness of one's own level of development would be instrumental in the reflection and active thinking needed for effective learning to occur in the area of ethics. Instructional activities should include opportunities for students to learn about their own levels of ethical development.

If technology education is to address the ethical elements of the national standards and to successfully contribute to the technological literacy of students, it is important to provide opportunities for learners to develop ethical decision-making skills. This will require a conscious and deliberate effort. Pressures to cover specified technological content and other parameters placed on teachers by educational settings will require that ethics instruction be integrated into existing course materials. There is not room for separate lessons, and even if there was, that would not be the most effective approach. Using case studies, group discussion, and other active learning strategies, students should be guided to consider ethical dilemmas within the context of various technologies being studied. Ethical decision-making strategies should also be taught and opportunities for reflection and practice provided in conjunction with technology education technical content.

Cross-Curricular Ethics Instruction

One of the recognized problems in many United States educational systems is compartmentalization of subject matter. Rather than provide a holistic, real-world presentation of material, schools often provide experiences where students move between classes in mathematics, science, technology, language arts, social science, and other subjects with little evident connectivity or coordination. Purposeful efforts are needed on the part of educators to provide opportunities for students to recognize connections between school subject matter.

Most technology education professionals in the United States are familiar with initiatives to integrate the study of mathematics, science, and technology. Efforts should also be made to provide cross-curricular learning experiences between technology education and the humanities and social sciences. To do otherwise reflects a narrow view of technology education that fails to fully recognize aspects of technological literacy related to technology and society.

One of the facets of the national standards (ITEA, 2000) that is sometimes misunderstood is that they are standards for technological literacy – not standards for technology education. Technology education must play a prominent role in this process, but all school subject areas should contribute to accomplishing the outcomes specified in the standards. Professionals in fields other than technology education are likely to be unfamiliar with the standards, so it is important for technology educators to take the initiative in implementation of the standards.

In the area of ethics instruction, technology educators have opportunities for collaboration with faculty in disciplines that have not traditionally been viewed as related to technology education. Whether making connections based on philosophy lessons covered in a mythology class or considering the ethical paradigms of the United States Constitution as presented in a history class, opportunities abound for technology educators to collaborate with other faculty on issues related to ethics instruction.

A probable ramification of inclusion of ethics in instruction is engagement and comment from members of the community. Parents and other citizens with ties to schools typically will scrutinize any instructional activities related to ethics instruction. It is important for educators to be proactive in this regard, offering a sound rationale for ethics content.

Service learning projects, employing an instructional strategy that is becoming quite popular in the United States, involve having students use knowledge and skills gained in class to complete a community-based project that assists with a real-world need. Service learning projects provide excellent opportunities for community members to observe the positive aspects of ethics instruction. It is also very important for ethical content to be grounded in those universal values that diverse groups of people have agreed on. Content for ethics instruction should focus on constructs and ethical decision making models that are derived from widely respected sources. Community input into the teaching of ethics and values in technology education should be received if offered, but care should be taken to avoid implementation of content that has not been validated through careful research.

In summary, ethics and values can and should be taught as an integral part of technology education. Technology teachers should consider innovative strategies for addressing integrity, responsibility, fairness, caring, initiative, interpersonal skills, and dependability as components of technological literacy. They should also help students to develop a thoughtful approach to ethical decision making, perhaps adopting a model such as that presented in Figure 1. As described in the *Standards for Technological Literacy* (ITEA, 2000), ethics and values are key elements of life in a technological world, and all students should have opportunities to gain knowledge and skills needed to be good citizens.

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Ethics and Technology Education: another ac-prac trap or an education for humanity?

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Introduction

This paper explores the inter-relationships of ethics, technology and education – each of which, alone, is not an uncomplicated concept. Following a prologue there are discussions of ethics (and values) per se and then technology (and design) per se. A broader technology discourse is then presented and this serves to introduce the related sissues of *intention, existentialism, democracy,* and *choice.* Some issues of educational context are presented before a particular position is given on Technology curriculum. The paper concludes with what is perceived as the curriculum challenge for Technology Education.

Prologue

There are some striking features to witness in the encounter between Ethics and Technology. To begin with, both ethics and technology enjoy intimate, yet curiously different, relationships with our very human 'being' in the 21st Century. (It is recognised that ours is not the only technological species.) We cannot try to describe ourselves as a species without reference to our technological evolution. Nor can we explain our day-to-day 'being' without reference to technologies. We are who we are because of our technologies. The quality of our *existence* is intertwined with our technologies. Meanwhile, ethics, as a human construct, cannot 'be' without human reference. The notion of ethics is dependent on the existence of people, of 'others'. So, in turn, the quality of our *coexistence* is intertwined with our ethics.

Despite the obvious significance of the two phenomena to humanity, they have received very different kinds of attention over the ages. Technology has been a matter of practical action, tangible, indisputable in its reality, and little valued by the Academy. By contrast, ethics has enjoyed thousands of years of academic debate. The fact is that, so far as philosophy is concerned, ethics (or moral philosophy) is a major field of enquiry. Meanwhile, the notion of a philosophy of technology is a mere infant of less than a century and still far from the public eye. One crude deduction is that ethics, being a branch of philosophy, is often perceived as a matter of theory while technology is seen as a matter of practice.

There are some further commonalities between technology and ethics to note: both are contestable fields begging rational discourses; both are values-rich; both share interests with democratic theory; both have an interest in matters of determinism and free will; both beg sophisticated understandings about 'choice'; and, neither is an explicit or properly understood educational reality.

The nature of ethics (and values)

Interests in ethics have fuelled philosophical discourse for millennia and although ethics dropped somewhat from public discourse during the 1970's and 80's, it has regained its currency of late. This is hardly surprising given the technological, economic and environmental developments over that period. While we believe that ethics is important, it nevertheless seems difficult to articulate or seems difficult to apply to the 'real world' (whatever that may be). However, just because ethics may appear problematic does not mean that it cannot manifest itself as practical and personal action. Any study of ethics inevitably embraces terms such as morality, goodness, right and wrong, obligation, ideals and values and each warrants analysis of its meaning and role in ethical discourse. Abrief excursion into this philosophical area might be helpful.

Axiological ethics – about values

Axiological ethics focuses on values rather than directly on morality or 'what we should do'. It also explores something of our relationship with things – so offers a tangible connection with discussions of the material and technological world. With regard to *value* Dent (1995) says:

> Philosophical concern with value has focused on three connected issues: first, on what sort of property or characteristic of something its 'having value' or 'being of value' is; second, on whether having value is an objective or subjective matter, whether value reposes in the object or is a matter of how we feel towards it; third, on trying to say what things have value, are valuable. These concerns closely parallel concerns with the nature of good, from which value is seldom carefully distinguished in philosophical discussion, though the terms are clearly not synonymous. (Dent, 1995:895)

This acknowledged interplay between notions of 'value' and 'good' is a matter of some nuanced debate for philosophers. The issue emerges, for example, in Frankena (1973) who discusses ways in which the word 'good' can be used, and offers a practical analysis of values which distinguishes between 'moral' values (those we may contend to be good on moral grounds) and 'non-moral' values. As he says:

> ...one may commend a thing or say it is good on various grounds. If the thing is a person, motive, intention, deed, or trait of character, one may commend it on moral grounds; then, one is using "good" in the moral sense...One may also commend something on nonmoral grounds, and then one may apply the term "good" to all sorts of things, not just to persons and their acts or dispositions. (Frankena, 1973:81)

Other ethical avenues

Slote (1995:591-595) contends that perhaps the '...major problem...of moral philosophy...is coming up with a rationally defensible theory of right and wrong action', and he identifies four current dominant basic views or theories. The first is Utilitarianism – which has always been controversial – wherein right action is understood in terms of human good, pleasure and desire-satisfaction. Any means can be justified by a good enough end. The second is Kantianism, which contrasts utilitarianism in arguing that moral rightness is a matter of consistent and rational behaviour – less a matter of happiness than duty. The field of ethics, which is concerned with acting out of a sense of duty over personal inclination, is termed the deontological. Slote's third set is Intuitionism, or common-sensism, which counters the above views in arguing that there can be no unifying account of moral obligation. The only general moral principles are prima facie ones such as 'it is prima facie wrong to harm others'. Slote finally cites Virtue ethics which traces its roots to the Ancient Greeks and notions of 'situational sensitivity', how we should 'be', and draws upon inner traits (virtues) rather than being referenced to some external rule system. This *teleological view* can see the *good* independent of the *right* so, having identified that which is good, that which is right is that which maximises the good.

Of course the field of ethics is much more extensive, subtle and fascinating than this – not least because there are limitations in the kind of dualism that 'right-wrong' suggests. To imply that ethics is a matter of sorting out a binary is inadequate. Humanist, existentialist and post-modern theory (see e.g. Bagnall, 1998) all contribute, and alternative perspectives to the philosophical emerge through religious, race, gender and class agendas. Inasmuch as anyone may be interested in the quality of our existence and, indeed, of our co-existence, then we are faced with ethical questions and, thus, some degree of engagement with ethical discourse.

To the assertion that philosophical approaches may be out of touch with the real world comes a significant refutation from Singer (1995) who is concerned about the quality of life issues which abound. He argues that by living in an ethically reflective way it is possible to overcome the individually and collectively self-defeating goals of self-interest. He contends that:

> Ethics is practical, or it is not really ethical. If it is no good in practice, it is no good in theory either. Getting rid of the idea that an ethical life must consist of absolute obedience to some short and simple set of moral rules makes it easier to avoid the trap of an unworkable ethic. An understanding of ethics that allows us to take into account the special circumstances in which we find ourselves is already a major step towards attaining an ethics that we really can use to guide our lives. (Singer, 1995:204)

This 'practical' view is well supported. Warnock (1978:135) concluded her text noting that ethics since the 1960's had become 'a practical subject' and conjectured that a new language of ethics was in the process of being developed. Her recent text (Warnock, 1998) articulates clearly her practical focus on moral philosophy. Singer adds: 'I share Parfit's (1984) view that in the advancement of ethics lies the possibility of a new and more hopeful turn in world history; but it must be an advancement not only in ethical theory, but also in ethical practice.' (Singer, 1995:20). So it is that ethics is seen as being far from 'out of touch' and that it has a place in life and work.

Thus moral philosophers themselves see ethics playing a central and practical role in human discourse in the coming years. Ethics does not just 'happen' in a vacuum and it is through the application of our rational nature as autonomous beings with regard to others that we are able to determine appropriate and defensible ethical decisions. In presenting his case for an enlightened form of ethical subjectivism (in a context of universalisible [sic] principles), Singer is clear about the importance of such concepts as reason, argument, justification and defence. Further, 'Self-interested acts must be shown to be compatible with more broadly based ethical principles if they are to be ethically defensible, for the notion of ethics carries with it the idea of something bigger than the individual. If I am to defend my conduct on ethical grounds, I cannot point only to the benefits it brings me. I must address myself to a larger audience.' (Singer, 1993:10). This last comment reminds us of the potential cultural specicifity of ethical discourse. There are dangers when seeking some kind of universalisibility (sic - Singer) of ethical principles and then applying them from one culture or race with disregard to another. It is not insignificant that there are races and religions whose ethical (and/or) technological perspectives are significantly different from our own (see e.g. Ferre, 1995). Here, the matter of our global coexistence is paramount.

The nature of technology (and design)

There is a significant array of attributes to consider with regard to technologies:

- technologies are of the essence to our lives and cultures yet we are both a) largely unaware of this fact and b) could hardly define our existence without reference to them;
- all technologies have contested values. No technology is neutral or universally good;
- all technologies are created by a manufacturing or enabling process resulting from human intention or design;
- a technology cannot 'be' in any functional sense without a relational human input. This may well be less the case in the future;
- technologies often undergo 'function creep' – uses other than those originally intended;
- technologies converge and gain greater technological power than the sum of the parts;
- we are beginning to enter the time of the post-human condition, where the balance between our human identity as we have known it and the engineered human is shifting;

- the speed of emergence of technologies is almost always faster than the necessary associated ethical considerations and legal frameworks;
- technology is commonly viewed as autonomous or inevitable – 'that's the way things are going' or 'you can't stop progress';
- identity and power relationships are shaped by the technologies with which we interact; and,
- as the raison d'etre of technology, power and empowerment are subject to attribution, distribution and ownership – in equitable or inequitable, and often contested ways.

These attributes can be cross-referenced with the extensive literature documenting the contestable nature of particular technological phenomena. For example: over-production, consumerism and designed obsolescence (Packard, 1960; Toffler, 1971; Schumacher, 1986; Papanek, 1974; Carr, 1985; Suzuki, 1997; Ellyard, 1998); alienation and de-centring of humans from work practices (Morris, 1979; Fry, 1992); genetic patenting and engineering (Penenberg, 1996; Berlan & Lewontin, 1999; Joy, 2000; Somerville, 2000); dataveillance – the surveillance of people and personal data (Nixon, 1996; Riviere, 1999); robotics, nanotechnologies and the merging of the human and the artificial (Drexler, 1990; Caudill, 1992; Kurzweil, 1990, 1999; Joy, 2000); equity, democracy, design, technology and citizenship (Green & Guinery, 1994; Buchanan, 1995; Sclove, 1995; Winner, 1995; Feenberg, 1999; MacKenzie & Wacjman, 1999; Keirl, 2001a&b); and, last but by no means least, negative psychological conditions that accompany Western technology use and materialism – 'anxiety' generation (Van, 1998), 'psychological impoverishment' (Packard. 1960), and, 'consumption disorders' and 'existential disorders' (Schumaker, 2001).

If what has just been presented may seem an overstatement, it is argued that, in fact, when it comes to our relationship with our technologies, the opposite is the case. The ethical imperative is profound and there must be significant educational implications. To return to an earlier point, we have extensive *discourse* on ethics and we have extensive *practice* in technology. Somehow, the two have not yet enjoyed the best of interaction. Having pointed to the argument presented by latter-day moral philosophers (Parfit, Singer, Warnock, above) for a *practical ethics,* what might be said to facilitate a richer technological discourse?

A broader technology discourse

Interrogating intentions

Perhaps a way forward here lies in an exploration of the totality of the 'being' of technologies – by recognising that technologies 'don't just happen' and looking into how they actually do 'come to be'. Such investigation must involve looking well beyond the immediate reality or reification of technologies. While design is a key phenomenon here, there is more to the matter than the complex processes of designing. It has been argued that '…one might explore the ethical issues on a technology continuum of intention-design-manifestation-application with, importantly, *consequences* being assessed at every stage' (Keirl, 1998:218). In other words, *before* any design is under way some kind of intent takes place. This matter of intention is highly relevant. The ever-powerful interrogatory 'Why?' applied to the intention is the beginning of an ethical interrogation. The outcome of such interrogation may well be that the intention is totally unacceptable. Such interrogation may have various origins. For example, a single concern such as obsolescence may be negated or at least greatly marginalised. In a different way of working one might apply communal principles similar to those of Amish culture and conduct an analysis of the effects of a technology based on the spiritual values of one's people (Sclove, 1995). Further, one might draw on elaborate principles of design or sustainability which have been developed by individuals or groups (Mayall, 1979; McDonough, n.d.).

Acknowledging the existential and technology as phenomenon

Drawing on the thinking of Kierkegaard and Heiddegger, Ihde's *Existential Technics* (1983) contributed significantly to the emergence of a philosophy of technology. A decade later, summarising his analysis of the writings of three philosophers of technology, he comments that:

> …*philosophically* all three reject a simple means-ends or neutral tool analysis of technologies. Technologies are contextual and belong in different ways to *praxical gestalts*. They are also multidimensional with respect to their role within human experience and culture. Analyses which restrict such a larger perspective run the danger of *concealing* the full impact of any technology…(They)…also agree that technologies are non-neutral, although each focuses upon different aspects of the transformational powers of technologies in use (Winner on socio-political dimensions, Borgmann on social and ethical values, Ihde on perceptual-cultural dimensions). (Ihde, 1993:115-116)

In this summary the ethics-technology relationship emerges in the issues of instrumentalism, (non-) neutrality, human experience and culture, consequences, politics, and values. To perceive technology as phenomenon is to start from a position of recognition of human complexity and richness. Our 'being' and our 'being-with' are so shaped. Embedded in, rather than peripheral to, such an approach are ethical matters.

Democracy, technology and ethics

Warnock (1996) points to the common interest held by existentialist philosophers in human freedom. 'They are all of them interested in the world considered as the environment of man (sic)…because of his power to choose his own courses of action' (Warnock, 1996:1). She places existentialism '…with other decision-making moral theories' (Warnock, 1996:141). Freedom, and its sometime reciprocal, control are ethical concerns for both democracy and technology. Ihde's (1993) summary points to the problematic notion of the (mis)perception of our ability to control technologies (well encapsulated in the teasing ambiguity of Thompson's [1991] text title - *Controlling Technology*).

> To control technologies…is much more like controlling a political system or a culture than controlling a simple instrument or tool…particularly in a contemporary high technology setting…one in which the complexity and extent of technologies is unprecedented, with equivalently unprecedented degrees and types of human, social, and cultural transformations. (Ihde, 1993:117)

The intertwined nature of technologies and our lives is reflected in our political sytems and orders. Matters of power emerge when one asks do we control technology? Does it control us? Or, significantly today, is it used to control us? Of course the issues are not new. There are particular resonances with the Enlightenment period around the late 18th Century witnessed in Mumford's (1934) critique of 'progress' and throughout Postman's (2000) text. Rybczynski, (1983), Palmer (1994), Sclove, (1995), Winner (1995), and Feenberg (1999), all write lucidly of technology-politics relationships. They show how our choice-making (in free, limited or non-existent forms) about technologies mirror the kind of society we have in both enabling and disabling ways. Sclove (1995) discusses technology as both enabler and disabler of democracy and democratic process and points to the potency, or impotence, of the individual in society. As these political-democratic issues are explored it is matters of the individual and collective choice that emerge – choice of lifestyle, choice of environment, of education, welfare, governance and so on. Sclove's key claim is this:

> …it is possible to evolve societies in which people live in greater freedom, exert greater influence on their circumstances, and experience greater dignity, self-esteem, purpose, and well-being. The route to such a society must include struggles toward democratic institutions for evolving a more democratic technological order. Is it realistic to envision a democratics of technology? Isn't it unrealistic not to? (Sclove, 1995:244)

To achieve such ends as 'democratic institutions' and 'a democratics of technology' presupposes ethical engagements with justice, welfare and futures. Any discussion and envisioning of democracy is essentially an ethical question and throughout all these processes run matters of choice. Thus the question is begged, what choice, if any, have we over the use of the technologies of surveillance, genetic engineering and xenotransplantation, nanotechnology, waste, and the post-human future? Compound such questions with reference to the inequitable distribution of technologies within and across cultures and nations, or to issues or access to water and food, and the ethical connection between politics and technology is transparent.

Determinism, free will and choice

Throughout what has been presented so far the word 'choice' has appeared with some frequency. The importance of this word calls for some elaboration. One of the readily perceived impediments to the idea that we may have a choice at all is that of determinism. Are we truly free to choose – either within our cultural, social and political contexts or given the level of information we may hold? Have we a free will to exercise?

The determinists would say not. The broad thesis is that all events in the world are the effects of earlier events. A more focussed view concerning humanity questions '…whether we ourselves, persons, are subject to the same sort of causal necessity….Indeed, determinism has been taken as the more limited thesis that all our choices, decisions, intentions, other mental events, and our actions are no more than effects of other equally necessitated events.' (Weatherford, 1995:194).

In the technological determinist view, technological events are the driver of social, cultural and political developments. Any interactive model of the interplay of, say, a cultural influence on the development of a technology is denied. Technology drives us and is beyond our control. Such a position is anathema to 'practical' ethics, democracy and, hopefully, education alike. (Warnock [1996; 1998] argues that ethics implies choice and is thus apparently incompatible with determinism or, conversely, that 'choice' is illusory for determinists.) Underpinning ethics, democracy and technology is some sense of the right to, and the exercise of, free will. In turn, free will implies choice-making. However, there is something of a conundrum when we consider technology as many of us would deny that we played any part in the decision-making and development concerning the technologies in our lives. While we might refute technological determinism we are not best positioned, at present, to say that we, ourselves, willed our technologies into existence. Here the sense of our individual and collective disempowerment seems to emerge. It is hardly surprising that populist views on technology hold sway. 'That's the way things are going' – 'You can't stop progress' – 'It's all inevitable'. To yield to such views is to deny a capability to act which, of course, is both to deny the existence of choices and to deny the point of choosing to act. Sometimes this is the easy way out since making choices and exercising will in a democratic society require both strength and responsibility.

Oliver (1994) advocates '…*human* intervention (her emphasis) rather than reliance on the divine, free flow of market forces in an open economy…It will demand that communities and governments go through the difficult, yet immensely exciting, process of choosing a preferred destination and charting a path to achieve it.' (Oliver, 1994:49). Meanwhile, Palmer posits: 'Do we inhabit a world already formed by technological choices so complex that many seem almost invisible (e.g. the pencil, the telephone, the washing machine)? Do many technologies appear before us as autonomous and beyond choice (computers at work, videos at home, cars to go between them)?' (Palmer, 1994:77). This notion of technology as pervasive yet invisible is also cogently pursued by Sclove (1995). Both authors argue that choice – or importantly, the lack of it – is a focal matter for the social, cultural and political manifestation of technology. Packard (1960), Van (1998) and Schumaker (2001) all link our personal and social psychological wellbeing to the material world of production and what we are lead to believe are choices. With any technology there are foreseen and unforeseen consequences and the quality of knowledge and understanding we hold will directly influence the quality of our decision-making. Invariably the situation will be imperfect and we can only do our best. However, when obsolescence, over-production, low quality, high energy use, non-recyclability, and harm to the wellbeing of people are known and understood there seems to be no rational explanation for our 'choice' in continuing to design, manufacture, use and discard a mass of technologies. This is not a democratic practice.

Knowledge is a part of the matter but an equally important issue concerns the very *act* of choosing to choose - namely the matter if will. Will – as design or intention – is part of the act of conception of a technology. Yet when it comes to our take-up of technologies we seem unable to apply a will guided by any particular principles. Thus, there are two prerequisites of choice to consider: first, being equipped with a critical and emancipatory technological knowledge on which to base a choice; and, second, having the personal and collective political will to make the choice.

Singer's (1995) text focuses on the question of how we are to live. He discusses what he terms 'The Ultimate Choice' - between two fundamentally different ways of living – between ethics and self-interest. His case is both challenging and articulate. He points to two kinds of choices – restricted choices and ultimate choices. 'Ultimate choices take courage. In making restricted choices our fundamental values form a foundation on which we can stand when we choose. To make an ultimate choice we must put in question the foundations of our lives.' (Singer, 1995:5).

The matter of education

Before commenting on Technology Education, there are four contextual points to be put regarding the 'big picture' within which our field operates. First, education can be seen as ideology and contestation (Apple, 1979; 2001). As Apple (2001) argues, the dominant Western ideology of today valorises a particular economic model:

> The idea of the "consumer" is crucial…For neoliberals, the world in essence is a vast supermarket. "Consumer choice" is the guarantor of democracy. In effect, education is seen as one more product like bread, cars, and television…Thus, democracy is turned into consumption practices…the ideal of the citizen is that of purchaser. The ideological effects of this position are momentous. Rather than democracy being a *political* concept, it is transformed into a wholly *economic* one. (Apple, 2001:39)

The shaping of curriculum as purveyor of ideology in England and Wales was well documented by Simon (1985,1988). More recently, Smith (1999) comments 'The official 'mood' of school education in contemporary western society is dominated by a 'specify, measure and report' approach.' (Smith,1999:172).

Second, if democracy is the ideal, ethically-based, form of political organization then so must be the education systems on which it is based and for which it exists. In her cogent exploration of Education, Democracy and the Public Interest, White (1973) comes, inter alia, to two conclusions. She comments that 'There is at least *one* policy which *must* be in the public interest in a democracy. This (policy) is an appropriate education for a democracy.' (White, 1973:237). Thus education is the keystone for the well-being of the democracy and for the well-being of its participants. However, White also argues that the determination of what might constitute that 'appropriate education' cannot be left to 'experts' '...to be worked out much as the value of the gross national product is calculated' (White 1973:223-224). As public interest policies are about things which the public *ought* to have, White argues that they are, therefore, value judgements.

Moral judgements are central to the determination of the core policy (i.e. education) of a democracy.

Third, the increasing movement for Citizenship Education is to be critiqued for the kind of ideology or democracy it will serve.

> Talk of a thinking citizenry, rights issues, control of knowledge, ability to participate in democracy, empowerment to shape preferred futures, commitment to justice and equity – in all, ethical action – must come from a curriculum of empowerment not one of servility. Preparing the individual as servant of the state or tool of the economy is not what an education for democracy is about. (Keirl, 2001b:15)

Finally, it is to be remembered that a field such as Technology Education has, apart from it's own special educational contribution, a role to play in the general education of all students. 'General education' means, first, that education which is compulsory to all students of a certain age and, second, that education which is general in nature and which is articulated through all subjects and learning areas (e.g. literacy, numeracy, citizenship, technological literacy, ethics).

(Design and) Technology curriculum

'Curriculum' here is not taken to mean some sort of narrow prescription of what is to be taught in schools or of how it is to be taught. Rather, curriculum is taken to be '…all those discursive practices which affect what and how students learn, and what and how teachers teach.' (Reid & Johnson, 1999). This holistic approach is necessary if one is to appreciate curriculum as a matter of ideology and contestation.

Traditional technology 'education' has been constrained to a concern for skilling. However, a quality Technology Education is not about just skills at the kitchen worktop, computer keyboard or workshop bench. Skills *education* is a part of any quality education. Uncritical skill reproduction is not. Skilling taught as empowerment, as part of personal potential or cultural heritage, skilling explored as a part of one's being, skilling as exploration of mind-body and self-environment relations, skilling as community asset – these are some understandings of *skill as education*. Skilling 'to get a job' is simply not enough.

What, then, are the essences of a technology curriculum that will articulate matters of ethics, technology, choice and all the associated issues? It is argued that a quality Technology Education must be grounded by five major considerations. First, it must be understood as a prime device for students' personal knowledge creation. How knowledge is constructed is a matter as much for the student as it is for anyone else. Transformative learning must be valorised over transmissive learning. Second, values and ethics must emerge and be central, not marginal, to all D&T practice. Third, the personal and species' relationships with technologies must emerge – the existential warrants introduction. Fourth, the choice issues – both the instrumental capacity to choose as well as the will to act – should emerge. Finally, the pedagogical and curriculum implications for these four must be understood and articulated.

Curriculum design is of the essence and one recent iteration (DETE, 2001), which is grounded in a three-dimensional articulation of technological literacy, is offered as an example. By interweaving the operational, cultural and critical-emancipatory dimensions, holistic, critical and dynamic understandings of technology may be facilitated. Two strands which shape the pedagogy of this model are *critiquing* and *designing*.

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

Genuine criticism is far from the commonly applied negative comment but, rather, is bound up with reasoned opinion both inwardly and outwardly expressed. *Critiquing* can be seen as a way of acting as well as a way of thinking. 'Critical thinkers critique in order to redesign, remodel, and make better.' (Paul, 1995:526). Critiquing is taking things apart in purposeful ways. The disassembly, dismantling, deconstruction or analysis of something may achieve no more than an exposure of all the components. The judgements made when critiquing can expose the intentions behind designs, the hidden consequences of the use of technologies and the relationships between people and technologies. Through critiquing new meanings and knowledge emerge for the critic. This offers another way of seeing, judging and living in the designed world.

If design is pro-active, before the product, before the event, then critiquing is reactive – it happens not only *after,* but *because of,* the intention, product or event. There are elements of each in the other and in this way they reflect the dynamics and holism of this vital field of education.

The curriculum challenge

There is a strong case for Technology Education to embody ethics in its practice. There are public concerns about technologies and their effects. There are concerns about our personal and collective democratic impotence to participate in debate about technologies. There is extensive passivity about technological issues. There is extensive ignorance about emergent technologies. There is little understanding of the relationships between existence, coexistence, technology and ethics. To date, there has not been a critical holistic Technology Education.

A critical examination of our own 'self-interests' – as educators, perpetuators of (masculine?) tradition, members of classes, cultures and societies – may be a good starting point. However, our self-interest as technology educators must feed into education for the greater good, the ultimate choices of how we are to live in ethically and democratically defensible ways. Thus an education is needed which values reason, critique, judgement, advocacy, defence, and interrogation, (albeit through supported discomfort). An education is needed in all the nuanced uses of choice as both noun and verb. Such an education is articulated through rich, not impoverished, constructions of technological literacy along with such powerful activities as critiquing and designing. Through these it is possible to valorise the non-practical nature of technology and the practical nature of ethics.

So to the paper's title. We either submit to a deterministic position of affirming the millennia-old theory-practice binary – we fall for the ac-prac trap where skilling is both identity and nemesis - *or* we design an education for humanity. This latter must be more than a cliché. It could be: first, an important part of an education for our students in what it means to be human; second, an education for their roles as thinking, active global citizens; and, third, reciprocally, Technology Education's contribution *to* humanity – the ultimate choice.

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Chapter Seven

Policy, Politics and Technology Education

Technology Education and Politics: A chronological narrative and sociological perspective

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Achieving Technological Literacy: Educational Perspectives & Political Actions

Rodger W. Bybee

Biological Sciences Curriculum Study (BSCS)

Technology Education and Politics:

A chronological narrative and sociological perspective

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Introduction

Technology Education has a history, which appears exponential. There have been prolonged decades of school curriculum based upon the acquisition of routine skills and processes, followed by increasingly vigorous change towards design-based innovative curriculum in the last decades of last century, and fuelled by national political intervention and vision. It seems we are on the cusp of further change, as opportunities are being fostered through Commonwealth initiatives that will empower technology educators to shape technological education beyond the boundaries described in the National Technology Statement and Profile. This paper acknowledges the significance of political influence. It raises the notion that the discipline of technology can effectively critique itself and explores significant issues.

- What are the consequences of empowering people technologically?
- Will the technological and social changes benefit society and the environment?
- How might we come to comprehend the future of Technology Education through exploring past and present contemporary design?

Background

Decisions about the development and use of technology reflect a range of factors. They are influenced, for example, by the values and experiences of different people and communities, by the actual or predicted impact of technologies on environments, by the processes by which the decisions are made and by the political influence of different groups. Making decisions about technology can be highly political in that they often involve a complex mixture of consensus, conflict and compromise.

Educational organizations depend heavily on governments, and many Australian education systems exclusively seek funding from State and Federal sources. In meeting the political imperatives required for the funding, technology educators in Australia have been embroiled in the enactment of policies by making Australian students innovative, knowledgeable, skilful, adaptable and enterprising as a positive contribution to the changes in our social, environmental and economic circumstances.

Chronological Narrative

Technology Education has been a component of Australian curriculum in various forms since early last century, from early childhood to secondary levels of schooling. In the formative years, technology was essentially practically based, with State developed curriculum centred around gender exclusive groupings, which enabled boys to gain prerequisite skills for trades and for girls to participate in practical domestic arts in food and textiles. The curriculum was appropriate to the time and should not be demeaned; it was a significant educational commitment by all educational systems and achieved much in terms of craft and manufacturing skill-based training and transition into the workplace. The highly selective curriculum and limited pedagogical focus of yesteryear have gradually been transformed by Federal policies in the last decade of the twentieth century. Three policies have been particularly relevant in providing understandings about technology, through clarifying purposes and as important vehicles for fostering confidence about the place of technology in Australian curriculum.

National collaboration has provided both curriculum recognition and financial support in establishing technology education as an integral part of mainstream education. In 1989 State and Territory Commonwealth Ministers of Education endorsed *The Hobart Declaration of Schooling*, which provided *Common and Agreed National Goals for Schooling in Australia*, and technology was acknowledged as one of eight nationally recognized areas of learning. *The Hobart Declaration of Schooling* was significant, because it endorsed the educational experiences and achievements made by students in the disparate subjects which were represented collectively under the nationally recognized umbrella of technology.

In 1994 work proceeded on the development of a *Technology Statement* and *Technology Profile*. This work was undertaken at the direction of the Australian Education Council (AEC), the National Council of Ministers of Education. The Technology Statement and Profile were brokered to the Tasmanian Curriculum Services Branch, with collaboration by writers, consultants and trialing schools from all states and territories. The University of Tasmania completed a literature search for technology. These documents were significant, because for the first time, Australia had an agreed statement about the technology learning area, which provided a framework for curriculum development by education systems and schools. The content was unique in that it succinctly defined the learning area, outlined the essential elements, showed what was distinctive about it and described a sequence for developing knowledge and skills. Similarly, the Technology Profile was unique. Teachers of technology had described for them a progression of learning, which could be typically achieved during the compulsory years of schooling with the benefits of assisting teaching and learning, and a framework for reporting student achievement.

The nationally developed Technology Statement and Profile have been successful in achievements beyond curriculum mapping. They have been a resource for collaboration between teachers of different technology specializations (foods, textiles, electronics, information technology, materials etc.), linked progression to learning outcomes, provided understandings of learning area content for resource developers, established common terminology, emphasized strands (designing-making and appraising, materials, information, systems), and enabled teachers of different technologically based subjects to develop collaborative programs in schools.

At the time of releasing the Statement and Profile, Australia had separate national teacher associations, which were aligned with technology philosophically, but with independent structures. The Australian Education Council provided the incentive and financial support through National Professional Development Funding (NPDP) for the associations to meet as a federation with the central purpose of establishing national collaboration for the professional learning of teachers through the dissemination of the statements and profiles. The associations that made up the Technology Education Federation of Australia (TEFA) are:

ACCE	Australian Council for Computers in Education
ACET	Australian Council for Education through Technology
CAMEO	Council of Australian Media Education Organisations
DECA	Design in Education Council Australia
HEIA	Home Economics Institute of Australia
NAAE	National Association of Agriculture Educators

The establishment of TEFA as the peak body for the learning area has been both an outstanding achievement and a focus for controversy and disquiet. On one hand there has been acclaim for the exemplary work that was undertaken in professional learning and the way in which TEFA was able to acquire grants to obtain the finances to sustain itself beyond the initial establishment grants. Criticism has also been directed at TEFA; there are claims of self interest, limited benefits being realized by the member affiliate associations and limited recognition of technology education achievements across Australia. TEFA is a company with a board comprising six directors; there is a view that its membership and structure marginalizes many of technology education individuals and organizations who are not members of the six affiliate associations. These include: consultants, researchers, academics, vocational education teachers, primary teacher associations, state based associations, non-aligned national technology associations, individual student and teacher members, curriculum officers and decision makers on educational issues within government and non government jurisdictions.

Teacher associations have had a major role in shaping education in Australia and the support federally is strategic. There is a view that the Commonwealth is able to negotiate and implement many policy directions through associations, which may be less focused through state government departments. The Federal Government has made a substantial financial contribution to TEFA; if it is to realize its long term investment, the timely review of technology education being undertaken in 2002 through the Commonwealth Department of Education Science and Training (DEST) will provide the necessary consultation with key stakeholders, which may, in part, critically scrutinize TEFA's role in advancing the teaching of technology education in Australia. DEST have undertaken an ambitious project titled *A Shared Vision*. Diverse interest groups from all Australian States and Territories have been consulted through a quest to establish a new vision for the learning area, cognizant of the powerful society shaping potential of technologies, and the real and potential economic imperatives that can be progressed through, rightly or wrongly, aligning the technology with human intellectual investment and the economy. There is much to be done to realize the outcomes of the DEST technology proposal including circumscribing the compromises, trade offs or forced alienation between curriculum based on traditional technologies with new and emerging technologies.

The positioning of federally generated perspectives about technology education within state and territory programs and priorities will be somewhat tricky for DEST. There are complex state agendas including the emerging curriculum focus away from learning areas towards "new" or "essential learnings". Several states have policies which respond to ways in which general education prepares learners for a changing world, and addresses state concerns in areas such as reducing problems associated with a crowded curriculum, engaging learners more deeply in their learning, making learning more relevant, improving learning across curriculum disciplines and supporting the transfer of learning. This quest for interconnected and interrelated knowledge, skills and dispositions is sought in school programs which can be described as "cross-curricular rich tasks" or "authentic project based learning", and can contrast to the opportunities directed through subjects or curriculum with a learning area focus. The advocacy for technology education, re-visioned or not, may be difficult to sell to state education departments with significantly different policies and priorities being implemented.

The state priorities in Information and Communication Technologies (ICT) as learning and teaching tools may be perceived as appropriate areas for further funding. DEST have acknowledged that this area of technology has already been generously supported and that the learning area of technology education has been neglected or perceived as a lower priority; the delineation required to distinguish between ICT and the broad learning area will require political intervention to prevent funding being impeded. Without seeming to be negative by describing the limitations rather than the possibilities for the DEST initiatives, a resolution to how areas of vocational education and enterprise education assimilates with the new purposes of technology education will also need clarification. Vocational Education and Training (VET) and technology are not synonymous.

It is envisaged that DEST will support Technology Education through establishing a Technology Education Network. The Network will have many key questions to resolve including:

- In what ways can we account for teachers' constraints which maintain dated content and reluctance to change pedagogical approaches?

- How will technology educators undertake professional development that supports a critical understanding of technological literacy?
- Can a national body that is politically active and empowered to support the profession take account of the current diverse technology associations without alienation or risking irrelevance?

Sociological Perspective

To comprehend the pervasiveness and potential of technology education, we need to explore humankind's progress and mastery of technology and design. Through scoping the commercial imperatives and political interests we can begin to understand the portrayal of the learning area politically and critically examine its place in a dynamic world of changing opportunities.

Technology Education has a complex history that is interconnected within a framework of cultural democracy. The elaboration of materials into useful objects through the exploitation of technology and design systems draws heavily from the finite capacity of the natural world. Changes to Technology Education must take account of ethical and social futures; students will need to have curriculum connectedness with everyday life through studying human and environmental issues. Many would argue that our ability to use high technology as a tool for the design of spaces, products and services irrevocably disturbs the ecological balance. We often do not have to look further than our own backyards for examples; in Tasmania we can observe how political decisions, technology and product design, fuelled by consumerism, have turned a major river into a toxic pond and hectares of old growth forest into a land crippled by stasis.

On a global scale we are fast becoming aware of the huge risks taken in morphogenetic fields where technology has given us the ability to re-design, through modification, manipulation and cross-over, life itself. Dolly the sheep and crop plant design are contemporary examples of transgenic creations. The ethical and environmental issues associated with design and technology activities always seem to have to be argued from concerned citizens outside the vested interests of industry. This is because design and technology practices in the postmodern age are essentially the captive of the free-market economy. Their prosperity is directly related to political intervention and the profitability of consumerism.

Design, creativity, innovation and enterprise have been the emerging focuses of change to Technology Education in Australia; they have been part of a rich inheritance, which has been largely unrecognized within Technology Education. When exploring the future of Technology Education it may be significant to understand the future through tracing historical developments in design and product development. Design is as much a planning activity concerning systems and qualitative decision making as it is a product or service. The practice of design, particularly since the 1940s, implies a commitment to mass production under the rubric of the manufacturing industry. Design activities are controlled by commercial imperatives, political interests and the extent to which technology has the capacity to fulfill the demands of a brief. The machinery of manufacture, the need to contain costs, limiting the use of raw materials and saving production time, all impact on a designer's freedom. In Queen Victoria's reign, achievements in design and technology boldly stated the Empire's pre-eminent place in the world. In the twentieth century, Germany, Japan and the USA grew to be industrial powers through strategic investment in new design, pure and applied science and the development of manufacturing technologies. Throughout Modernism, stature and reputation in design and technology were very much based along nationalistic lines.

As Modernism gave way to Post-Modernism and as developed nations looked at solving the escalating financial, social and environmental costs of the traditional resource-intensive industrial economy, a new business and manufacturing paradigm took hold. The new way of doing things was known as the Post-Industrial phenomenon and this helped create the global economy. Multi-national corporations, transnational and cross-industry conglomerates established de-centralised, cost effective ways of manufacturing components and finished goods. Continuous investment in the design of better tools, systems and messages about new wants has become critical to the development and profitability of the contemporary free-market economy. Improving productivity and inducing ever-more consumption are essential to the continuing viability of most multi-national enterprises. Through these, corporations and not nation states have created new forms of design expression that have become global in intent and, in turn, have created unease with individual national strengths, local economic exchange and cultural values. A significant focus for review of Technology Education must take account of learning strategies for a global and rapidly changing economy.

In the book *The Uses of Decoration*, Malcolm Miles tells us 'productivity has undergone historical change, in that development in the post-industrial world is a question of capital flows and consumption in sectors such as financial services and mass communications media, rather than of discrete urban economies based in manufacturing. The mass media is a powerful design industry where new electronic technology has enabled broad sweeps of the globe to be reached by mega print and television groups. In the Post-Modern and Post-Industrial world the design of the mass media marketing message and its strategic release to targeted audiences is every bit as important as the intrinsic value of the product it represents.

Politicians are well aware that as free-market economies grow and become more prosperous, their need for commodities increases. Commodities are designed and promoted as needs, they are very often presented to us as an outward expression of progress and affluence and they are retailed as objects and services of the 'now'. The carefully designed corporate logo is promoted as being iconic, implying values of substance, reliability and quality. The branding of a product or maker is perhaps the most significant design problem set for contemporary mass media companies. There are special challenges associated with foregrounding a new product or company entering the marketplace just as there are different issues that have to be addressed in modernising the image of a longstanding, respected product. While graphic signs are an essential part of the marketing package, so are perceptions associated with words. Since the 1960s the term 'designer' has been used to advertise an array of products from drugs to denims. In this context 'designer' is meant to identify a product that has undergone extensive elaboration of materials and ideas. There is a legacy of understandings about the meaning of design and the political avoidance of the term and wide general public perception of the term will continue to be a significant issue for technology educators to explore.

Australia has been provoked into the persuasiveness of globalization. Politicians are aware that the devaluation of the Australian dollar and deregulation of our capital markets will increase our export capacity, and hopefully bring Australia from a position where we are less dependent upon exports which are unprocessed. There is a belief that globalization will improve the chances for people by enabling them to receive greater opportunities, and that democracy will have a greater chance of becoming globally compelling. Changes have meant that twenty-first century technology and design systems have rehabilitated the heavy industry practices of Modernism. Automation, robotics, computers and cyber space have completely changed how and where designers practise. For example, the contemporary designer may initiate computer-generated designs in one country and then the product is created at high-tech plants in several other countries. In recent years technological advance is so rapid in software design that very often, commercial advantage depends on the frequency of releasing new models.

Ivan Illich cautions us in our rush to exploit technology by commenting 'People feel joy, as opposed to mere pleasure, to the extent that their activities are creative', he goes on to add 'the growth of tools beyond a certain point increases regimentation, dependence and exploitation'[2]. The reason Illich is cited at this point is to emphasize the pre-eminence of creativity in the design process. Technology might produce new tools for the manufacture of products and services, however they are only aids and, by themselves, cannot add value economically, socially or culturally.

The creative work of the designer always remains central to the production of innovative, functional and relevant products and services. This may be the focus for a campaign to politicians by design and technology educators, with the purpose of articulating explicit links that show the essential benefits of supporting school curriculum where the purposeful application of knowledge, experience and resources can contribute to rehabilitate a nation through the creation of products and processes, which meet human needs.

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Achieving Technological Literacy:

Educational Perspectives & Political Actions

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Introduction

More than any time in history, technology education seems poised to assume a more significant role in American education, but how should the profession proceed? In particular, how should the professionals in technology education approach the political processes implied by the proposed changes. Many questions attend the political arena—What does it mean to get actively involved in the political process that brings about purposeful change in the status of a curricular area such as technology education? What might be the consequences, both positive and negative, if one does or does not get involved in the process? Should political activity be limited to selected individuals, groups, and associations in the profession or should all professionals become politically active? Should political action become a primary purpose of our professional associations?

This essay identifies perspectives associated with the reform of technology education and begins the discussion of political activity as it applies to achieving technological literacy. In developing the paper I begin with a general discussion of different domains of educational reform. The second section uses those domains to present a useful model for understanding the translation of broad, abstract purposes, such as achieving technological literacy, to more concrete policies, programs, and finally to practices of teachers. The model incorporates the role of politics as the goals are translated to practices. Several national reports, e.g., *Standards for Technological Literacy* (ITEA, 2000), *Technically Speaking (NAE, 2002)*, are used as examples that clarify various components of the model and associated politics. Finally, I elaborate recommendations for political leadership for technology education.

Educational Perspectives and Political Difficulties

Reform in technology education can begin in different ways. Professional technology teachers could change how they understand effective practice and function in the classroom. Professional technology educators could design new programs that take content, assessment, and instruction into account. Policy makers could set new policies based on what they think citizens need and want. Finally, those who review trends and issues in society and technology education could use their analysis to identify new goals and purposes.

The loosely connected levels at which reform operates those just identified, could be described as—purpose, policy, program, and practice. Each level has its own perspective on what is important, how the educational system works and the implied politics of reform. The philosophers who talk of purposes can argue their case, publish their ideas, and try to persuade others: their influence, however, is limited to persuasion. Policy can set conditions for effective programs and practices, but at the national level, it cannot mandate school programs and classroom practices. Setting the conditions, however, does influence decisions and can result in mandates at the state and local levels. Setting a curriculum framework and adopting a program within a state or school district directly influences effective practice and provides certain opportunities for students to learn about technology. It does not control technology teachers or technology teaching.

Here is an essential issue for technology education: we need a system that is consistent and coherent, one that has a coordinated set of purposes, policies, programs, and practices. We have to honor the right of states and local school districts to set policies and select programs they think will help their students achieve higher levels of technological literacy. But state and local school personnel also have a responsibility to design and implement technology education systems that achieve common goals such as technological literacy.

Purposes

Internationally and locally, technology educators need a purpose, ideally one that is congruent across the different grade levels and different aspects of the discipline. Without a purpose, technology education lacks direction, coherence, and coordination. The purpose statement for contemporary reform might be "achieving technological literacy for all students." Support for this goal already exists in reports such as *Technically Speaking* (NAE, 2002).

Virtually everyone in technology education at any level should be able to agree on a purpose such as achieving technological literacy. Widespread agreement and support provide unity and universal acceptance among technology educators in all aspects of the discipline and at all educational levels. Paradoxically, the strength of purpose statements—universal agreement—is their abstract quality, which also is their weakness. Those concerned with other, more specific aspects of technology education do not regard purpose statements as helpful or useful; and subsequently they may represent a political backlash if their concerns are not addressed. This is why purposes need to be translated into policies.

Policies

Translating a major purpose into specifications and requirements that are usable by various educational factions introduces policy. The *Standards for Technological Literacy* (ITEA, 2000) exemplifies national policies. Policies can address different aspects of education, such as curriculum, instruction, assessment, professional development, equity issues, disciplines, grade levels, teacher education, and program implementation; they should represent the board initial purpose and the specific concerns, needs, and requirements of the educational component being addressed. They also should inform and regulate the decisions made in the actual development of programs. Policies would, for example, help answer questions about how to achieve technological literacy through curriculum materials developed for students in elementary schools. Although policies are not as abstract as purpose statements, they lack the ultimate practical value for classroom teachers.

Policies provide an essential bridge between purposes and programs, but they lack the usefulness of lesson plans. Curriculum frameworks, a new feature on the technology education landscape, have proven helpful to supervisors and curriculum developers at local, state, and national levels, but they remain policy statements, a little more concrete than national reports, but not as usable as curriculum programs. Herein lays a need for political action. Policy changes, whether national, state, or local often present major challenges.

Contemporary reform can be characterized as one that predominately consist of policies much more than one of programs. Certainly we need policies, but I think we have reached the point of diminishing returns from policy statements. Now we need programs, whether they are developed by national groups, such as the International Technology Education Association, the BSCS, or other groups.

Programs

Technology education programs should be consistent with policies. They are, in fact, a concrete representation of policies. The continuity between purpose statements and programs should be strong and well coordinated. Examples of technology education programs abound. They include a variety of curriculum materials, teacher education programs, and assessment packages.

In the adoption process of educational reform, many local school districts develop policy statements and then identify programs that best match these policies. When district personnel realize the magnitude of developing a technology education program,

they often find it more reasonable to opt for a program developed by another group and commercially available. Here one confronts the policies of selection and implementation.

Practices

Any technology educator who has made a presentation at a conference also has had the experience of answering teachers' questions about the appropriateness of the purposes, policies, and programs in their specific situation. The explicit implication is that the purposes, policies, or programs are useless or to be kind, not very helpful. These questions reinforce the need for the final step in translating purposes to practices. Each classroom is a unique system. Each teacher has particular strengths and skills, understands his or her students (as individuals and as a group), and works within this unique environment. What this suggests is that technology teachers have a professional responsibility to adapt materials to their individual classroom situation. Of course, teachers ought to have support, for example, through professional development. That assigns appropriate responsibility to other technology educators, such as supervisors and teacher educators; and to school personnel, such as superintendents and building principals. Adaptations and improvements also should be consistent with local, state, and national policies, especially those programs related to effective teaching whose outcomes inspire popular consensus.

The Politics translating the Educational Perspectives

At the interface between these initiatives are technology educators, who assume responsibility for translating purposes to policies, policies to programs, and programs to practice. Their work is absolutely critical to the whole process of technology education reform; and, their work is, in large measure, political. Indeed, the essential feature of this process relates to my theme of political activity. Political action must be informed by national perspectives and mediated by local mandates. School personnel working on reform should be familiar with the *Standards for Technological Literacy* (ITEA, 2000) and demonstrate sensitivity to local issues and concerns.

Individual technology educators face a difficult task ensuring consistency and coordination among different components of the system. Each political step is like a phase change in states of matter: it requires energy for activation. By interacting, teacher educators, state and local supervisors, assessment specialists, and professional developers all facilitate the translation of policies to programs and programs to practices.

National reports provide technology educators with the language necessary to justify general policies, broad guidelines, and comprehensive frameworks for curriculum programs and instructional practices. With occasional exceptions, however, the reports seldom translate abstract purposes and policies into concrete programs and practices. If reform is to continue, educators must develop programs consistent with report recommendations, their respective disciplines, and approaches to technology content within the requirements of school systems, and with the requisite needs and interests of students. The development of new programs brings educational reform closer to reality and to the human scale of classrooms.

The aforementioned terms—*purpose, policy, program,* and *practice*—characterize various perspectives of educational reform, but any assessment of reform also must examine the changes that result. I equate change with improvement—at the level of technology teacher practices and students achieving higher levels of technological literacy. The real arena of reform is the classroom. Contemporary reform will only occur when technology teachers, technology teaching, and student learning change. Yet at the most basic, essential, and important level, that of the classroom, reform is extraordinarily difficult. Why is this so?

The Dimensions of reforming Technology Education

Table 1 summarizes some of the dimensions of educational reform. If one considers time, scale, space, duration, materials, and agreement on different educational perspectives, the difficulties become clear. It may take a year or so to develop new statements of purpose and revise goals, but to actually adapt curriculum materials and teaching strategies in response to the new purpose takes much longer, perhaps seven to ten years.

Those who discuss the reform of technology education often convey little understanding of the scale of change we are trying to achieve. Holding workshops for 20 teachers or visiting a school and talking to students and teachers in order to improve technology education are admirable gestures, but the number of school districts (about 16,000), schools (about 110,000), and technology teachers (more than 1 million) is too large to assume that such gestures contribute very much unless they consistently focus on one set of messages, such as the national standards. This does not take into account the critical issue of scale, namely one visit for one hour, compared to the hundreds of hours a teacher spends with students during a school year.

Let us consider for a moment the space involved in reform, that is, the location of change and the potential impact of that change at that location. Purpose statements abound and have been widely disseminated. The actual objectives of technology education—acquiring technologic knowledge, developing process skills and habits of mind, understanding the personal and social dimensions of technology, and examining careers—are common worldwide. The emphasis on various goals and programs, of course, varies considerably.

Once a change has occurred in one of the perspectives, how long does it last? Answering this question provides considerable insight. Goals can change every year. As long as society changes, the goals emphasized will change, and as long as technology advance, these goals will undergo continual modification. Why a year? This is about how long it takes to develop, publish, and disseminate an article, report, or book. Establishing policies may take longer, perhaps several years, but they usually last longer, a minimum of five years. What about the duration of a program once it has been developed and adopted by a school district?

Table 1

Educational Perspective	*Time* *How long it takes for change*	*Scale* *Number of individuals involved*	*Space* *Scope and location of the change activity*	*Duration* *How long innovation stays once change has occurred*	*Materials* *Actual products of the activity*	*Agreement* *Difficulty reaching agreement among participants*
Purpose • Reforming goals • Establishing priorities for goals • Providing justification for goals	1-2 Years To Publish document	Hundreds Educators who write about aims and goals of education	National/ Global Publications and reports are disseminated widely	Year New problems, new goals, and priorities proposed	Articles/ Reports Relatively short publications, reports, and articles	Easy Small number of reviewers and referees
Policy • Establishing design criteria for programs • Identifying criteria for instruction • Development frameworks for curriculum and instruction	3-4 Years To develop frameworks and legislation	Thousands Policy analysts, legislators, supervisors, and reviewers	National/ State Policies focus on specific areas	Several Years Once in place, policies not easily changed	Book/ Monograph Longer statements of rationale, content and other aspects of reform	Difficult Political negotiations, trade-offs, and revisions
Program • Developing materials or adopting a program • Implementing the program	3-6 Years To develop a complete educational program	Tens of Thousands Developers, field-test teachers, students, textbook publishers, software developers	Local/ School Adoption committees	Decades Programs once developed or adopted, for extended periods	Books/ Course Ware Usually several books for students and teachers	Very Difficult Many factions, barriers, requirements
Practices • Changing teaching strategies • Adapting materials to unique needs of schools and students	7-10 Years To complete, implementation and staff development	Millions School personnel, public	ClassRooms Individual teachers	Several Decades Individual practices for a professional lifetime	Complete System Books plus materials, equipment, and support	Extra-Ordinarily Difficult Unique needs, practices and beliefs of individuals, schools and committees

I would estimate that once a school program for technology changes, the new version lasts a decade. Once school districts adopt a technology program, that is, the textbook and materials remain, in various forms, for at least two cycles of district review and revision. Finally, what about the duration of classroom practices? Individual teaching practices probably last several decades, the professional lifetime of most technology teachers. Is there a more compelling reason to concentrate on educating the undergraduates who will eventually become the technology teachers of tomorrow? Undergraduate courses in technology provide models of teaching and obviously have tremendous influence.

Materials increase in size and complexity with each educational perspective. New purpose statements can be presented in articles and reports and other relatively short publications or disseminated via the web. Policy statements require more expansive formats, perhaps a monograph or a book in length. Technology programs require a complex set of student and teacher materials, including books, equipment, power point presentations, and various other educational technologies. Classroom practices also require extensive materials as well as equipment and support within the school system. A hands-on, materials-oriented program in elementary schools, for example, presumes some arrangement to supply and replenish kits for teachers.

All these perspectives illuminate the issue of reaching political agreement. Developing and publishing new purposes involves a relatively small number of people, and they do not have to agree entirely with the author or authors. Agreeing on more specific policies is more difficult and often requires political negotiations recognizing and accepting and trade-offs. Adopting a new program for technology education means considering a national agenda, state frameworks, local syllabi, community priorities, budgets, and what is most important, teachers' knowledge, skills, and beliefs about technology and technology education. But the story does not end here. Once a district agrees on a program, a further difficulty arises, that of accommodating the needs and concerns of the teachers who must implement the program. School personnel must agree on teaching strategies and on how to accommodate the program and the philosophy inherent in earlier agreements.

Even at a general level, Table 1 gives the impression that reform has just begun. If we are really serious about improving technology education, we should begin thinking about and acting on developing and implementing programs and improving teaching through ongoing professional development.

Difficulties of Reforming Technology Education

Table 2 illustrates another aspect of the political difficulties of educational reform (using technological terms such as *risk, cost, constraints, responsibilities,* and *benefits*, as categories). Moving from the abstract, impersonal scale of the national report to the concrete, personal scale of the classroom, descriptions in the table indicate that vulnerabilities increase dramatically. The responsibilities and requirements of leadership likewise increase. Educators outside the classroom place a tremendous burden on technology teachers, often with little recognition of their needs and little support for the tremendous changes required. It is incumbent on every educator who is not in a K-12 technology classroom to support those who are ultimately responsible for reform. Table

2 assumes that the new purposes in the many reports on reform must be transformed into policies, programs, and eventually practices. The political problems increase as these transformations reach technology classrooms, the critical level of reform, although, at the same time, the benefits to students also become clear.

Table 2

Perspectives	Risk to Individual School Personnel	Cost to School in Financial Terms	Constraints Against Reform for School	Responsibility of School Personnel for Reform	Benefits to School Personnel and Students
Purpose - Reforming Goals - Establishing priorities for goals	Minimal	Minimal	Minimal	Minimal	Minimal
Policy - Establishing design criteria - Identifying criteria for instruction - Developing frame work for curriculum and instruction	Moderate	Moderate	Moderate	Moderate	Moderate
Program - Developing materials or adopting a program - Implementing the program	High	High	High	High	High
Practices - Changing teaching strategies - Adapting materials to unique needs of schools and students	Extremely High	Extremely High	Extremely High	Extremely High	Extremely High

Individual perspectives on reform are often constrained by professional responsibilities. For technology teachers, these might be the practical requirements of classroom life, and for others, curriculum development and state bureaucracies. We need leadership at all these levels from those in a position to translate and adapt purposes to policies, policies to programs, and programs to practices. Key leaders in this process of adaptation are teacher educators, supervisors, assessment specialists, professional developers, and school administrators, who can not only function in ways that control and regulate the process of reform and cross boundaries, but also reduce constraints and provide support and feedback for innovative practices. These leaders work to articulate the purposes, policies, programs, and practices of technology education; and their responsibility is to do a thorough and excellent job. Other individuals in leadership positions are responsible for adapting policies to programs and programs to practices.

The frameworks described here provide a useful assessment of progress in transforming technology education, although one also can get a sense of progress by determining the time, budget, and effort being spent on the various initiatives. Is the school district spending more time, more money, and more effort on developing its goal statement or on implementing the new technology education program? At the national level, is funding concentrated on policy statements or on various curriculum materials and professional development programs? I have observed considerable policy effort at the national and state levels. At the local level, committees often spend little time discussing and debating philosophy and goals; more time on policies for elementary, middle, and high school; a great deal of time developing curriculum materials or deciding which program to adopt. But they devote very little time, money, and effort to implementing a program or to professional development once a program has been developed or adopted. (I would be happy if many agencies and school districts prove this analysis wrong.)

Personal Perspectives on Political Actions

The perspectives presented in this essay have primarily been internal to the technology education profession. That is, I have addressed changes implied by the *Standards for Technology Literacy: Content for the Study of Technology*. The political actions either directly state or implied would belong to a diverse group mostly within the profession of technology educators. So, the discussion at least partially, answers the question - What does it mean to get politically involved in technology education? I have tried to convey the message that political action is not something done by specifically designated individuals. Political action involves all those within the profession of technology education.

To the question - What are the consequences? - I can answer a more coherent system of technology education and increased possibilities of achieving higher levels of technological literacy. Who should be involved? Well, it seems clear, to me at least, that some responsibility for political actions falls to all. Political action has the greatest power and largest possibility for change when it comes from within and has a unified purpose, such as achieving technological literacy through implementation of programs and practices designed to achieve the national standards.

Should political actions be a primary purpose of professional organizations such as ITEA? For the type of actions discussed or implied in this essay, my answer is yes. However, if the questions implies large scale political action (with a capital "P"), my response would be no. The purposes of professional organizations vary and include political actions such as lobbying (within legal limits), but extend to other, non-political domains such as publications, programs, and professional development.

In closing, I would note that the work of education has increasingly become political. Leadership within the technology education community understands this and has established ties with agencies such as the National Science Foundation (NSF) and organizations such as the National Academy of Engineers (NAE). These associations have not always been easy, they have always been political and, for the most part, they have advanced the goal of achieving technological literacy.

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Chapter Eight

Technology Education and Vocational Education

The Perplexing Relationship between Technology Education and Career and Technical Education in the US

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Examining Cognitive Bases for Differentiating Technology Education and Vocational Education

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The Perplexing Relationship Between Technology Education and Career & Technical Education in the US

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Introduction

These are interesting times for Technology Education (TE). Efforts to position TE as the delivery system for technological literacy (TL) in the K-12 curriculum have led to new and powerful alliances among the Science, Mathematics, Engineering, and Technology Education (SMET) communities. Due in large part to TE's efforts, TL *will* become a component of America's 21st century curriculum. However, science education—a required K-12 subject with a national K-12 technology standard all its own—is far better positioned than TE to become *the deliverer*. Within a decade, science education will declare itself *the deliverer* of TL in grades K-12, and will show test results to substantiate its claim.

Meanwhile, Career and Technical Education (CTE) is working to re-invent *their* high school curriculum for the 21st century. CTE's talk of problem-solving activities, clusters rather than unit shops, education rather than training, articulation with higher education, and baccalaureate-degreed teachers, might easily be mistaken for TE rhetoric. Ironically, that could lead CTE to use the *Standards for Technological Literacy (SFTL)* to guide/justify *their* new curriculum.

The purpose of this paper is to address the relationship between TE and CTE. I found it impossible to do so without casting this issue within the *TL for all* context. Currently, TE is positioning with SMET, while downplaying its relationship with CTE. Paradoxically, TE programs in most states across the US continue to harvest federal and state vocational monies to fund new labs, hire TE administrators, and update curriculum.

Those who suggest TE has no role to play with respect to vocation are in denial. One of the fundamental arguments for TL is the benefit it provides the economy and workforce (Pearson & Young, 2002, pp. 40-42). Industrial Arts/TE has more than a century of "history" with vocational education/CTE *because* of the pre-vocational implications of the IA/TE curriculum, particularly at the high school level.

The TE SMET alliance and TL for all initiative may—or may not—play out well for TE. With no direct access to K-5 education, limited access to grades 6-8, a high school curriculum that *Technically Speaking* would characterize as "technical competency" [for some], a nationwide critical teacher shortage and teacher education crisis, and shared access to the *Standards for Technological Literacy*, TE's role in the TL for all mission remains an open question.

TE plays a very important role in general education and should certainly continue to move forward with SMET initiatives, particularly at the K-8 level. That said, TE also needs to *clarify the purpose* of its high school curriculum, and the ways in which that curriculum does, or does not articulate with CTE as well as with 2- and 4-year technical *and* professional*/* post-secondary education.

Historical Evolution of the Relationship

Early 20th Century: The Dichotomy Begins to Take Shape

The current relationship between TE and CTE is the result of a century tension between the two groups. From the onset, early leaders in the field we now call TE recognized both the general education and vocational benefits of their work. While most early manual training experiments were vocational in nature, some were grounded in the principles of general education (see, for example, Gerbracht & Babcock, 1969, Foster, 1997). In the early 20th century, Bonser and Mossman (1923) were among the first to conceptualize curriculum models that involved the study of industry. Their work became the basis for the general education philosophy of industrial arts (IA) throughout the 20th century (Foster, 1997). Less well known is the fact that Bonser conceded the vocational benefits of IA *at the high school level*, suggesting it was "of the very highest value as applied to vocational work" (Bonser, 1914, as cited in Lewis, 1996).

The Smith-Hughes Era: Forced Choices

In the early 20th century, the escalating demand for skilled workers led to the establishment of the National Society for the Promotion of Industrial Education, which mobilized a broad coalition of support for a new vocational education system. Charles Prosser emerged as the leader of this movement. His social efficiency philosophy—the notion of preparing individuals for specific jobs based on an analysis of tasks and "habits" to be performed in that job—not only shaped the Smith-Hughes Vocational Education Act of 1917, but provided the framework for vocational education throughout the 20th century.

The Smith-Hughes Act forced those in the manual training community to choose between vocational and general education philosophies. The "vocationalists"[5] became the trade and industry (T & I) vocational educators, while the "generalists" chose a path that led to IA education. Vocationalists benefited immediately from federal monies

[5] "Vocationalist" will be used throughout this paper to refer to the vocational education community, and those within the IA/TE communities who believe strongly in the vocational purposes of their work. "Generalist" will be used to refer to those in the IA/TE communities who believe their field is a component of "general education."

provided by the Smith-Hughes Act. Generalists did not. Thus, the Smith-Hughes Act accentuated a tension between generalists and vocationalists that has defined their relationship over the past century.

This tension was evident as new national associations set sail in mid-twentieth century. Soon after the founding of the American Vocational Association (AVA) in 1926, IA vocationalists successfully lobbied for an IA Division, which was formally established in 1932 (Barlow, 1986). What is now the National Association of Industrial and Technical Teacher Educators (NAITTE) also sought to include both vocationalists and generalists. Their 1937 constitution said they would "embrace all persons who devote half or more of their time to teacher-training in Industrial Education, either general or vocational" (Evans, 1988, p. 23).

William Warner led a contingency of generalists who wished to strengthen alliances with the general education community. Although both the AVA and NAITTE were a viable option for IA generalists in 1939, Warner chose instead to establish the American Industrial Arts Association (AIAA). Three years later, the AIAA's "recognition of a need for closer affiliation with leadership in the general field of education" (Barlow, 1967, pp. 83-84) led them to establish the AIAA as a new department of the National Education Association (NEA).

Latter 20th Century: Conceding the Pre-vocational Component of IA/TE

Despite their strong general education commitment, even the staunchest of IA/TE generalists in the latter half of the 20th century acknowledged a *pre-vocational* role:

- Warner (1947, 1965) felt that high school level IA provided "a sound basis for a possible industrial-vocational education" (p. 41).
- Lux (1970) wrote: "The opportunities to provide a sound and thriving industrial arts that would serve both pre-citizenship *and* pre-vocational purposes have not been enhanced by the myopically conceived and even more narrowly interpreted federal legislation" (p. 221).
- Maley (1973), wrote: "How does one study occupations with a sense of meaning and relevancy?…. The task of broadening the student's perspective of the range of employment possibilities is most important" (p. 4).
- Jackson's Mill Industrial Arts Curriculum Theory (Snyder & Hales, 1981) included this goal statement: "To explore and develop human potentials related to responsible work, leisure, and citizenship roles in a technological society" (p. 42).
- *Conceptual Framework for Technology Education* (Savage & Sterry, 1990), the most recent "framework" endorsed by the ITEA prior to the Technology for All Americans Project, made numerous references to pre-vocational purposes of TE, including:
- "Technology education should… enhance skills and understanding regarding occupational productivity, personal responsibility, and career opportunities in the community and world society" (p. 27).

- "Recommendation #6: Technology education can provide a foundation for an increasingly technologically capable work force. Technology educators should contribute to the technical preparation efforts through the community college level and at four-year institutions" (p. 30).

Federal Vocational Funding for Industrial Arts/Technology Education

Sensing an opportunity in the late 1960s and early 1970s, a group of IA leaders/vocationalists lobbied for a share of the federal vocational monies (Steeb, 1979). Their efforts literally paid off with the passage of the 1972 amendments, which "permitted the funding of industrial arts education programs…that…facilitate one or more of the purposes of vocational education as defined in Section 108(1) of the Vocational Education Act of 1963" (Steeb, 1976, p. 171). In 1976, IA gained more direct access to these funds by successfully lobbying for the inclusion of IA as a "line item" in the federal legislation (Steeb, 1979).

IA vocationalists had their prize. IA generalists were forced to re-examine their values and choose between principle and principal. Temptation quickly won out. By 1976, 76% of the states had already included IA in their state vocational education plans, and 64% of the states had begun to use these federal vocational monies for IA education (Steeb, 1976).

The Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1990 was a response to the changing nature of the US economy and social climate. The Perkins Act encouraged the abandonment of many of the tenets of social efficiency/job-specific training. Rosenstock (1991, p. 434) observed, "The Perkins Act of 1990 is unlikely to grab the attention of regular educators. But it should. The act is an important step in redirecting vocational education and, ultimately, in restructuring our high schools for the twenty-first century." Wirth (1992, p. 154) seconded the motion, saying it "contains the potential for a conceptual restructuring of vocational education—and beyond that, offers fresh hypotheses for the liberalizing of general education."

The changes set in motion by the Perkins Acts of 1990 and 1998 have been largely ignored by TE academics and leaders. We should take more notice. The Perkins Acts have encouraged vocational education to integrate their work with academic subjects, and through the Tech Prep initiative, articulate closely with postsecondary education. These changes "were intended to position the Perkins Act as a tool for educational reform" (American Vocational Association, 1998, p. 8). In light of the fact that even TE *generalists* embrace both of these goals, it behooves the TE community to become more proactive with respect to developing a vision for TE at the high school level, with careful consideration to how the high school curriculum does or does not fit into the bold new 21st century CTE initiatives.

The Perkins Acts have *not* escaped the notice of TE supervisors and practitioners. As part of my research for this paper, I surveyed state TE supervisors across the US regarding their use of Perkins monies and other state-budgeted vocational education monies for TE.[6] I found that 40 (83.3%) of the 48 states for which I received data currently use Perkins monies to support TE programs. About two thirds of the respondents also said they use state-budgeted vocational education (non-Perkins Act) funds to support TE programs. Although federal monies provide only a small percentage of TE support, this use partially explains why many states position TE administratively within CTE, and why many consider TE a component of vocational education.

Current Status of the Relationship Between TE and CTE

For all of the aforementioned reasons, there remains, a tension between the TE and CTE communities. On the one hand, some generalists maintain TE has little or no role to play with respect to the workforce, and thus should have little or no relationship to CTE. On the other hand, many local administrators have literally built their TE programs with vocational monies. Mixed messages continue to confuse people both within and beyond the profession.

Contemporary literature supports a dual mission for TE—TL as general education, *and* pre-vocational purposes. While making the case for TL, ITEA's *Technology for All Americans: Rationale and Structure for the Study of Technology* (1996) includes, among others, the following pre-vocational references:

- "Indeed technological literacy is vital to individual, community, and national economic prosperity" (p. 6).
- "Technological activities provide the base for the country's economy. As new advances provide more opportunities, the need grows for technologically skilled engineers, innovators, and workers to develop and maintain a competitive edge in a global economy" (p. 8).
- "As a result of taking TE, students. . . develop personal interests and abilities related to careers in technology" (p. 40).
- "Some students who study technology in high school will pursue technological careers after graduation, such as engineering, architecture, computer science, engineering technology, and technology teacher education" (p. 40).

Similarly, *Technically Speaking* (Pearson & Young, 2002)—perhaps the most visible anthem for TL—addresses the pre-vocational aspects of TL in considerable detail in a section titled "Supporting a Modern Workforce," some of which is summarized as follows:

> Because our economy is increasingly being driven by technological innovation and because an increasing percentage of jobs require technological skills, a rise in technological literacy would have economic impacts. For example, a technologically literate public would generate a more abundant supply of technologically savvy workers who would be more likely to have the knowledge and abilities—and find it easier to learn the skills they need—for jobs in

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[6] I sent a brief survey by email, and followed up repeatedly with non-respondents. For the 10 states that did not have a state supervisor identified, or for which I did not receive a response, I asked the state CTE supervisor or a TE teacher educator for this information.

> today's technology-oriented workplaces. To the extent the study of technology encourages students to pursue scientific or technical careers, then improving our technological literacy would also lessen our dependence on foreign workers to fill jobs in many sectors. (pp. 4-5)

Beyond the literature, many *practitioners* believe that TE plays a pre-vocational role. Sanders (2001), conducted a national study of middle school and high school TE programs. Approximately 60% of the respondents associated their program with general education, while roughly 40% associated more with vocational programs.

Sanders (2001) also asked respondents to rank the purposes of TE. The list included 10 purposes used in the Schmitt & Pelley study of 1963, two additional purposes from the Standards for IA Programs Project study of 1979, and four more culled from the *Conceptual Framework for Technology Education* (Savage and Sterry, 1991). Of the 16 total purposes, respondents ranked "Provide vocational training" dead last. "Develop skills in using tools and machines," which ranked first in both 1963 and 1979 dropped down to 11th. Clearly, practitioners do not perceive TE as vocational training. However, "Make educational and occupational choices," "Provide technical knowledge and skill," and "Provide pre-vocational experiences" ranked third, sixth, and tenth, suggesting that practitioners continue to harbor at least a moderate commitment to pre-vocational purposes.

A cursory examination of the high school TE curriculum is also telling. I suspect *Project Lead the Way*—pre-vocational engineering courses—are the most rapidly increasing high school TE course titles in the US. In Virginia, "Introduction to Engineering" has been offered at the high school level for more than a decade. Many TE programs offer *three years* of Drafting/CAD in high school, and employ the same texts and instructional methods as do CTE Drafting/CAD programs. Instructors in these TE programs provide pre-vocational skills to students pursuing engineering and architecture, and take pride in graduates who find immediate employment using AutoCAD.

While TE leaders and university faculty generally accentuate the *differences* between TE and CTE, in high school practice the boundaries are often somewhat difficult to define. Over the next few decades, the changing goals of CTE will make it even more difficult to distinguish the differences at the high school level.

The Climate for Change in the CTE Community

Rapid technological change in the last quarter-century has resulted in what many call the *new economy*. Analog machines have been replaced by increasingly sophisticated digital technologies. Our military might, medical prowess, and production capability are all defined by technological innovation, which in turn impacts workforce needs. Lynch (2000) sums this up succinctly: "Fewer than 20% of the jobs in the new economy are classified as unskilled. This is almost an exact reversal of the nature of the American work force just 40 years ago" (p. 23).

According to Gray (1995, 1996), parents and students are fully convinced that good jobs now require a college education. Citing government data, he describes a mass student exodus over the past two decades, out of T & I programs into the non-honors/non-advanced placement college prep track. According to Gray, the data indicate most of these students are failing in college, leaving them without marketable skills and without a college degree.

As a result of the new economy, changing public perceptions, and a public education system that some say is currently failing "students in the middle," there is a growing realization in the CTE community that the job-specific training model is no longer an effective means of preparing workers for the 21st century. CTE's new name signals a new philosophical approach. . . as did TE's name change about 15 years ago, and we know how different TE looks just 15 years later. Building on the ideas begun with the Perkins Act of 1990, CTE leaders are proposing bold new alternatives.

Lynch (2000) has captured much of this in a comprehensive research report titled *New Directions for High School Career and Technical Education in the 21st Century*. He concluded:

> … the new economy clearly calls for more inclusion of *thinking* and *culture* into career and technical education…. It isn't just "training" for specific jobs, but 'education' to make decisions, solve problems, find answers, and draw on a variety of disciplines and cultural contexts to make sense out of changes, challenges, and day-to-day operations in the workplace…. This leads to the integration of vocational and academic education, which may be among the most important recommendations emanating from Congress in the past three Perkins Acts. (p. 33)

This language is reminiscent of that which we might find in the TE literature. The notion of integrating with academic subjects—which CTE has worked toward for more than a decade—is a recurring theme in TE literature, and perceived by some to be the most significant way in which TE can impact education (Herschbach, 1997). Of particular relevance to this paper are the purposes of high school CTE that Lynch (2000) proposes for the 21st century:

- "providing career exploration and planning;
- enhancing academic achievement and motivation to learn more;
- acquiring generic work competencies and skills useful for employment; and
- establishing pathways for continuing education and lifelong learning" (p. 42).

CTE seeks to redefine its 21st century high school curriculum. The terminology they are beginning to use—problem-solving, career exploration, academic achievement, motivation to learn, and pathways to continuing education—is more akin to TE generalist philosophy than Prosser's "habits of work." CTE's new directions may be more in step with the goals of TE at this juncture than at any other time in history.

Communication Channels

The current relationship between TE and CTE might be likened to a marital separation. Communication channels have broken down, the two parties are rarely seen together in public, and expressions of contempt are sometimes heard behind closed doors. Yet, one partner continues to receive financial support from the other.

ITEA's elimination of its Liaison Committee several years ago—which sought to foster communication between ITEA and the TE Division of the ACTE—is symptomatic of the communication challenge facing all levels of the profession. The TE

Division of ACTE is arguably the primary formal connection at the national level between TE and CTE. Yet, attendance at ACTE-TE Division meetings has been meager over the past two decades, and although the vice-president of the TE Division serves on the ACTE Board of Directors, all indications suggest that TE has had relatively little input into CTE policy issues in recent years.[7]

Despite the relatively idle traffic along the communication channels, there are pressing questions that suggest an urgency for greater dialogue:

- Can TE successfully court the STEM alliance while TE programs in most states continue to receive federal and state vocational monies?
- If the TE/STEM alliance continues to escalate, could that new relationship result in TE some or all federal and state vocational monies? What impact might this have on TE programs?
- If—as *Technically Speaking* seems to recommend—science and other non-technical subjects become the delivery system for K-12 TL, what future role *will* TE play in education?
- What role, if any, should TE play in CTE's curriculum for the 21st century?

If enhanced dialogue is deemed a worthy goal, what steps might be taken toward that end? Keeping in mind that most educational decision-making in the US occurs at the state and local levels, it would be critical to involve state and local supervisors in the conversations. Nationally, the ITEA might reinstate its Liaison Committee, and the ACTE-TE Division and ITEA might expand the committee by inviting key individuals from both camps to join the committee. The Perkins Act reauthorization, scheduled for 2003, could serve as a key agenda item.

The NAITTE is another avenue for enhanced dialogue. Its *Journal of Industrial Teacher Education* (*JITE*) and annual conference sessions have always provided an opportunity for the formal interchange of ideas between the two groups. The notion of forging a closer relationship between generalists and vocationalists could help to revitalize NAITTE, which has struggled with membership over the past decade. NAITTE might consider alternating its meetings between the ACTE and ITEA conferences on a trial basis. Alternatively, NAITTE, the ACTE-TE Division, and ITEA might jointly seek external funding to support a series of meetings.

While meetings and literature provide excellent communication opportunities, each of these constituencies host separate meetings and publications, so communication *among* the various groups is limited. To address this problem, Listservs could be established to facilitate dialogue across the different constituencies. One Listserv might be open to all, while a second could be used privately by a working group, such as the ITEA / ACTE-TE Division Liaison Committee.

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[7] I drew this conclusion from ACTE-TE Division literature and from Summer and Fall 2002 telephone interviews with Joseph Burke, William Dugger, Theodore Lewis, Joseph Scarcella, Kendall Starkweather, Daisy Stewart, and Doug Wagner.).

Future Scenarios

I have been asked me to predict the impact of both an improved—and severed—TE/CTE relationship. Predicting the future is dicey business. The following three scenarios are an attempt to suggest different possible twists and turns the TE/CTE relationship might take, in light of ongoing efforts between the TE and SMET communities, and related factors.

Blue Sky Scenario

The *Technology for All Americans Project* succeeds beyond all expectations, TE becomes a required K-12 subject alongside English, mathematics, science, and social studies, and thus receives additional general education support. Reauthorization of the Perkins Act in 2003 results in an enhanced relationship between TE and CTE, and TE programs in nearly all 50 states are supported with federal and state CTE monies. In addition, the new Perkins Act provides substantial support for TE teacher education, and TE begins to prepare technology teachers for grades K-12 in unprecedented numbers. In accordance with the recommendations of *Technically Speaking*, *all* teacher education students are required to take a course in TE to prepare them to assist in delivering K-12 technological literacy. TE finds meaningful ways to integrate its work with most K-12 school subjects, including CTE. High school TE effectively articulates with 2- and 4-year postsecondary technical *and* professiona*l* programs.

Cloudy Skies Scenario

As per Bybee's (2002) recommendation, one required TE high school credit is supported in many of the 50 states, resulting in exploding high school TE enrollments. Reauthorization of the Perkins Act results in continued federal vocational monies for TE in most states. However, there is no new federal money for teacher education or K-8 TE, and state and local revenue shortfalls result in reduced support for TE programs. Where there is good local support, TE continues to do reasonably well with its 9-18 week middle school requirement. But the dire shortage of licensed TE teachers leads to masses of "emergency hires" and alternatively licensed TE teachers and the use of courses from other subjects to meet the one credit requirement in TE. A lack of communication between TE and CTE leads to new CTE courses that look surprisingly like TE courses and are justified with the *SfTL*. Confusion persists regarding the role of TE at the high school level.

Tornado Watch Scenario

State standards and accountability grow ever important in educational reform. In the spirit of the *SfTL* and *Technically Speaking,* reform efforts emphasize the integration of TL content into academic subjects. Science education develops TL curriculum consistent with its "Science and Technology" standard (National Research Council, 1996) and the *SfTL* along with standardized assessments, and quickly emerges as *the* recognized TL delivery system. Science thrives in the schools, *because* situating science content within the context of technological problem-solving finally allows kids to "get" science. Due to increased academic requirements, the public perception that the new economy demands a postsecondary education, and a severed relationship between TE and CTE, the responsibility for developing *technical competence* moves from the high school to 2-year colleges. Federal CTE dollars are re-directed to 2-year colleges, or to alternative high schools for "academically disadvantaged" students. TE loses all federal and state vocational monies, and support from general education sources decreases as well. High school TE enrollments plummet, though middle school TE continues to tread water where local support allows. During TE's final years in the high school, it is increasingly perceived as a "dumping ground" for the academically disadvantaged, as alternative high schools and privatized trade schools gradually absorb this clientele.

Conclusions

The current TE/CTE relationship is strongly influenced by a century of tension between the two, as well as by recent efforts to position TE as a deliverer of TL and build the SMET alliance. While the TL argument is highly relevant for TE at the K-8 level, Pearson and Young (2002) would categorize most of what TE aspires to at the high school in a category beyond TL; it's what they refer to as "technical competency," new-speak for vocational capability. For this reason, it will be difficult to use the TL argument to justify most of what TE does in grades 9-12.

The *new economy* cries out for precisely the sort of curriculum delivered by exemplary TE high school programs—broadly conceived "systems" courses in Communication, Energy & Transportation, Production technologies, and the like. Courses such as these provide technological understanding and capability, valued by engineering, architecture, and other professional fields. They also provide an ideal foundation for continued study in a technical career area at the 2-year college level.

Motivated by the Perkins Act of 1990, CTE vocationalists have begun to speak *our* language. *They're* vision for a "new" high school curriculum is one that addresses problem-solving, utilizes clusters rather than unit shops, provides education rather than training, articulates with higher education, and is delivered by baccalaureate-degreed teachers.

In light of these realities, TE should clarify and then promote *its vision* for the high school curriculum—both within and beyond the CTE community—as aggressively as it has promoted its vision for TL in the SMET communities. The technological understanding and capability delivered by TE's high school curriculum is an ideal fit for the new economy. Rather than avoiding this issue because of the imagined embarrassment caused by the "V" word, TE should aggressively promote the critically important role it can and should play in the 21st century high school.

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Examining Cognitive Bases for Differentiating Technology Education and Vocational Education

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Introduction

Technology education is a recognised field of study in Australia and other countries. For instance, in Australia, Technology is one of eight key learning areas with a nationally agreed statement and profile to guide its teaching in Australian schools (Curriculum Corporation, 1994). This statement characterises technology education in terms of four strands (designing, making, appraising; information; materials; and systems) across four bands. Also, as in other countries, Vocational Education and Training sector has also developed in Australia, which is charged with providing educational experiences, which develop outcome-based competencies against industrial standards (The National Training Board, 1992). The purpose of this paper is to examine the relationship between these educational endeavours.

The answers to many questions are inherent in how they are asked. For instance, to pose the question of the relationship between technology education and vocational education presumes some accepted and stable concept of each. It asks if these conceptualisations denote essentially different educational endeavours, or if there is a dualism - technology education vs. vocational education. In this paper I would like to examine how such a dualism is often constructed and the merits of such a construction.

There has been substantial previous work that can be related to this question, especially surveys developed to ascertain characteristics of technology education programs. For example Sanders (2001), drawing upon previous survey instruments developed and administered to 406 teachers in 19 USA schools, a Technology Education Programs Survey (TEPS), in order to examine changes in technology education practice. His findings are helpful not only in examining such change over time, but also in illustrating the kinds of dualisms that can be found in practice (and the extent to which they are subject to change) as well as those that give rise to the kinds of questions used in such survey instruments.

In terms of Sanders' findings on contemporary technology education practice, there is a number of important observations to be made. Firstly, there has been a substantial move, but there continues to be resistance, in identifying technology education as general education, with 40% of respondents still identifying their programs with vocational education (perhaps partly because they are administered under such a label). Secondly, the ranking of the importance of subject content purpose has shown a strong move in the value afforded the problem-solving skills and the application of technology to solve problems, application of science and mathematics, and understanding the nature and characteristics of technology. At the same time there has been a decrease in value afforded the purposes of technical knowledge and skills, discovering and developing creative talent, skill in using tools and machines and understanding technical culture. Thirdly, there has also been a shift in instructional methods for 3 in 4 teachers, from building projects from plans supplied by instructors, to modules and technological problem solving.

With respect to the survey instruments themselves, it is also important to note assumptions underlying the form, content and interpretation of the various questions. For instance, the sets of questions involve the following kinds of conceptualisations and relationships among them:

- Concepts of 'technical knowledge and skill', 'skill in using tools and machines', 'vocational [education and] training'; and an implicit direct relationship among them;
- Concepts of 'using technology to solve problems and satisfy needs and wants', and 'using problem-solving skills' and implicit conceptualisation of this as 'technology education'
- Implicit conceptualisation that 'vocational [education and] training' as conceived (e.g. as skill in using tools and machines) is essentially different from 'technology education' as conceived (e.g. as 'using technology to solve problems and satisfy needs and wants', as well as 'using problem-solving skills'); and
- Implicit conceptualisation of both technology and vocational education as essentially different from education focused on the 'application of science and mathematics'.

These kinds of characterisations are consistent with those in the wider field of educational discussion, which assume that we can make the following kinds of differentiations:

- General knowledge vs. Specific knowledge
- Theoretical knowledge vs. Practical / functional knowledge
- Conceptual understanding vs. Proficiency in skills
- Creative abilities vs. Reproductive abilities
- Intellectual skills vs. Physical skills
- Preparation for life vs. Preparation for work

I would like to examine such differentiations in this paper and their implications for the relationships among what are currently called technology education and vocational (education and) training. In order to do so, I will draw mainly on cognitive science against a background of economic and work place change.

Examining the Differentiations

General Knowledge vs. Specific Knowledge

The main problem with this differentiation is that it relies on the idea that it is possible and desirable to acquire knowledge that is general, and transfer it readily to a variety of different specific situations as needed. However, the research currently informing cognitive science calls into question the idea of the transfer of general knowledge, and has concluded that the quest for direct transfer of general concepts and procedures is misdirected (e.g. Beach, 1999; Bransford & Schwartz, 1999; Hatano & Greeno, 1999).

It is now recognised that knowledge and learning are highly situated (e.g. Collins, Brown & Newman, 1989; Lave & Wenger, 1991). That is, learning is more effective if undertaken in the context of its intended use, and constructed meanings are strongly related to their utility and the socio-cultural features of the situations of their acquisition. Moreover, learning is more effective if its relationship to function is transparent and if learners receive immediate helpful feedback (Pea, 1987). For these reasons, individuals find it difficult to discern the relatedness of different situations, even though the 'concepts' that they appear to need in new situations seem to be related to ones they already seem to have (Pea, 1987).

Further, the quest for transfer, and research into its effectiveness suffer from assumptions that transfer should be sequestered (Bransford & Schwartz, 1999), should be direct (Bransford & Schwartz, 1999), is non-paradoxical (Simons, 1999) and involves the static movement of memorial structures to new aspects of the world (Beach, 1999; Hatano & Greeno, 1999). Rather, what is now understood is that we should be preparing people for future learning by developing an understanding with the situations in which we acquire meaning (Bransford & Schwartz, 1999), in order to achieve transformation of self, knowledge and identity in relation to social structures (Beach, 1999) and in order to connect different ways of knowing and representing meaning (Stevenson, in press a).

For these reasons, the differentiation between specific and general knowledge is under challenge. All knowledge seems to be specific, related to purpose, and contextualised. Even the 'general' knowledge that schools seek to develop is related to its schoolish context and called upon for its utility in meeting schoolish goals. Rather, powerful, generalisations of specific knowledge seem to result from multiple, diverse, rich experiences and understandings of the specific and the concrete and from transformation in relation to the socio-cultural context. Such experiences need to be consequential, i.e. transforming of self in relation to the context. So, as a principle to guide the dualisation of vocational and technology education, the differentiation, general vs. specific, is at best problematic.

Theoretical Knowledge vs. Practical/Functional Knowledge

A major problem with this dualism is that it relies on an essentialist view of the transmission of knowledge to learners. That is, it assumes that knowledge, structured in the form of theoretical disciplines, should be given privilege over 'intuitive' or 'misconceived' ways of knowing; and transmitted to individuals in the same way as it is organised in the theoretical literature. That is, individual constructions of idiosyncrative representations of meaning are not sought; and are seen to be second-rate.

However, research on conceptual development indicates that individuals represent meaning functionally rather than in terms of disciplines of knowledge or even in words (e.g. Nunes, 1999; Pozo, Gómez, & Sanz, 1999; Schnotz & Preuβ, 1999). Moreover, research on how students in general education represent knowledge argues for less conflation of the qualities and types of knowledge involved, recognising that all types of knowledge may be represented both explicitly and tacitly (de Jong & Ferguson-Hessler, 1996; Stevenson, 2001). Still further, the knowledge that expert professionals (e.g doctors, architects, lawyers and engineers) actually use seems to be at a distance from the discipline-based theoretical concepts that are learned previously at university (Boshuizen et al, 1995; Bromme & Tillema, 1995; Rambow & Bromme, 1995; von der Weth & Frankenberger, 1995). Rather, through practice, professionals' knowledge appears to become encapsulated, related to prototypical cases found in experience, with attached scripts for specific action, also based on practice and utility (Boshuizen et al, 1995; Custer et al 1999). Based on such research, it has been suggested that education should seek integration of the different ways of representing professional knowledge – that learning for the professions should involve both a particularisation of theory and a theorisation of actual practice (Leinhardt et al, 1995).

Thus, the idea that one set of vocations (the professions, such as medicine, law, architecture and engineering) draws upon theoretical discipline-based knowledge and another set of vocations (e.g. the trades) draws upon a functional kind of understanding is flawed. Rather, we all draw upon knowledge organised according to function and context, we can have more than one kind of representation of meaning, these representations can even be seemingly incompatible, and we draw upon the representation of meaning that best fits the current purpose and context. Similarly, in his anthropological studies, Bloch (1998) concluded that verbalised forms of knowledge are really translations of the ways in which concepts are actually understood in practice.

Hence, the idea of a separation of functional and theoretical knowledge in terms of supposed mental representations, and the view that theoretical knowledge is more powerful for problematic activity is misleading. Rather individuals appear to transform their understanding in response to practice, in order to develop representations more related to function and which serve them well. Individuals operate upon theoretical concepts and transform them to make them their own. The affordance of privilege to theoretically organised knowledge, and the view that it is represented as such in learners, ignores the research that indicates that theory, which does not make sense to individuals in terms of functional utility, remains inert and inaccessible even when it 'should' be accessed and used.

For these reasons, the idea that educators should transmit theoretical knowledge to learners is misplaced. What is needed is for theory to make contact with existing contextualised functional representations of meaning and for rich connections to develop; so that theory becomes related to practice; practice, to theory; and both, to context and function . In the process, representations for practice and representations in terms of theory will both undergo change. Put more simply, irrespective of the field of endeavour, neither experts nor novices necessarily cognize in terms of theory; and certainly not in terms of theory they don't understand. And understanding comes from relationships with function, practice and context.

Thus, at best, a differentiation based on a separation of theoretical and practical knowledge is at odds with the ways in which individuals acquire, represent and draw upon meanings for routine and problematic activity.

Conceptual Understanding vs. Proficiency in Skills

This differentiation is perpetuated by cognitive psychology's persistent separation of knowledge that and knowledge how, which can be traced to Ryle (1949). This separation was developed by Ryle to give value to performance without having to invent verbal explanations of it. However, over time, the class-based affordance of value to knowledge-that over knowledge-how has re-asserted itself.

This may be partly due to cognitive psychology's appropriation of the division and its theorisation that declarative and procedural knowledge are essentially different, with understanding resident in declarative (conceptual) knowledge and the capacity to achieve goals resident in procedural knowledge. This separation of kinds of knowledge has been powerful in advancing theories of skill development and in developing computer models of cognitive processes (e.g. Anderson, 1982). However it is increasingly being recognised that the schemata that are proposed as mental representations appear to be based in experience and to be performatory (e.g. Carlson 1997). Such recognition is in accordance with Bartlett's (1932) original conceptualisation of schemata as dynamic and in interaction with the environment. Accordingly, it seems more reasonable to suppose that if individuals draw upon schemata for practice, then there would be strong linkages between the capacity to handle the situation and various ways of understanding the nature of the situation, e.g. as between Boshuizen's scripts and encapsulated concepts (Boshuizen et al, 1995).

Another problem with the theorised separation of declarative and procedural knowledge is the tendency to conflate verbal representations of meaning with understanding (Poole & Stevenson, 2001). While no cognitive psychologist would argue that understanding is encoded in words, much of the literature is written as though this were the case – very little literature celebrates understanding that may be tacit (Polanyi, 1966) or that can be represented in pictorial and other images (Paivio, 1979). Moreover, there is an increasing literature arguing for 'multiple intelligences' (Gardner 1983, 1999) and 'practical intelligence' (e.g. Sternberg, 1985, 2000); for cognitive psychology's attention to normative aspect of knowledge (e.g. Gardner, 1999; Gardner et al, 2001); and for the importance of tacit knowledge (e.g. Atkinson & Claxton, 2001).

Thus, an equation of conceptual understanding with the verbalisable to the exclusion of other ways of constructing meaning, and a denial that procedural activity involves meaningful understanding, appear to be under renewed challenge.

Intellectual vs. Physical Skills

This differentiation supposes that the capacity for intellectual operations is somehow superior to the capacity for undertaking physical action. Yet both are thought by cognitive psychology to be represented as cognitive procedures, and no differentiation is made between the productions that are executed in enabling physical action and those that are executed to enable such intellectual operations as those involved in arithmetic addition (e.g. see Anderson, 1982).

Indeed, powerful theories, such as Anderson's, for the explanation and modelling of the acquisition of intellectual procedures are based heavily on understanding the stages of acquiring physical skills (e.g. Fitts, 1964). Both kinds of development are thought to commence with the use of declarative knowledge and the gradual verbally mediated composition and proceduralisation of sets of individual productions, with practice, over time. Moreover, both physical and intellectual activities require problem-solving; and the cognitive explanations of the problem-solving of intellectual problems is the same explanation that can be applied to the accomplishment of new problematic physical tasks.

Thus, this differentiation is hard to sustain from a cognitive psychology point of view. It may be though, that, as with other differentiations, there are class and power dimensions involved. For instance it is supposed that more 'thinking' is involved in higher status work than in lower status work; and that therefore the cognitive procedures involved in thinking are of more value than those involved in physical doing. Further, the assumption that work is more concerned with physical activity than symbolic thinking is also under threat, with qualitative changes in the nature of work as discussed later. Hence, there seems to be little substantive basis for a cognitive separation of 'physical' and 'intellectual' skills.

Creative Abilities vs. Reproductive Abilities

This differentiation arises from the view that there is a difference between the capacity to reproduce known ways of operating in a familiar situation, and the capacity to create new concepts, procedures and artefacts. There is evidence that complex problems such as those of creativity and design require a different problem-solving model from that advanced by Newell & Simon (1972) for problem-solving in general (e.g. see Middleton, 1998); and that expert creative problem-solving is more controlled and less automatic than that of experts solving more routine problems in other fields (Yashin-Shaw, 2001). Moreover, because of the complexity of many creative problems, visual imagery can be powerful in assisting the problem solving process for such problems (Middleton, 1998). However, the work of Middleton (1998) and Yashin-Shaw (2001) indicates that one can identify the various cognitive procedures that are involved in the generation, exploration, evaluation and executive control processes of creative problem solving.

Thus, the cognitive procedures, which enable creative activity, are merely a set of procedures, alongside other procedures, which can be executed in pursuit of particular goals. Presumably, as for other cognitive procedures, such creative problem-solving procedures can be learned; and applied to one's knowledge base in developing creative solutions to complex problems. What remain to be determined, though, is whether one kind of capacity has more utility than the other in wider life pursuits as opposed to vocational pursuits. This question is addressed in the next section.

Preparation for Life vs. Preparation for Work

Vocational education seeks to develop individuals for work. This is often contrasted with education that claims to have as its main motive the development of capacities needed for life in general. In this latter case, it is advanced that individuals, among other things, need to follow and develop their own interests, learn how to learn, learn how to be reflective, learn how to be self-directed, and learn how to adapt. This kind of focus is sometimes contrasted with preparation for work, which is supposed to involve developing knowledge related to the interests of others, and learning specific, routinised skills, in an unproblematic way.

Yet, there is now overwhelming literature on the subject of economic change which indicates how uncertain the future is, how important adaptability is, and how industry is increasingly relying on value-adding through innovation, and so on (e.g. Berryman & Bailey, 1992; Harvey, 1989; Hirsch, 1991; Gibbons et al, 1994; Lundvall & Borrás, 1997; Nonaka & Nishiguchi, 2001). That is, the days of being able to predict the structure and content of work from year to year appear to be over and the capacities needed for work have been undergoing qualitative change for some time.

What is now thought to be needed in work is a variety of capacities which vary from industry to industry and from individual to individual, but which might include the capacity to perform at high levels of skill, and/or to adapt and innovate, and/or to solve new problems, and/or to work with others in teams, and/or to create new knowledge, and so on. With jobs becoming casualised and with industry globalising, people also need the capacity to change jobs, re-fashioning their capacities as they go. Some of the capacities needed in changing personal situations and workplaces are captured in various statement of key or core skills and competencies (e.g. Mayer, 1992; US Department of Labour Secretary's Commission on Achieving Necessary Skills, 1992), but these lists are growing with continuing attempts to capture the seemingly inexpressible key capacities of contemporary work. The focus is shifting in this discourse from technical to social and personal capacities, from codified to tacit knowledge and from stable to transient knowledge (e.g. see Gibbons et al, 1994; Lundvall & Borrás, 1997).

Ironically the capacities emerging as important for work of the future are more like those associated with preparation for life: personal, social and reflective skills in using, connecting, adapting and constructing various kinds of meanings. Hence, it is increasingly problematic to impose a division between preparation for life and preparation for work.

Conclusion

Contemporary dualistic constructions of knowledge (e.g. knowledge vs. skills, and theoretical vs. applied) can be traced back to the ancient Greeks. So it is worth examining the above analysis in terms of the divisions that Aristotle developed. He saw art or technical skill (*techne*) as different from scientific knowledge (*episteme*), practical wisdom (*phronesis*), intelligence (*nous*), and wisdom (*sophia*) (Thomson, 1976). However, it needs to be remembered that these differentiations arose from a highly classed society where the highest pursuit was political office. The evolution of these divisions into contemporary differentiations works towards preservation of the same kind of privilege, based essentially on class. For instance, the contemporary technicist view of that work, which is the subject of vocational education and training, is used to characterise only some kinds of work (e.g. carpenters, office workers, hairdressers, police, electricians and child care workers) whose educational development is now in vocational education and training, but not others (e.g. dentists, medical practitioners, nurses, scientists, teachers, engineers and lawyers), whose educational development is now in universities.

The persistence in seeing vocational knowledge only in the *techne* sense of the practical is based on the view that vocational knowledge is technical, enables control over causes, and is useful in application. Yet, while this is true, such a restricted view of vocational knowledge does not reflect contemporary work, or the vocational education and training needed to prepare people for work. As outlined above, knowledge needed for work has been undergoing rapid qualitative change. Firstly knowledge for contemporary work is "practical" in the *phronesis* sense of practical wisdom, because working involves normative judgements on the part of the individual worker. Secondly, in successful enterprises, it is the capacities of the individual to use the understanding that comes with *episteme*, which are drawn upon for "value-adding" syntheses and activities. Thirdly, frequently, the call is also for *nous* and *sophia*- the intelligence and wisdom to do the 'mature' and 'sensible' thing. Certainly, it is true that the place of theory (*episteme*) in vocational education has been under continuing threat in the "outcome" emphasis of competency-based training. And with several decades of older worker retrenchments, a great deal of the accumulated organisational wisdom of enterprises has been lost. However, it needs to be recognised that these policy determinations have been at odds with workplace realities, as discussed earlier in this paper.

Technology education has had a continuing relationship with vocational education. While vocational education has been focused explicitly on preparation for work, technology education has sought to take a wider view, more focused on the individual learner, and more focused on developing knowledge that has broader application than specific jobs. Accordingly, technology education has moved over time from a focus on industrial arts to a focus on the concepts of technology and design and on the procedures of technology and design problem solving. At the same time, it has not left behind totally, just de-emphasised, the skills needed for working with tools and machines.

However, at the same time as technology education has sought to transform itself from its industrial arts roots, neither industry nor vocational education has stood still. Industry can no longer rely on the predictable tools, equipment, materials, processes and skills that characterised the relatively static jobs of the past. It is challenged by the changing nature of what society values, and the various globally competitive ways in which society can meet its needs. Workers can no longer take a job for life. Increasingly they are casualised, adapting to different jobs continuously; or, if in a core job, asked to operate across processes and systems and/or at a level that does not rely on the individual application of routinised skills. While there were moves as long ago as in the 1980s for vocational education to address these challenges (e.g. OECD, 1980), governments in Western societies have chosen to adopt competency-based training with its explicit emphasis on observable outcomes. Indeed, the later need to identify key/core skills and competencies may well be partly a reaction to the inadequacy of competency-based training as a form of vocational education.

Thus, ironically, while the differentiations on which a technology education vs. vocational education divide can be constructed are problematic, ironically, the target content of technology education is more suitable for the real demands of contemporary vocational pursuits than the target content of contemporary competency-based vocational education. People in workplaces need to understand technologies and be able to work alone and with others in solving complex problems. They also need highly developed social and personal skills in order to cope with their changing personal and workplace situations and to contribute effectively to workplace problem solving, knowledge creation and even routine activity. Ironically, also, the idea of general knowledge, abstracted from practice, is under challenge. It is now recognised that meaningful knowledge is best acquired in situated, functional practice; that we know 'with' our context; and that consequential transitions (preparing us for future struggles with new situations are highly linked to socio-cultural aspects of the transitions.

An examination of the substantiveness of the assumptions underlying dualistic constructions of vocational vs. technology education indicates that the problem for technology education is not to establish the worth of developing technology and design concepts and problem solving capacities. Rather the problem is to ensure that this development is well grounded in meaningful practice. It is not to deny the importance of specific, concrete, functional knowledge, but to use this as an important basis for developing further connected meanings with existing individual meanings and other ways in which meanings can be rendered, e.g. as in theory, and in practice.

The continuing separation of technology education from vocational education is under threat, as vocational education continues to evolve to address the challenges of work in changing economic circumstances. Over the coming years, it is inevitable that vocational education policy will have to change in order even to meet the needs of industry. It would be hard to believe that industry will persist with a flawed system of meeting its emerging needs for a productive labour force. One of the perils of not forging a strong relationship with vocational education is that technology education may be displaced by vocational education. One of the perils of forming a strong relationship with vocational education is that of becoming captive, from time to time, to inappropriate government policies like those of competency-based training.

A suggested direction for forging a more productive relationship between technology education and vocational education is to consider the suggestions of Leinhardt et al (1995) for integrating professional knowledge. Their suggestions include developing shared responsibilities involving the adoption of a parity of value for theoretical and practical ways of knowing and the development of various kinds of instructional activities, as follows:

- Valuing both codified and uncodified knowledge or practice of workplaces
- Making uncodified knowledge and practice explicit, formal and examinable
- Systematically reflecting on multiple episodes of workplace practiceExamining knowledge associated with different practices [e.g. workplace practice, vocational education and technology education], while using thinking associated with a different community of practice and vice versa
- Using resources to slow down time when examining practice, facilitate reflective revision of practice, and examine consequences of work-based activity
- Theorizing practice and particularizing theory

Thus, it is concluded that it is possible to use different labels to denote what is called technology education and what is called vocational (education and) training. But this kind of labelling is based on dualistic constructions that are problematic at best. Moreover, the realities of living and working in a rapidly changing society argue against out-moded views of the capacities that are increasingly needed for personal, social and economic survival. It is suggested that it is inevitable that vocational education will continue to transform itself in response to the changing demands of industry, and will move to occupy the space that those in technology education regard as theirs. A proactive move is suggested that technology education seek to be the agent that values and integrates the various ways of knowing that are valued in academic and workplace communities.

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Chapter Nine

Technology Education Teacher Shortage

Technology Education Teacher Shortage

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Introduction

There has been a great deal of discussion about the teacher shortage in technology education and impact that this has on the development of a relatively new and under resourced curriculum area. While there is some research in terms of the supply and demand of teachers, there is little that looks at what this means for principals, teachers and student learning. This paper explores some of the reasons why we have a teacher shortage and considers the effect that this has on the development of vibrant and challenging technology education programs in schools across Australia.

Is there a technology teacher shortage?

> "The worldwide teacher shortage is expected to worsen over the next few years as growth in student numbers outstrips teacher recruitment, a United Nations report has found.
>
> According to the study, *A Statistic Profile of the Teaching Profession*, education standards are also in jeopardy in developed countries such as Australia which face an ageing workforce and a lack of new recruits" The Age 7th October 2002.

This article goes on to suggest that a significant number of qualified teachers choose work other than teaching and that the diminishing status of the profession is one of the key factors for this.

It has been acknowledged that there is a general teacher shortage in Australia. The teacher shortage is not unique to Australia, and because of this the problem has been compounded.

Ritz (1999) discusses the current and predicted supply and demand for teachers and more specifically technology teachers in the United States. Ritz claims that "Increased technological literacy and growing school populations should cause a natural increase of technology education professionals. However, with the retirement of so many teachers, critical shortages are appearing in a number of states, particularly those in the southeast region".

In the past Australia has often been able to draw on teachers from other countries to supplement the teacher supply when there have been the greatest shortages. While these countries are struggling to find teachers Australia is unlikely to be able to draw from overseas sources. In fact Australia is likely to lose some young graduates in the short term at least, as incentives to teach overseas increase with countries such as the United Kingdom aggressively trying to recruit teachers to address its own teacher shortage problems.

The combination of qualified teachers choosing not to enter the profession, those leaving to go to other careers and those retiring, along with a limited number of teacher training courses, has led to significant concern for the staffing and development of quality programs in the technology learning area.

The extent of the teacher shortage, and the areas that are most effected by this have been subject to considerable debate. Some research and a great deal of anecdotal "evidence" support the notion that technology education is greatly affected by this teacher shortage. A survey carried out in November 2000 by the Australian Education Union

> " …identifies that the most dire need for teachers is in technology, languages, science, maths and information technology subject areas" The Age 16 January 2001.

More recently we hear that

> "The worsening teacher shortage is causing headaches for school principals, who are struggling to fill positions, a survey has found. The greatest shortages are in languages other than English, information technology and technical subjects such as woodwork and automotive according to a national survey by the Australian Secondary Principal's Association" The Age October 8th 2002.

Gibson (1998) claims that teacher shortages have been predicted in technology education for some time. Gibson stated that there were a limited number of universities offering technology teaching courses at the time, and that most were administering drastic cutbacks in the area.

These cutbacks did in fact occur in many states, and the teacher shortage has been a direct result of this. Williams (2002) further discusses this in a survey carried out late 1999 to early 2000. At this time shortages were reported in NSW, Victoria and South Australia, it was predicted that there would be shortages in Western Australia and Tasmania in the near future, and there was a significant shortage of technology teachers in the Australian Capital Territory.

The demise of several training programs has been identified as the key reason for these shortages. Many states have suffered from significant changes to training programs, the reduction of offerings within them, or the complete demise of the programs. The University of Melbourne for instance ran most of the programs in Victoria. All ceased to exist, leaving the state with no training at all. The effects of this are clear now, and the impact on school programs severe. Many schools have been unable to find new and replacements teachers, and existing teachers who were using postgraduate courses as a way of retraining and updating their skills and knowledge have in some cases become disillusioned with a system that provides little support for them.

In Australia the level (and therefore impact) of the teacher shortage varies significantly, depending on the current teacher supply of new teachers in each state and territory. There is a number of different types of courses available in each state and territory, and the number of graduates varies significantly.

Firstly, in terms of primary education. There appears to be an increasing number of universities that have introduced some technology education either as core or elective studies. These programs range from quite comprehensive core technology studies to those that offer minimal "real" technology education electives that students may or may not choose to engage in. There are still a large number of teacher training institutions that offer no technology education in their primary education courses. To complicate this, some institutions have what may appear to be subjects addressing technology, however, the actual content does not reflect this. Generally this is the result of lack of expertise within the university. For instance, there may be a *Science and Technology* study that is being taught by a science expert who has little if any technology expertise. They are therefore likely to have a very scientific approach to the study –which may not necessarily address key aspects of technology education.

While the secondary teacher training situation appears to have improved even if only slightly in terms of training, the predicted supply of teachers is unlikely to meet the demand in most states and territories over the next few years:

- Queensland and the Northern Territory do not envisage a shortage in the near future. In Queensland this is clearly the result of teacher training that has continued to supply an adequate number of technology teachers over recent years.
- In Tasmania and Western Australia there does not appear to be a teacher shortage currently, but there are concerns about the number of technology teachers retiring in the near future and a teacher shortage is predicted as a result of this. The supply of teacher is unlikely to address the perceived demand of new and replacement positions.
- The Australian Capital Territory has a general oversupply of teachers, but is experiencing a severe shortage of secondary technology teachers.
- NSW currently has a teacher shortage and is likely to continue to do so for some years. While strategies have been put in place (Gibson and Barlow 2000), to increase the supply of teachers in the state, there are concerns here also about the impact of teachers retiring over the next few years.
- In Victoria there is currently a technology teacher shortage and this is likely to continue to be for some time. Until 2001 Victoria had not had any teacher training for a number of years. In 2001 a postgraduate course was introduced at Latrobe University and in 2002 a degree at the University of Ballarat. Both courses were introduced to address the fact that there was not teacher training in the state. While the efforts of both universities have been appreciated by many, there have been some concerns about the content and staffing of the courses. In effect a relatively small proportion of the courses is actually technology education. To exacerbate this problem, neither of the institutions have any permanent staff with Technology expertise. Sessional and guest lecturers are used to deliver much of the technology, and at other times lecturers with no background (or understanding) of the area run the course. Therefore while efforts have been made to address the problem in the state a number of issues still need to be addressed.

Given that retirement of current teachers is a key issue for technology education, it needs to be recognised that even in the states and territories that are currently well supplied, there is a risk of shortages in the near future as a result of this. A survey of technology department staffing was carried out by the Technology Education Association of Victoria (TEAV) in 2000. 62 secondary schools responded to the survey, representing 420 teachers. It found that at least 30% of teachers currently in these secondary schools would retire within the next five years, 60% of the schools surveyed claims that they had already experienced a teacher shortage, and 87% anticipated a shortage within the next four years. While these was only a sample of secondary schools in the state, it appears to reflect the situation in the state.

Teacher supply and demand

Since the recognition of technology education as one of eight learning areas and the development of the National Profiles and Statements in 1994, there is a general expectation throughout Australia that teachers will provide students with comprehensive technology education programs in their primary schooling. However, it is evident that there are still a large number of primary school teachers who lack confidence teaching in the area. This lack of confidence is partly due to lack of training, and partly due to lack of experience and support in the area.

The 1997 ASTEC report Foundations for Australia's Future: Science and Technology in Primary schools found that primary teachers lacked confidence in teaching in the area of technology. The report stated that "more remains to be done if the majority of primary school principals and teachers are to understand fully the nature and purpose of primary technology education" (p.17). It went on to suggest that universities need to review their pre-service training to ensure that the technology learning area was addressed adequately and that authorities needed to act quickly to plan and implement ways in which to improve teacher confidence in the area.

Unfortunately there does not seem to have been a radical change from this position. The ASTEC report suggests that there was little substantial technology in teacher training at the time. While there may now be some improvement in terms of the number of universities that incorporate some technology education into their courses, many still do not include it as a core study, and even less have comprehensive technology components. As a result of the limited technology education training in some universities and the general lack of confidence in the technology education area, principals have difficulty finding suitably qualified or experienced teachers to teach or lead in the area in schools. This generally translates into limited programs in many Australian primary schools.

Secondary school technology teacher training varies in each state and territory. There appears to have been a shift to post graduate courses in technology training in recent years. There are several reasons for this: In some instances it could be argued that this has occurred primarily because all of the other training ceased to exist and it is the quickest way to train new teachers. Others may argue that technology education should draw on people who already have some sort of trade or other "practical" qualification. Some would say that this approach is an effort to address the low enrolments in some of the technology education courses. However, there are still many who believe that comprehensive specialist pre-service training ie desperately needed in many states if we are to have an adequate number of teachers qualified to teach technology education.

There are several factors to consider when looking at the supply of teacher, including the quantity and quality of teachers. The quantity required is not being met at this stage in most states and one of the two territories. There are a number of factors that will influence teacher quality, including the courses that they are graduating from. Most of these courses are likely to provide teachers with the opportunity to become "quality" technology teachers. However, there are some concerns when courses have been developed rapidly to address a need, but have not had the funding support to employ technology "experts". There appear to be some courses offered with limited technology because little or no expertise exists within the university. Another teacher quality factor is those who are attracted to the profession, and whether they are in fact the best candidates for the job.

In Victoria, principals claim to struggle in order to find replacement staff. Some say that they cannot find teachers with the adequate experience in design, some that they cannot find leaders in the technology learning area and others are unable to find any teachers at all (particularly in country areas). While some of the issues are not unique to technology education, the fact that the nature of the area has changes significantly in the past ten years is. Teachers who have been in the system for many years are unlikely to be able to address the new approaches to the curriculum unless they have undertaken some retraining or significant professional development. A number of the retraining programs no longer exist, which means that for many professional development is the only options available to them. The quality and availability of this has varied, as has the support for teacher to participate in comprehensive professional development programs.

Some schools are limiting programs or using teachers from other curriculum areas as a result of the limited number of available technology teachers. The survey carried out in November 2000 by the Australian Education Union

> " …found that 57.9 per cent of secondary schools in Victoria reported teachers taking classes outside their areas of expertise. This figure rose to 77.1 per cent in rural and remote areas". The Age January 16th 2001

The survey undertaken by the Technology Education Association of Victoria supports this notion in Victoria. It found that 25% of the schools surveyed claimed that aspects of their technology programs have been cancelled, and half of the schools had modified programs as a result of not being able to find qualified staff. Modifications to programs included substituting technology classes with information technology, eliminating some of the practical areas from the curriculum, increasing class sizes and combining senior classes. The impact on the quality of whole school programs was seen to have been significantly compromised as a result of the struggle to find suitable teachers.

While availability of training is a key reason for the teacher shortage, Williams (1996) claims that low enrolments had a significant impact on teacher training courses and therefore the supply of technology teachers. This raises other issues of the profile of and incentives for attracting teachers to the teaching profession, and more specifically technology teaching. It has been suggested that some of the changes to courses have been a result of these low intake levels. However, the change in structure does not appear to have fully addressed the problem. Perhaps the low intake was more a result of the drastic changes that had been occurring in universities, including the amalgamation of different tertiary institutions and the low profile of the teaching profession. Perhaps the structure does not need a radical change, but the incentives to enter the profession do. At the very lest it is evident that we need flexibility in the methods of entering and the courses themselves to ensure that they are attractive to a broader range of people.

There was official recognition of the technology learning area in the early 1990's (and evidence of many quality programs prior to this). However, there is still a limited understanding of the area and what it offers students. The public perception of teaching as a profession appears to be improving, but the technology learning area is still not well understood by parents, teachers (including careers teachers) and students. Enthusiastic role models are likely to be one of the greatest inspirations for students in terms of career choices. Yet we are still grappling with a proportion of teachers who are disillusioned with the system and changes that have been forces upon them in recent years, including some who firmly believe that the changes are not going to improve student outcomes. While this is the case we will struggle to find adequate role models for students.

In order for there to be a challenging and vibrant technology education community we need a large cohort of adequately trained and enthusiastic teachers in the profession. Currently we have a large proportion of teachers close to retirement, which can translate into people who are not interested in updating their skills and knowledge. For many there have been significant changes to the learning area during their years of teaching and they are struggling to accommodate the changes or simply fed up with them.

School technology programs have been modified, compressed or completely removed in some schools as a result of lack of staff. In terms of student learning this can mean the quality of the programs being run in schools is often compromised and this in itself raises ongoing issues in terms of how the students, teachers and parents view the area. At a time when we need to promote the worth of the learning area low quality programs do little to show its value.

What should be done?

Given the current situation in Australia it is evident that the issue of the impact of the teacher shortage needs to be addressed. There are a number of ideas being considered already, but it is likely that a multiplicity of initiatives is needed.

Educating the community

We still have significant ground to cover in terms of educating the community about what technology education is and what it offers in terms of student learning outcomes. While we have a community that remains ignorant of the worth of the area we will continue to battle to entice students into courses and to ensure that all students in schools have access to comprehensive, quality technology programs.

We need to better educate teachers, careers advisers, principals and academics if we are to able develop an adequate number of quality teacher training programs and comprehensive and challenging school programs in all states and territories. If we are to attract new teachers into the profession they need to see enthusiastic role models and quality programs and outcomes.

Teacher training

Primary

There is a need to for all primary teacher training courses to have technology education as a core (and reasonably comprehensive) component of the course. Many teachers lack confidence in the area and this is unlikely to change until all teachers have at least some experience in the area. It needs to be recognised that technology education is an area in which a large number of teachers lack confidence, partly due their own personal lack of experience in the area and partly because of the practical nature of the area.

Secondary

There needs to be least one comprehensive specialised technology teaching course in each state and territory. Each of these needs to be flexible enough to cater for both post year 12 students and people who have experience in other areas. Post graduate training is needed in each state and territory in order to cater for people who want to continue further education in the area, teachers who wish to teach in technology education, technology teachers who wish to update their skills and knowledge or complete a higher level of training.

If we want to encourage students to consider design and technology professions (including teaching) we need to have a cohort of teachers who are well informed and enthusiastic about the area.

We need to carefully look at incentives for people to enter the system. Ideally we need a mix of post year 12 students and those who have some other experience in the field. Therefore we need incentives for both. Some possibilities (none of them new) are:

- Scholarships. There are many different types of scholarships that can be considered, ranging from those that cover training costs to those that provide additional financial support throughout the training period, and possibly additional incentives to actually teach at the end of the course.
- Incentives to attract professionals such as design professionals into teaching. This might be part time work as a teacher and part time in other design work. In order for this to happen schools need to be flexible enough to accommodate this.
- Recognition of prior study and experience in terms of exemption from study.

Undoubtedly the most attractive incentive is going to be recognition of the importance of teaching and particularly technology teaching as an area of great importance for students.

In addition to this the introduction of standards for technology teachers may provide further incentives for teachers to consider training and retraining options. The notion of standards is not new, and has been explored in different contexts for some years. In Victoria, the Standards Council for the Teaching Profession (now the Victorian Institute of Teaching) developed *Profiles* for technology teachers were developed in 1996 (these can been found on the VIT web site). While these began to outline some of the qualities that were seen to be important they needed further development and, more importantly, to be fully implemented, which required government ratification. However, they were (and still are) a useful starting point to consider for the development of standards.

Professional development

Professional development programs are crucial to provide support for teachers in terms of learning new skills and knowledge, keeping abreast of new curriculum requirements, ideas, resources and to provide networking opportunities. It is also a possible interim measure in terms of training – particularly to train teachers from other curriculum areas or those with little current knowledge of the area who wish to take on technology education. However, currently there is a trend of low participation rates in professional development. Often this is the result of other areas being clearly identified as educational priorities, at school or a system level. Funding is also a key factor, and there is also the issue of a large cohort of teacher nearing retirement who may not be interested in learning new skills at this stage of their career.

Incentives are clearly needed to engage people in professional development programs. Tertiary accreditation is a valid incentive that is already available. Perhaps the problem again is to do with recognition of the area and its importance in the curriculum. Perhaps if technacy became an educational priority we would see a dramatic change to participation in professional development.

Conclusion

Technology education has suffered from being under resourced and under valued for many years. Despite this there are still a large group of enthusiastic technology educators who are convinced of the worth of the learning area and prepared to continue to argue for it. In many ways those in the technology area are advantaged, as we have had to justify the existence of the area for so long. We have had to articulate what it offers students and why it is so important as a core part of the curriculum. We have heard all the arguments against the area, we know about the ignorance that still exists out there. Perhaps we are in a far better position than most!

In recent times there have been some positive signs in terms of Commonwealth support for the area and many of the states and territories appear to be beginning to recognise the value of the area for students and society. There has always been evidence of many vibrant programs that are producing quality products and instilling in students' inspiration, creativity and innovation. The quality of a number of these programs continues to grow, despite the lack of new teachers entering the system. We appear to be at the turning point both in terms of teacher supply and support for technology curriculum. There is evidence of an increasing number of teacher training programs, and some development in terms of an understanding of the technology learning area. There are many positive signs for technology educators. We just need to make sure that we act on them.

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Technology Education Teacher Shortage

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Introduction

The information reported in this presentation is a direct result of discussions with colleagues in the technology education profession, a review of literature, and resulting analysis of gathered data. The review of literature indicates a healthy debate has been underway regarding the teacher shortage in technology education. Supply and demand issues have been written about at the local, state, and national level. The assigned questions provide the framework to address issues in technology education that relate to supply and demand as well as education in general. The questions allow for a look at factors that encourage people to enter the teaching profession and the impact of these factors on the profession. The questions allow for an opportunity to discuss strategies that technology educators can use to develop a proactive plan of action to fill the projected employment needs. The questions allow for a discussion of diversity in its teacher recruitment and retention efforts. We are at an interesting point in history with so much to gain as a profession and at the same time so much to lose if we can not beat the supply and demand challenge that faces all in education.

Why does technology education have a teacher shortage problem? Are the reasons similar to the teacher shortage in other subject areas or are they unique to technology education?

Teacher supply and demand has been the topic in newspapers, magazines, and professional education journals, as well as, numerous WEB sites, and government reports. In some publications the supply and demand situation is taken lightly as writers suggest that if all of the teachers that were prepared would only teach there would not be a shortage. Other publications suggest that the teacher supply and demand situation is a result of teachers leaving the profession within the first five years of beginning the teaching process. Still other publications address the "graying" of the workforce and discuss the numbers that will be needed in the future. The question of whether we have a teacher shortage or not is in the numbers as reported from a variety of sources.

With out a doubt the Technology Education profession has been making an effort to get a handle on the supply and demand information for years. Technology Education Specialists in State Departments of Education across the country have kept data on the number of programs at the elementary, middle school, high school, and collegiate level for years. In Georgia, for example, a report covering two five year periods from the 1975-76 school year through the1979-80 school year and the 1980-81 school year through the 1984-85 school year indicated the number of technology education teachers graduating from Georgia Colleges and Universities to be 151 and 96 respectively. The numbers indicated a steady drop in teacher production. The total number of public schools increased from 422 to 444 while the total number of teachers decreased from 621 to 513. The number of schools with only 1 teacher increased from 236 to 308 while the number of schools with 3 or more teachers decreased from 43 to 13. The total number of schools with no teacher listed increased from 22 to 39 and the number of teacher educators decreased from 33 to 15. The impact of comprehensive high schools and Trade and Industrial Education programs can explain the drop in numbers of multiple teacher programs. The growth of Industrial Technology programs at the collegiate level may explain the drop in numbers graduating with technology education degrees.

In a newspaper article from the Atlanta Journal-Constitution, 26 March 2002 it was reported that Georgia schools will need between 12,000 and 20,000 teachers a year for the remainder of the decade, but the state's teacher colleges only graduate about 3500 students a year. (www.accessatlanta.com/ajc/epaper/editions). Another communication this one from the Georgia Association of Educators dated 16 October 2002 indicated that Georgia is experiencing the most severe shortage of qualified classroom teachers in history. School boards are experiencing difficulty in hiring bus drivers, paraprofessionals, and other Educational Support Professionals (gaEnews@yahoogroups.com). There is real concern at the state level regarding the demand for teachers. There is also real concern for the inability of the state to supply the needed teachers.

The profession was also keeping track of the teacher supply and demand situation at the national level through a series of surveys taken during the late 70's and throughout the 1980's and reported by Rex Miller in the journal Industrial Education. In the January 1989 issue of Industrial Education, Miller's article "IA Teachers Supply and Demand, 11th Annual Survey", reported interesting results as follows:

- The results of the eleventh annual survey have some points of interest. Many of the states have now reached the equilibrium stage of "no surplus and no great need for new teachers". This condition is destined to change when World War II and Korean War veterans opt to retire at 55 or soon thereafter.
- Recruitment for undergraduate students is getting difficult.

Miller's article reported a total of 47,306 teachers in the profession, 1670 teachers being produced by colleges and universities. The report also indicated that states would need 1609-1619 teachers with a shortage of 314 teachers projected and a surplus of 248-258 teachers expected. Of course the states reporting a shortage did not indicate an influx of teachers from states that were reporting a surplus. While the report indicated essentially a break-even situation the surplus in California did not seem to satisfy the need in New York City and/or the state of New York.

A review of the 1996-97 Industrial Teacher Education Directory (Dennis, 1996) indicates a 22 percent decrease in the number of graduates in technology teacher education programs from the previous year (Dennis, 1995). This decrease implies that the number of qualified applicants for technology education teaching positions is getting smaller. The number of programs producing teacher candidates is also decreasing further implying that the pool of qualified applicants will only get smaller. In a recent Mississippi Valley Technology Teacher Education Conference presentation using the 2001-2002 CTTE/NAITTE Industrial Teacher Education directory it was reported that 1). several technology teacher education programs have closed or were being closed, 2.) enrollment was small in the majority of the programs, and 3.) the number of programs per state was small (Cardon, 2002). The trend seems evident.

The profession continues to survey states looking at the supply and demand issue. Shirley Weston reported, in an article "Teacher Shortage – Supply and Demand" posted on the International Technology Education Association web site, the 1995 and 1996-97 Survey Results. The results reported indicated 37,968 current middle school and high school technology education teachers and a projected 13,089 vacancies from 1996 thru 2001. Weston wrote:

> . . At a time when enrollment in, and graduation from, technology teacher education programs are on a downward spiral, the demand for teachers is on an upward trend greatly accelerating the gap between supply and demand. . . Major factors driving this demand include increasing student enrollment and a graying teacher workforce.

In general, additional insight comes from a series of national reports. For example a major factor contributing to the expected growth in teacher demand is increasing student enrollment. The total student enrollment, including both public and private schools, is expected to increase from 49.8 million in 1994 to 51.3 million by 2006 (Gerald and Hussar, 1996). Another major factor affecting the demand for teachers is the age of current teachers and administrators. In 1994, 12.4 percent of the elementary school and 15.4 percent of the secondary school teachers were between 50 and 55 years of age, while 11.5 percent and 10.6 percent of elementary and secondary teachers respectively were 55 years or older (Bandeira de Mello and Broughman, 1996). Which indicates that almost 24 percent of the elementary teachers and about 26 percent of the secondary school teachers could be expected to retire in the next 12 to 15 years. Additionally, due to the average age of principals tending to be higher than that of teachers, a higher percentage of retirement could be expected among principals. Since teachers are typically chosen from the ranks of teachers, this could also affect the demand for teachers in the next 12 to 15 years. Still another article "The Coming Job Boom" reports on the "hot jobs" or some occupations with the largest projected growth from 2000-2010 (Eisenberg, 2002). The job listed with the largest change in number of jobs was teachers (K-12) with 711,000 projected for the time period from 2000-2010. This article also noted that school districts and universities would need 2.2 million more teachers over the next decade, not to mention administrators and librarians.

The total teaching force in the country is composed of three groups of teachers: 1) continuing teachers who were present and teaching in the previous year, 2) new entrants into the system, and 3) returning and migrating teachers. Any future supply discussion requires information on current as well as those teachers in the teacher-training pipeline, and on the reserve pool of individuals who are qualified to teach but who are not currently teaching. Data on the latter is elusive.

Unlike teacher supply, the components of teacher demand are much more clear-cut. Teacher demand depends on enrollment growth, teacher turnover, and mandated policies regarding curriculum and mandated class sizes. Teacher turnover includes death, retirements, disability, and other either voluntary or involuntary events.

Having considered information regarding supply and demand we can say that Technology Education is experiencing a critical shortage of teachers at all levels. Like many areas of education the numbers from local, state, and national sources indicate the critical shortage that we face. The facts are that we are not graduating the required number of qualified teachers to meet the shortage. Alternative certification models are not filling the voids. The circumstances surrounding the graying of the workforce, reduced numbers in the pipeline, reduced number of programs, an increasing student population, and other societal factors all combine to create a major shortfall of teachers. With the information at hand we can see why not only technology education but also other subject areas are experiencing a teacher shortage.

What are the factors that most encourage people to enter the teaching profession? The technology education teaching profession? Do these factors remain constant over time or are they subject to change? How might the technology education profession go about emphasizing these factors to its advantage?

Recently while researching using the WEB a topic called Interprise Poll – Kids and Career 2001 caught my eye. Searching further I discovered a document titled "Kids and Careers 2001 America's Future Workforce Speaks Out". The document was presented by Junior Achievement Incorporated and gave an interesting look at kids today and what they want to be (Junior Achievement Inc. 2001).

The document began by relating the following:

> By 2008 the youth labor force, ages 16 to 24 is expected to increase its share of the labor force to about 16 percent, growing more rapidly than the overall labor force for the first time in 25 years, according to the U. S. Department of Labor. In fact, the U. S. economy will create more than 20 million new jobs within seven years.
>
> Put simply, job opportunities will be plentiful over the next decade. But how informed are today's students on the career options of a not-too-distant America?

The document went on to discuss what initiatives were going on to help tune kids into careers. They talked about career academies, apprenticeship opportunities, and other work based learning activities. They talked about the survey results and in brief reported the following:

> For the second year in a row, the profession of "doctor," long considered to be one of society's most prestigious and lucrative careers, was the top job choice (according to 11.9 percent of student respondents). A close second was "businessperson"(9.1 percent), followed by "computer/internet professional" at 7.8 percent (projected to be the fastest growing profession, "computer engineer is expected to grow by 108 percent until 2008, according to the U. S. Bureau of Labor Statistics), and "teacher" (7.1 percent). . .

Entertainer and then athlete followed teacher. The interesting note is that in the entire teacher notations there were no "technology education teacher" comments. Most were notations were just "teacher" so there is hope to convert them if we take advantage of the opportunity.

Most students were confident of one day attaining their ideal job. As to why they would choose a particular job the responses went from "fun and exciting" to "money" to "interesting" to "to help others". According to the survey responses they want an active life outside of the workplace. The next generation of workers seems to place a higher value on lifestyle and family than on money.

When asked about the preferred career information source the students chose the Internet more than any other source including parents, guidance counselors, teachers, and job shadowing. Typically peer influence is a factor but seemingly not among this group.

Another report from the internet was titled "High Paying Auto Technician and Retailing Jobs Go Wanting Even In Gloomy Economic Times" (Automotive Retailing Today, 2002). This report was a study to measure awareness of and attitudes toward auto industry careers among students, parents, and educators. The study reported the following:

> The bad news is that few teens currently aspire to automotive careers. Only two percent of all teens (13-18 years old) would choose a career in the automotive industry according to the study. A career in health care ranked the highest. But the good news is that the disinterest results from a lack of information, and quickly reverses when they learn about the high demand and pay.

The study also found that on average the teens began thinking about careers at age 13, and that parents provide major influence. While peer influence generally is a factor in shaping teen's attitudes when it comes to a career 80 percent in the survey indicated they trusted their parents "a great deal", compared to just 34 percent who trust their friends and 42 percent who rely on their teachers. The teens choose a career direction before college and it is roughly a three-year process. The survey also found that 45 percent of all teens would make a career decision in their junior or senior year in high school. The study demonstrated a need to do a better job in combating outdated images of the industry and raising awareness among students, parents and educators about the incredible potential of these jobs.

In a survey of students completed for this paper the bulk of the students indicated they would consider teaching 1) to make a difference in the world, 2) enjoy children, 3) enjoy sharing what you know {experiences}, 4) for summer vacations, 5) enjoy life long learning and 6) stable employment. Pay was not a consideration as most indicated they knew that teachers did not make good money early in their career.

In a recruitment letter that Dr. Bob Hansen sent to students interested in technology education teaching he addressed the following:

> We are promoting a career opportunity to help high school students make decisions about their futures. Students who are interested in learning more about current technology and who think they would be interested in teaching youngsters about up-to-date technology should consider the option to teach technology education.

Hansen went on to explain that positions were available, position was stable during tough economic times, summer break for vacation/summer job/continuing education, sharing knowledge and experiences with others, help others discover interests and aptitudes, and more. Many of the items covered were items covered by students and the surveys discovered on the Internet.

The factors that encourage most to teaching seem to be intrinsic. Those that might be interested in technology education teaching seem to be more interested in mechanical things as well as the intrinsic values. The areas that change over time would be current content oriented but still technological in nature. The technology education profession can take advantage of this information by sending letters to teachers and requesting there participation in recruiting teachers for collegiate and university programs. Serious campus recruitment of undeclared/undecided majors, use WEB site to promote program using live video camera that can be manipulated by the visitor, and be proactive in promoting the profession.

What are some strategies the technology education profession might use to attract, retain, and graduate more prospective teachers to fill the current and projected employment needs? Why are some technology teachers reluctant to be proactive in encouraging new teachers to enter the field?

A survey of educators in the profession provided interesting responses to questions regarding student recruitment. The bulk of the responses were related to 1) poor pay, 2) poor preparation in collegiate and university programs, 3) you have to love teaching more than anything else to succeed as a teacher, 4) students treat teachers badly, 5) they do not want to go to college, 6) students are aware of low respect, and 7) students are not told about the teaching profession.

Some of the strategies were covered in the previous section. Most of the solution would be an effort to improve the attitude of the teachers in the technology education profession as well as the teaching profession in general. Increased pay would help but education is already the biggest budget in most states. Really we need to provide a means of growth within the profession that allows teachers to advance without having to leave the classroom. Such a system should be designed predominantly by teachers and would be based on differentiated pay and responsibilities. Professional development opportunities should be plentiful and easily available. Limited class sizes and good administrative support.

Chapter Ten

Primary School Technology Education

Elementary School Technology Education in the United States: Determined to Succeed, Against All Odds

Sharon A. Brusic

Virginia Tech

Critical reflections on pedagogical practices in design and technology education in primary and early childhood education: Recipe, ritual or research based?

Marilyn Fleer

Monash University

Elementary School Technology Education in the United States:

Determined to Succeed, Against All Odds

Sharon A. Brusic
Virginia Tech

Introduction

Peer into a random sample of elementary school classrooms across the United States (US) and chances are that you will *not* see many children engaged in technology education (TE) activities. The distressing fact of the matter is that elementary school technology education (ESTE) in the US is still a fairly rare phenomenon in the majority of schools. However, if observers targeted certain locations to study what's going on in elementary classrooms, they would assuredly find a different result. From coast to coast, there are pockets of creative and enthusiastic elementary teachers who have transformed their curricula and made TE an integral part of their lesson plans. These innovative teachers bring ESTE to children in kindergarten (ages 4-5) through the 5th grade (ages 9-10) using a variety of teaching-learning practices. ESTE has come a long way since its historical beginnings, but it has a long way to go, too. In the US, ESTE is clearly a work in progress with a bright future—if the leadership is there to make it happen and the momentum doesn't fade. In the next several pages, ESTE in the US will be examined in greater depth in order to assess where it came from, what it looks like today, how it's working, and how more teachers can be brought on board in American schools.

ESTE: Then and Now

Modern ESTE programs in the US have roots that go back more than 100 years to programs established during the manual training, manual arts, and industrial arts eras of the late 19th and 20th centuries. In fact, researchers have documented numerous historical influences that likely affected what is now referred to as ESTE, including the work of American philosopher John Dewey, Swiss educational reformer Johann Pestalozzi, and other renowned educational thinkers (see Foster, 1999; Miller, 1979; Snyder, 1992). But, it was primarily the work of Frederick G. Bonser and Lois Coffey Mossman, colleagues at Teachers College of Columbia University (New York City), that helped to bring attention to early ESTE-like programs called industrial arts (IA) and attempted to position them in the elementary curriculum. Their book, *Industrial Arts for Elementary*

Schools (Bonser & Mossman, 1923), is widely recognized today as the first publication to provide a classic definition of this general education subject called IA in the US. In addition, they established the elementary IA curriculum and philosophy that would significantly influence the K-5 movement for the next several decades.

Bonser & Mossman (1923) explicated specific values that they deemed important to the study of IA for children aged 6-13, including objectives relating to health, economics, art or aesthetics, social, and recreational purposes. A large section of their book suggests "constructive," "investigative," or "appreciative" (p. vii) activities that can help young people learn about IA through six major themes based on human needs. These include food, clothing, shelter, utensils, records for transmitting experience (communication), and tools and machines.

Although Bonser's & Mossman's (1923) efforts were important (Foster, 1995) and elementary school IA continued to grow during the second quarter of the 20th century, Miller (1979) claimed that significant strides were not made in advancing the mission during that time period. It was not until about the 1950s-1970s that elementary IA began to flourish again. Miller cites ample evidence of growth in all areas, including the establishment of university courses to prepare teachers, the publication of six books focused upon the preparation of teachers to address IA (e.g., Miller & Boyd, 1970; Scobey, 1968), the employment of many IA specialists to work with classroom teachers and elementary students, and the establishment of the American Council for Elementary School Industrial Arts (ACESIA). ACESIA, now known as the Technology Education for Children Council (TECC), provided leadership to the elementary IA movement through numerous publications, including a monograph series.

Miller (1979) predicted that the 1980s decade would be a period of continued growth in elementary IA. He recognized that the "back to basics" trend that was just beginning to take hold could actually produce a "dampening effect" (Miller, 1979, p. 55), but he felt confident that the need for all citizens to develop "technical literacy" (p. 55) could become the "…'rallying cry' or point of focus" (p. 55) for elementary IA during the 1980's. In fact, this is indeed what happened in the US, although the focus was more broadly on technological literacy, not technical literacy. And, most of the growth and development occurred a bit later (i.e., late 1980s until present day).

For example, Virginia Tech researchers developed, field tested, and published ESTE curriculum materials for grades 1-6 between 1985-93 under a grant from the National Aeronautics and Space Administration and in collaboration with Delmar Publishers (see Brusic & Barnes, 1992; Brusic, Dunlap, Dugger & LaPorte, 1988). The project, dubbed *Mission 21* – to focus on the important mission of preparing youth for the technological demands of the 21st century, claimed to "…promote technological literacy in the elementary school through a problem-solving approach" (Brusic et al., 1988, p. 23). Furthermore, the curriculum resource materials included technological problem solving activities and implementation guidelines for connecting the activities to all areas of the elementary curriculum (see Brusic & Barnes, 1992).

Mission 21 was one of the first projects (approximately $275,000 total funding) to focus on ESTE during the last quarter of the 21st century. But, many other ESTE projects soon followed, thanks in particular to new funding sources from the National

Science Foundation (NSF). Project UPDATE (Todd, 1994; Todd, Doyle, & Hutchinson, 1993) and the Children Designing & Engineering (CD&E) Project (Hutchinson, 1999) are two such examples of NSF-funded projects specifically focused on ESTE. Both of these projects use thematic units and the design and technology (D&T) approach to engage young students in solving problems using the design process. Combined, these projects garnered more than $2 million in funding to train teachers and develop ESTE materials that correspond with math and science concepts.

The most prominent achievement in recent years came with the publication of the *Standards for Technological Literacy* (*Technology Content Standards*) (ITEA, 2000), produced by the Technology for All Americans (TfAA) Project. This document specified 20 standards and 100 benchmarks (statements of the knowledge and abilities that students demonstrate to meet a standard) that delineated what all children in grades K-5 should know and be able to do in order to advance their technological literacy. (There are additional benchmarks for grades 6-12.) This book and its companion volume for the elementary school level, *Technology Starters: A Standards-Based Guide* (ITEA, 2002), provide a fairly clear picture of the consensus focus of many ESTE programs across the nation. These national standards clearly specify that: "Technology is not an add-on subject in the primary grades. Rather, the study of technology is an integral part of the elementary curriculum" (ITEA, 2002, p. 2). And, in fact, the *Technology Content Standards* (ITEA, 2000) are not the bailiwick of TE alone; they were written for all children (K-12) and all teachers – in *all content areas*. William Wulf, President of the National Academy of Engineering (NAE) and the author of the book's foreword stated, "To have an impact, they [the *Technology Content Standards*] must influence what happens in every K-12 classroom in America….And, certainly, it cannot happen without the participation of teachers – all teachers, not just technology educators" (ITEA, 2000, p. vi). The portion of the *Technology Content Standards* that Technology Educators will eventually claim as their own is still unknown and will likely vary from state to state as curriculum is developed based on their vision.

Why ESTE?

Since the 1980s, the field of IA in the US has gradually changed to TE (i.e., focused more broadly on technology instead of industry) and the call for technological literacy clearly took center stage in the transformation. Most ESTE curriculum materials and publications since the mid-1980s (when the name of the field was officially changed from IA to TE) mention the need to develop technological literacy as a fundamental goal of ESTE (e.g., ITEA, 2002; Brusic et al., 1988; Nannay, 1989; Wright, 1999) or TE in general (e.g., ITEA, 2000; Pucel, 1995; TfAAP, 1996). However, the message seemed to become crystal clear when individuals *outside of the TE community* in the US took notice and published a groundbreaking and eloquent report titled, *Technically Speaking: Why All Americans Need to Know More About Technology* (Pearson & Young, 2002). This report and its website (see www.nae.edu/techlit) is the result of a two-year study by a group of experts (including a small number of technology educators) backed by the NAE and the

National Research Council. The Committee on Technological Literacy (as the group was named) was charged "…to begin to develop…a common understanding of what technological literacy is, how important it is to the nation, and how it can be achieved" (p. vii). In addition to reporting a dearth of K-12 programs in the US that focus on technological literacy, Pearson & Young (2002) expounded on the dire need to prepare all Americans, beginning in the early primary grades, to become technologically literate citizens, claiming that:

> Exposure to technological concepts and hands-on, design-related activities in the elementary and secondary grades are the *most likely ways* [italics added] to help children acquire the kinds of knowledge, ways of thinking and acting, and capabilities consistent with technological literacy. (p. 57)

In their report, Pearson & Young (2002) describe the goal of technological literacy very simply as providing "…people with the tools to participate intelligently and thoughtfully in the world around them" (p. 3). But, they go on to describe in detail how all people, including the entire country, would benefit from it. They cite such benefits as better preparation to make well-informed decisions in matters related to technology, improved citizen participation, and positive outcomes for the economy, perhaps by generating more "technologically savvy workers" (p. 5).

If attainment of technological literacy is not justification enough for ESTE, then it's not difficult to find a host of other reasons for it. In fact, the literature is replete with other rationales supporting ESTE initiatives. For example, Richard Peterson (1986) lists 12 characteristics of the ESTE program and many of these provide further justification of it's value, such as tying the curriculum together, building on children's natural instincts to manipulate, motivating students to learn, and integrating community resources. Robert Nannay (1989) provided some additional, albeit similar, justifications in his TECC monograph chapter.

Unfortunately, many of the rationales for ESTE are purely speculative because there is almost no research to back it up in the literature. One exception is Foster's (1997a) qualitative research study that focused exclusively on identifying the benefits of ESTE to children (see also Foster & Wright, 2001). Foster studied students in 2nd and 4th grade classrooms over a period of one quarter of a school year. He drew numerous conclusions that provide substantial support for ESTE. His study is one of the first attempts to methodically document the benefits of ESTE using respected research practices. Foster claimed that the ESTE activities in his study:

> …provided rich contexts for the development of children's vocabulary, language use, and creative communication….provided dynamic environments for students to exercise process skills in mathematics and science…encouraged students to exercise complex thinking processes which are usually taught to older children. Problem-solving and creative thinking were especially evident. ESTE activities improved children's technological knowledge and capabilities. Children were encouraged to practice perceptual and motor skills for which they were developmentally ready, but which were not included in the traditional curriculum….ESTE provided authentic scenarios for children to practice and improve several social and life skills. These included engagement, responsibility, personal growth, and the ability to work with others. (Foster, 1997a, pp. iii-iv)

Another exception is the work being done at Hofstra University (New York). In

1997, a new Master of Arts program in Elementary Education with a specialization in math, science, and technology (MST) was started. To date, graduates of their program have generated more than 100 theses based on their action research involving the integration of MST in elementary classrooms (J. Koch, personal communication, November 13, 2002). Among other findings, the results of these studies are providing further evidence of the benefits of ESTE. Koch & Burghardt (2002), key leaders of this initiative, report that this interdisciplinary approach using design technology as the "keystone that brings the unit together" (p. 31) has yielded numerous benefits, including a positive change from teacher-directed to student-centered learning and improved problem solving, higher-level thinking, and conversation by children.

It is impossible to provide thorough coverage of all the ways that ESTE has been justified in U.S. schools. Virtually every ESTE reference gives some attention to this topic including several authors in the *ESTE Yearbook* (Kirkwood & Foster, 1997). They point out many benefits of ESTE such as helping children to develop motor skills, making sense of their technological world by providing a meaningful context to learn, developing their creativity and problem solving abilities, and enriching the elementary curriculum by engaging them in meaningful hands- on learning. Kirkwood & Foster (1999) make a strong case for ESTE by relating it to concurrent trends in elementary education such as subject matter integration, collaborative learning, concrete learning, and curricular relevancy (which provides the motivation to learn). Further, ITEA (2002) identified and described a series of key pedagogical principles and then explained how these are supported through ESTE. Their overview describes how ESTE supports constructivism, development of multiple intelligences, dimensions of learning, multiculturalism, interdisciplinary learning, cooperative learning, problem solving, and the project approach. Clearly there are a lot of ways to argue for inclusion of ESTE; the challenge lies in proving these claims to the key players who can make ESTE a reality for primary children in the US.

What are the Key Concepts?

The *Standards for Technological Literacy* (ITEA 2000) might be the logical place to start looking for the key concepts of ESTE programs, particularly since it was the result of a substantial consensus-building process over several years in the US. However, the *STL* don't necessarily represent the only perspective of ESTE in the US. Moreover, they are not mandated standards and only time will tell whether or not they truly get implemented.

According to Foster (1997a, 1997b, 1999), ESTE can actually be divided into at least three groups based on philosophical differences related to whether TE is viewed as content, process, or method. Foster describes the *content view* as the one held by individuals who believe that there is a distinct knowledge base for technology. He places the TfAA Project and many historical approaches (e.g., Bonser & Mossman, 1923; Scobey, 1968) in this category because of their identification of distinct content that is unique to technology (or IA). Foster portrays proponents of the *process view* as supporters of the D&T or problem solving approach to TE (e.g., Todd, 1994; Todd & Hutchinson, 1991), where emphasis is placed on the process of doing technology (i.e., designing and making solutions to technological problems), not the technology content itself. "Thus it [the process view] differs from the *content* view insofar as it focuses more on technological capabilities than on knowledge" (Foster, 1997a, p. 36). According to Foster (1997a, 1997b, 1999), the *method view* places other areas of the elementary curriculum before the technology activity or content. In this view, TE is clearly used to support and enhance other areas of the curriculum, especially math, science, and social studies.

In reality, Foster admits, these three views of TE are seldom seen in isolation; most ESTE curricula and programs tend to combine perspectives to varying degrees. Nowhere is this more evident than in the TfAA Project materials (ITEA, 2000; ITEA, 2002; TfAAP, 1996) where content, process, and method philosophies are blended together in one package. The *STL* (ITEA, 2000) clearly identify content (knowledge) for the study of technology as Foster (1997a) claims, but technological *processes* and technological *capability* are key components of the expectations within this directive as well.

> …technology has a process, knowledge, and context base that is definable and universal….The processes include the human activities of designing and developing technological systems…Technological knowledge includes the nature and evolution of technology; linkages based on impacts, consequences, resources, and other fields; and technological concepts and principles….The context of technology involves the many practical reasons why it is developed, applied, and studied. (TfAAP, 1996, p. 16)

Moreover, the elementary ITEA materials make it clear that the intent of ESTE is to integrate it with core subjects and enhance the existing elementary curriculum, thus representing the *method view* of TE. "At this level, technology provides the theme or context for studying other subjects" (ITEA, 2002, p. 2). The book provides numerous examples of technological activities and specific strategies/ideas for connecting them to science, math, social studies, health and safety, language arts, reading, and even career education. Interestingly, Foster & Wright (1996) concluded in a separate study that selected TE leaders overwhelmingly viewed ESTE as a *method*, not a content or process. "The focus of elementary school technology education, the leaders suggested, should not be on learning facts or mastering technical skills, but on the use of technological activities to reinforce the existing curriculum" (Wright & Foster, 1997, p. 34-35).

So, what are the core concepts of ESTE in the US? The answer to this question is clearly a difficult one to provide since there is an obvious lack of philosophical agreement in the US. Indeed, the answer depends on one's standpoint and differs considerably based upon that philosophy. If one's philosophy is more compatible with the *content view*, then the *STL* (ITEA, 2000; ITEA 2002) are probably the best place to look for key concepts at the elementary level. There one would find an extensive list of ideas in the form of standards and benchmarks that should be addressed in grades K-5. The *STL* provide direction for addressing technological knowledge (e.g., nature and evolution of technology, social and environmental effects of technology), processes (e.g., designing engineering solutions, using technological processes and systems), and contexts (i.e., technologies associated with medicine, agriculture, energy & power, information and communication, transportation, manufacturing, and construction).

Individuals who favor the *process view* of TE will find it more difficult to identify an articulated set of key concepts or skills. However, there are a number of good resources for teaching children designing and engineering processes that include concepts related to control, mechanisms, ergonomics, aesthetics, structures, materials, and energy (e.g., Dunn & Larson, 1990; Garratt, 1996; ITEA, 2002). And, of course, one could look at the *STL* (ITEA, 2000) and focus exclusively on the process standards.

Lastly, proponents of the *method view* can find numerous examples and case studies in the literature of ways to integrate technological activities with the existing elementary curriculum. Many teachers find great success integrating ESTE with children's literature. See the *Books to Briefs* section of nearly every issue of the *Technology & Children* journal since spring 1998 and selected chapters of the *ESTE Yearbook* (Kirkwood & Foster, 1997) for examples. Other teachers have reported great success integrating ESTE through social studies (e.g., Foster & Kirkwood, 1994), mathematics (e.g., Wright & Foster, 1996), and science (e.g., Jackson, 1996). The method view is not based on any specific technological concepts or skills.

Getting ESTE Implemented

ESTE programs exist across the US, with some states showing stronger support than others. For example, ESTE standards exist in some states such as Florida and Texas. Virginia is the only known state to sponsor a Children's Engineering Convention (annually since 1997) and they launched a new journal focusing specifically on ESTE in 2002. New Jersey is the home of several highly respected ESTE projects and researchers there have provided much ESTE leadership, especially in the areas of D&T and children's engineering.

U.S. school systems rarely hire individuals whose sole responsibility it is to teach or provide support to ESTE. In the overwhelming majority of US schools that address ESTE at all, regular classroom teachers typically take it upon themselves to plan and implement ESTE programs, oftentimes with little or no support for training, curriculum, and materials/equipment. In some locations, schools might adopt ESTE for all classrooms and benefit from funding for supplies or professional development. But, this is the exception, not the rule.

Brusic (2001) and Kirkwood (2000) collaborated on developing an ESTE survey in order to gain further insight about ESTE implementation. Kirkwood used the instrument to study recent graduates of a teacher education program who were required to take an ESTE course as part of their undergraduate education. Brusic studied Virginia elementary teachers who had training through a major D&T ESTE project. The results of both studies indicated that there were several barriers to implementation. In Virginia, teachers expressed concerns about pressures to have students perform well on standardized tests. Teachers from both studies claimed that insufficient planning time and lack of equipment and supplies were implementation barriers.

Classroom elementary teachers are the most important key to getting ESTE implemented in more schools. Unfortunately, very few pre-service teachers (i.e., college students studying to be elementary teachers) have received any ESTE training whatsoever. According to Linnell (2000), only 15 universities across the nation currently offer ESTE courses, a decline of 25 programs compared to 1975 figures (Kieft, 1997). Of these 15, only five required these courses of all pre-service elementary teachers; most were offered as electives and some only sporadically. Elementary teachers are clearly entering the work force with inadequate preparation to address ESTE in their classrooms.

ESTE researchers clearly agree that pre-service courses are key to advancing the ESTE mission in schools. And, practicing elementary school teachers seem to concur. Teachers surveyed in Brusic's (2001) and Kirkwood's (2002) studies agreed on the top two ways to increase ESTE implementation—requiring an undergraduate class (during pre-service training) and offering more ESTE workshops (in-service, summer, etc.).

Lewis Kieft (1997), an individual who has taught ESTE courses for many years in Michigan, described the essential components of pre-service ESTE courses. He recommends the use of thematic units with a major technological focus to provide pre-service teachers with the tools they need to integrate ESTE with the curriculum. Further, Kieft provides guidelines on how to setup and deliver an ideal ESTE course, emphasizing the need to engage pre-service teachers directly with ESTE in the elementary classroom. They must see and experience the challenge and excitement of ESTE activities in order to be convinced that ESTE is not only possible, but also beneficial for children. Linnell's (2000) findings support this and there is evidence that many ESTE instructors at the university level use this approach.

There is scant research about the ideal way to prepare elementary teachers for ESTE. And, most of the suggestions provided in the literature are not that remarkably different from any other subject matter (e.g., experiences with lesson/unit planning and classroom management strategies, techniques for materials/equipment organization, meaningful engagement in D&T activities). Basically, pre-service ESTE courses should probably be delivered in much the same way as other TE courses—with lots of practical and motivating experiences to build students' technological understandings and their appreciation for ESTE, coupled with quality curriculum and instruction experiences that enable these future teachers to translate technological concepts into meaningful lessons/activities. Furthermore, ESTE courses should help these aspiring teachers to feel successful with TE, because lack of confidence now will likely deter implementation later.

There is a great need for expanded ESTE offerings, both at the pre-service and in-service levels. Universities that don't currently offer ESTE programs ought to pursue the possibility of initiating one, perhaps as a special offering at the graduate level. At the very least, technology teacher preparation programs should be integrating ESTE experiences in their teaching methods courses in order to prepare future TE teachers to carry on the ESTE mission. One practical way of doing this is by engaging students in service projects to local elementary schools (as part of courses or through student organizations) in order to gain some experience with K-5 students. At Virginia Tech, for example, pre-service technology teachers plan and implement *Youth Technology Day* and pre-service elementary teachers implement *Design & Technology Day* annually as part of their courses

(Brusic, 2000).

The College of New Jersey initiated a new MST emphasis for elementary and early childhood education majors that may prove to be a great boost to ESTE implementation. At the graduate level, ESTE proponents ought to take notice of Hofstra University's program (Koch & Burghardt, 2002). This unique program engages practicing teachers in an interdisciplinary approach that shows great promise. The initial results from their teacher action research efforts with D&T themes are quite positive. It's hard to imagine a better way of preparing ESTE teachers than engaging them in articulated programs through pre-service teacher education or graduate education. It is likely that the prolonged indoctrination to ESTE will have a more lasting effect in the classroom.

Certainly there are other creative ways to further advance the ESTE mission. Foremost, it is imperative that technology educators cease preaching to themselves and focus their efforts where it can really make a difference—the elementary community. ESTE proponents ought to do extensive publishing in elementary journals and get on the program at elementary conferences. Faculty should mentor graduate students to conduct ESTE research and disseminate their findings in both the TE & elementary communities. Further, ESTE is certain to benefit from collaborative partnerships and joint projects between TE and elementary faculty. These endeavors must be encouraged and supported.

Concluding Remarks

ESTE in the US is at a pivotal point in its long history. There appears to be a growing interest in ESTE across the country, particularly since the release of the *Standards for Technological Literacy*. Moreover, there are some good funding sources to make change happen, a growing body of knowledge about ESTE, a few external allies in the effort to promote technological literacy beginning in the primary grades, and some solid evidence that children and teachers benefit from these programs. But, progress seems excruciatingly slow, particularly when one looks back in history and sees how long and hard that TE & IA educators have labored to get ESTE-like programs established in American schools. Sometimes the efforts seem futile. There is a tendency at this point to simply enumerate (again) all the things that must be done to advance this important mission. Collect more data. Train more teachers. Convince more administrators. Generate more curricula. Build more coalitions. Exalt the praises of ESTE to more people. Then move on—hoping that key people heed the advice and speed the progress.

Instead, perhaps now is the time to look for inspiration outside of TE—in fact, outside of the United States. It's the story of early childhood education schools in Reggio Emilia, Italy that originated just after World War II thanks to the dedication of parents and citizens, and the leadership of an Italian teacher named Loris Malaguzzi (Edwards, Gandini, & Forman, 1998). These schools, which have since received acclaim in early childhood education communities around the world, were initially started by local community members using money they acquired from selling effects left behind by the retreating Germans (e.g., war tank, trucks, horses). The Reggio Emilia childcare centers and schools cater to the needs of young children aged 4 months to age 6. They have a reputation for fostering young children's intellectual, social, and emotional growth through a unique, collaborative classroom environment. Aspects of these programs bear some resemblance to ESTE initiatives, not the least of which is their focus on project work and problem-solving at this very young age. Reggio schools developed in response to a community need, but they were built on many of the same philosophies (e.g., John Dewey and Johann Pestalozzi) that make TE stand out as a unique part of the curriculum today. Moreover, they became successful—*against all odds*.

ESTE in the US has an uphill battle to face. Like the Reggio schools, ESTE has been amazingly successful in certain parts of the country. The success of these programs is mostly due to the hard work of a few determined educational pioneers. It is important to celebrate those successes—and nurture them—because these programs are creditable evidence that ESTE is possible and valuable. And hopefully, with determination, commitment, and perhaps a little luck, every child, in every elementary classroom across the US, will one day have the opportunity to learn and grow through ESTE activities led by competent and dedicated teachers.

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Critical reflections on pedagogical practices in design and technology education in primary and early childhood education: Recipe, ritual or research based?

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Introduction

> For some, technology symbolizes such things as repression, drudgery, and threat. For others, it is alien and beyond their economic means. For still others, it's the hope for the future (Custer, 2000:108).

Custer (2000) argues that technology, and therefore technology education, should be broadly conceived, inclusive and abstract. It is argued by Custer (2000:98) that when technology is thought of too narrowly, 'and primarily as an artefact, then the tendency is to ignore the larger issues of how that artefact may or may not be woven throughout the fabric of culture'. When technology is conceived as an artefact, the focus in education is on the 'perfection, efficiency, functionality, and utility' of the artefact. The sterility of this view of technology is translated into classrooms in ways which treat the artefact as disembedded from its social context, as value-free and ignores the social process which evolve these technologies in society. However, this is one definition of technology education among many perspectives.

This paper examines the rituals and the recipes that have evolved in technology education, with a view to considering the embedded and disembedded pedagogical practices that have been created to improve learning outcomes for children. This paper analyses the diversity found in classrooms and centres through the presentation of an analytical framework, and argues for the need to introduce a range of technological practices within any given school year.

Curriculum recipes and rituals

Curriculum development in primary and early childhood technology education is a relatively new phenomenon in many countries around the world. Most studies of curriculum development in technology have demonstrated that technology education can be viewed as a process involving problems, designing, evaluation and some form of constructing or doing. As Stevenson (2000) suggests:

> To design, it is said, one must "find" and define the problem in conceptual terms and make plans, judgements and decisions based on conceptual principles….Making, on the other hand, is seen in academic communities to involve and use tools in routine ways to accomplish well-defined and known goals. It is seen to involve procedural knowledge, developed through practice over time….Appraisal or evaluation is also seen to rely on conceptual principles in the same way as does design, and attracts academic value (p.133).

In Australia the Curriculum Corporation of Australia (1994) have defined technology education as the 'purposeful application of knowledge, experience and resources to create products and processes that meet human needs'. In New Zealand technology is viewed as 'a creative purposeful activity aimed at meeting the needs and opportunities through the development of products, systems, or environments. Knowledge, skills, and resources are combined to help solve practical problems. Technology practice takes place within and is influenced by, social contexts…' (New Zealand Ministry of Education, 1995 cited in Pavlova, 2000:115). In the USA the goal of technology education is to produce students with a more conceptual understanding of technology and its place in society, who can thus grasp and evaluate new bits of technology they might never have seen before (cited in Pavlova, 2000:115).

However, Seeman (2000) in a thoughtful paper has asked questions about the relevance of a process approach for all Australians. He argues that the social embeddedness of technologies is so important that it cannot be removed from technological learning. He cites two examples to illustrate the social embeddedness of technologies - the introduction of the steel axe into remote Indigenous communities, and the construction of pandanus baskets by Indigenous women:

The steel axe

Most traditional indigenous communities today use the short-handled steel axe for hunting and gathering, and for crafting goods for the tourism market. However, when missionaries first handed out the axes to encourage church patronage, a ripple effect disrupted long standing social structures (Sharp 1952). The axe was traditionally a man's tool. The prized smooth stones of traditional axes were tradeable items linking local groups with trade lines across the country. For groups in the far north the hardwood axe handle had to be traded from desert groups to the south as local woods were less suitable. Some men held particular status because of acquired skills as trade negotiators, and because they had established friendships across vast lines of trade. Skills of diplomacy in trade gave rights to men to regulate the axe…To gain a traditional education in the production of axes was to develop social trading skills, technical knowledge, and techniques in assembly and selective extraction of local natural resources. …

> …for a school to teach a module that leads to the fabrication of a traditional stone axe without genuinely developing skills in trade negotiation, and in the selective extraction of raw timber from the environment in a socially acceptable way (Seeman, 2000:63).

Pandanus basket construction:

For women in island communities, learning the technical skills of basket construction is necessarily a social event deeply embedded in the sustainable human and environmental relationships. The whole exercise necessarily integrates social, technical and environmental knowledge and skills. To represent the pandanus "curriculum" in a series of parts would be to misrepresent the quality of the integrated knowledge these women have developed. A disintegrated curriculum simply produces disintegrated judgements and hence inadequate solutions to the project or problem at hand (Seeman, 2000: 66).

These examples highlight not only how artefacts and systems are socially embedded, but that isolating them from their social context in technology education renders the experience invalid. Consequently, limiting children's learning to segments of reality, however contextualised in the classroom (ie making a birdfeeder), is a narrow and disembedded approach to technology education. Seeman (2000) argues that much of Western technical education is 'Modularised, and taught as if technical skills were defined independently of the social and environmental contexts, western technical education has had minimal desirable impact in remote indigenous communities' (p. 64). Seeman (2000) illustrates the complexity of technology, and the need for considerably more thought to the evolution of appropriate pedagogies to capture the social embeddedness of technology.

Wellbourne-Wood (1999) has also argued for this by stating that 'little attention has been given to researching the cultural and social characteristics' of design and technology education (p.5). There is clearly a need to develop a better understanding of how schools and centres translate research and curriculum support into classroom practice.

Research on practice

> …there has been very little research undertaken which is associated with the implications of delivering technology education in the existing school environment. Most schools have been left to fend for themselves and organize their facilities in the best way they know how (Wells, 2000:30).

Over the past ten years there has been an increasingly larger number of studies directed towards determining how technology curricula is translated into practice in classrooms in a range of countries around the world (Anning, 1994; ASTEC, 1997; Compton and Jones, 1998; Jones, Moreland and Northover, in press; Johnsey, 1995; Jones, 1997; Jones and Compton, 1998; Jones and Moreland, 2000; McCormick & Davidson, 1996; Moreland and Jones, 2000; Moreland, Jones and Chambers, 2000; Moreland, Jones, Milne, Chambers and Forret, 2001; Solomon, 1998; Stables, 2000; Stables et al., 2001; Stein, McRobbie and Ginns, 2000).

Interestingly, Ginns, McRobbie and Stein (2000) have argued that the 'newness of technology as a learning area, the teachers' lack of familiarity and explicit knowledge of technology and technology education were shown to be sources of difficulty for teachers implementing technology programs' (p. 79).

In a study of children's technological experience in both the UK and Finland, Jarvinen and Twyford (2000) found that although teachers in each learning context subscribed to the same constructivist principles and children were constructing the same 'sound-making (rattle)' device, the Finnish approach was open-ended yielding a rich diversity of devices, whilst the UK children constructed similar devices to that presented by the teacher. Jarvinen and Twyford (2000) argued that:

> …if pupils are always guided too much by prescribed design work then they may find it more difficult to work creatively (p. 35).

However, they also questioned the open-ended approach:

> …Alternatively, pupils should be enabled to carry out their design ideas with knowledge and understanding (p. 35).

Badham (2000) in detailing a study by Kimbell et al., (1996) discusses similar notions of open and closed technological design briefs and the subsequent outcomes for children. However, the study examined the practices of teachers in primary and secondary schools, finding the following disparity across education sectors (Badham, 2000:87):

Figure One

Pedagogical comparisons of Design and Technology Education (Kimbell et al., 1996, cited in Badham, 2000:87)

Primary	Secondary
Children working individually, but in a collaborative manner;	Children working individually;
Task- specific constraints, but thereafter open-ended (all produced different outcomes)	Task – specific brief set;
Materials/processes – not specified;	Materials – specified by teacher;
Designing – carried out mainly through materials;	Designing – done in advance on paper;
Low proportion of teacher input- primarily a progress chaser.	High proportion of teacher input – predominantly directive.

Badham (2000) argued that in the study by Kimbell et al., (1996), primary children were working autonomously in conditions of uncertainty, whilst the secondary students were dependent upon the teacher and working closely to the specificity of the tightly framed technological design brief. Jarvinen and Twyford (2000) highlight in their work that in conditions of certainty, the product is known and social interaction between peers is reduced. In these contexts Jarvinen and Twyford (2000) argue that limits are placed upon children's own knowledge and experience. However, in conditions of uncertainty, a variety of product outcomes are likely as a result of the children's freer interpretation of the design brief. In these contexts social interaction between peers is critical for gaining a wider use of design ideas and children's own knowledge and experience is important for effective learning.

In a study of pre-service teachers' capacity to fully appreciate the knowledge requirements of implementing technology education syllabus documents in Australia, Ginns, McRobbie and Stein (2000) found increased conceptual and procedural knowledge gains made by students when involved in open-ended projects in which autonomy of design and construction featured. They argued that a range of technological tasks were also necessary, ranging from 'guided experiences to ill-structured, independent projects' (p. 82) with sustained project work also featuring at different points in the teaching-learning program. In addition, Ginns, McRobbie and Stein (2000) in reviewing the literature, suggest that authentic or 'real life' technology contexts should be established. They note two conditions for authentic learning environments – 'problems are ill defined or so loosely defined that students can establish their own problem frames, and students experience uncertainty and ambiguity in finding solutions' (p. 81).

Extensive and detailed research in New Zealand in technology education over the past five years (see Compton and Jones, 1998; Jones, 1997; Jones and Compton, 1998) and beyond has shown that even with experienced teachers of technology, children experience confusion in relation to the outcomes that they are expected to work towards (Moreland and Jones, 2000). This research has also demonstrated that teachers' formative assessments and interactions are mostly directed towards children reinforcing successful collaborative group work and technological task completion (see Jones and Moreland, 2000; Jones, Moreland, and Northover, In press; Moreland and Jones, 2000). With in-servicing directed at teachers' understanding of conceptual, procedural and societal knowledge, teacher-child interactions become planned and allow for better understanding of progression of learning in technology education – for teachers and for children (Moreland, Jones and Chambers, 2000). More recently, Moreland, Jones, Milne, Chambers and Forret (2001) have developed a framework for analysing student technological literacy for multiple conceptual, procedural, societal and technical knowledge:

- Dimensions of student technological practice, which includes the operationalisation and integration of conceptual, procedural, societal and technical variables in technological activity;
- Conceptual-knowledge and understanding of relevant technological concepts and procedures;
- Procedural-strategic application of procedures and processes;
- Societal-aspects related to the interrelationship between technology and groups of people;
- Technical-skills related to manual/practical techniques and tools (p. 2).

Progression in learning according to Moreland, Jones, Milne, Chambers and Forret (2001) involves development in understandings of the nature of technology; increasing complexity and sophistication; and the capacity to consider and work with generic and specific dimensions of conceptual, procedural, societal and technical knowledge.

When teachers lacked a deep knowledge of conceptual and procedural technological knowledge Stein, Ginns and McRobbie (2000) found that:

- Student uncertainty about what to focus on during lessons resulted;
- Teachers took on the role of facilitator rather than teacher;
- Teachers had limited capacity to monitor technological learning, ascertain progression, direct student attention to new or more complex ideas or support technological language acquisition.

Stein, McRobbie and Ginns (2000) found in their study of three teachers in Australian classrooms that they 'did not capitalise upon numerous opportunities for fostering their students' learning' and that these missed opportunities were likely due to the 'newness of the learning area and the limitations of their conceptual and procedural knowledge of technology' (cited in Ginns, McRobbie and Stein, 2000:79). In another study, Stein, Ginns and McRobbie (2000) found that 'when teachers have limited understandings of the knowledges that are drawn upon during technological activity, they are limited in their ability to provide the necessary support to monitor and encourage student's discernment of what is important about a technology experience' (p. 230).

Collectively, these studies demonstrate that whilst open-ended contexts produce uncertainty, they allow for child independence and a diversity of artefacts to be produced, supporting creativity and high level technological learning. However, the nature of the interactions for supporting this learning is problematic, being left mostly to chance rather than design. Insufficient research has been directed towards the nature of the interactions within the open-ended technological experiences.

Clearly, technology education is more than the introduction of an open-ended problem, the provision of a selection of resources and the allocation of time for groups to respond. This simplistic approach to technology education may well yield riches, but the riches derived, occur more by chance than by design. More needs to be understood about the subculture of design and technology that is drawn upon or created during classroom activity. In this way, a better understanding of the relationship between open-ended and more closed learning challenges can be established and more thoughtful pedagogical planning would then be possible.

Designing pedagogical diversity

Some researchers have classified the diversity of practice into:

> …the Craft-Based approach, the Technology Concept approach, the Design approach, the Occupational or Vocational approach, the Science/Technology/Society (STS) approach, the High-Tech approach, the Integrated Subject approach and the Applied Science approach (de Vries, 1994; cited in Jane and Kelly, 2000: 233).

Although a range of ways of sorting, classifying and naming of technology education practice is possible, thought should be directed towards the range of ways that technology may be experienced in a classroom and what it means when only one way of learning in technology is provided. For instance, Figure Two demonstrates a range of perspectives on technology and design education practices that are generally enacted within classrooms and centres in Australia (Fleer and Jane, 1999; Fleer and Sukroo, 1995).

Figure Two

Pedagogical perspectives on technology and design education

Learning Context	Focus	Perspective	Pedagogical Example
Discrete technology	Tightly framed design brief	Teacher-centered	Building bridges out of straw to support a matchbox car (See Fleer and Jane, 1999)
Simulation technology	Interactive technology	Child-centred	Invention Room; Imagination Room; (see Fleer and Sukroo, 1995)
Purpose-oriented technology	Symbiotic technology	Community-centered	Designing a new playground or classroom layout (see Fleer and Sukroo, 1995; Harriman, 1996).
Values-based technology	Socially critical technology	Values based	Designing and appraising bags – examining their purpose, the content and values (see France, 1999; Fleer 2000)
Culturally-framed technology	Cultural construction of technology	Culturally analytical	Cultural analysis of technology (see Seeman, 2000)

Technology and design education is often presented in classrooms as a discrete learning experience for children. We often see work sheets that present a challenge to children and invite them to come up with a solution. For example building a bridge from straws to support a matchbox car (child's toy, approximately 5cm long). This discretely framed design challenge is generally disconnected from children's real lives or cultural context (Custer, 2000) and the design challenge is frequently set by the teacher and often closed (Badham, 2000). Another pedagogical approach to design and technology education has been to set up a more open-ended design challenge, mirroring aspects of the children's or the adults' lives. For example, setting up an invention room in which children can act out being inventors and designers. In these environments the focus is on the children's interests and experiences with the teacher supporting the direction they wish to take. Fantasy and creativity often play an important role in this approach.

Purpose oriented technology on the other hand concentrates more on real world problems that arise, such as designing new lunch order systems or a new classroom layout (Fleer and Sukroo, 1995). Whilst the pedagogy features an open-ended approach, the reality of the children's lives largely shape the directions that the children take in their technological work. These three approaches represent the most common forms of pedagogy that have evolved in primary and early childhood technology and design education in Australia. However, it is becoming increasingly recognised by teachers that technology, and therefore technology education is not value-free (Cross and Fensham, 2000). For instance in an important paper by France (1999), teachers were invited to consider how they could represent technology education to their children in ways which encouraged children to consider values and ethics during technology education. France (1999) found that teachers' programs and pedagogical practices can reflect an issues based approach.

France demonstrated that children from ages five to twelve years were easily able to deconstruct or study everyday objects such as bags from a social perspective. In her study the children developed critical reflection skills and actively explored values and ethics through taking:

- A personal perspective – why is the bag special to you?
- A perspective of other individuals and groups – what might be in the bag?
- An historical perspective – what sort of bags were used by their grandparents?
- An environmental perspective – drawing flow charts to map the life cycle of plastic bags; and
- A producer perspective – who made the bag and who benefits?

Fleer (2000) in building upon France's work has also demonstrated that young children can easily engage in technological activities which foreground ethics and values. More recently, Keirl (2000) has questioned how we make decisions about which values and ethics to consider in our programs:

> …not only are there numerous, rich and competing values but, also that these are central, not peripheral, to technology and to Technology Education discourse…whose values ought be considered, whose ought be given ascendancy, whose are marginalise? (Keirl, 2000:13).

Broadening this area even further has been the work of Petrina (2000). He argues that technology education needs to be further politicised so that learners have agency. That they have sufficient agency to not just recognise the inequities that are created as a result of particular technologies, but that learners have the capacity to interrupt these institutionalised beliefs, practices and developments. He states:

> This means questioning technocratic assumptions, and capitalist notions of autonomy, determinism, and progress…this active intervening entails the production of political artefacts or texts – the deconstruction, reproduction and politicised, built world (p. 196).

Petrina (2000) has argued for the emergence of critical literacy in technological practice. He suggests that there is a need to make explicit the "'waste' of production, consumption, identity, regulation and representation" (p. 199). In particular he asks:

- Whose identity is appropriated and represented in our technological or technoscientific practices (or in this artefact, sign, text, etc)?
- Whose identity and what is regulated through our practices (or in this artefact, sign, text etc)?
- What are the mechanisms through which representation and regulations are occurring?

- How can this identity, representation, production, consumption, regulation, or waste be re/appropriated, reproduced for collective justice? (Petrina, 2000:202).

Petrina (2000) argues that since the late 1990's most countries have gradually shifted their emphases in technology education toward economic development and competition (See Figure Three below). The arrows indicate the direction of curriculum change, demonstrating an overall movement from an essentially humanistic, value-based approach to a more economically driven imperative.

International Emphases in Technology Education in the Late 1990s (Grades 9-13)

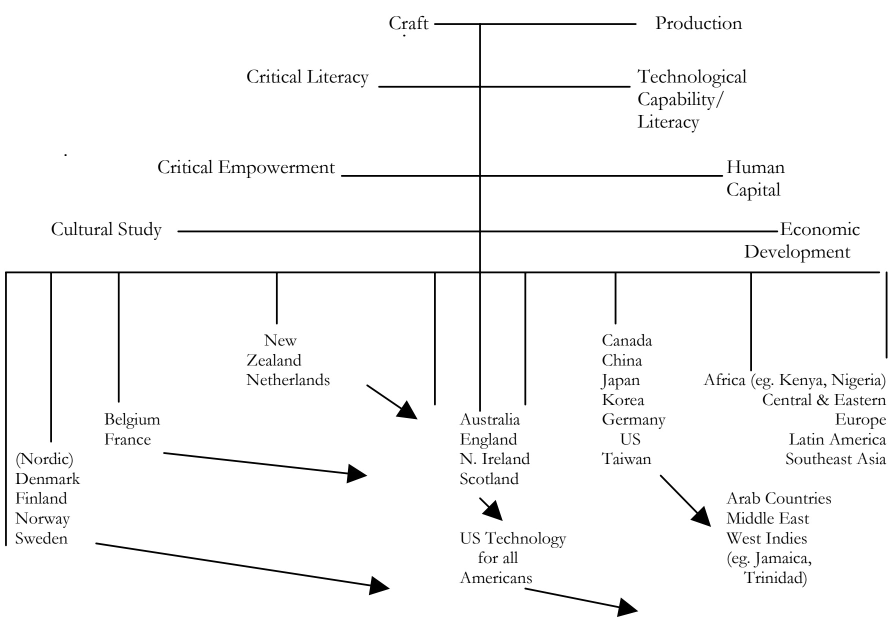

Figure Three

International emphases in Technology Education (Petrina, 2000:190).

In recognising that values are central to pedagogical discussions of technology and design education, it is possible to explore the place of culture and begin to appreciate the importance of embedding this area of educational study within a socio-historical framework. For instance, Seeman (2000) provides an example of socially constructed view of technology education from Australia, whereby the embeddedness of the technology was central to the learning philosophy:

Rainwater tank scenario

One student identified his grandfather's traditional land in the arid zone of central Australia as needing a more sustainable way to store rainwater. The student was aware that he could have gone to a retailer of fibre-plastic rainwater tanks, but decided against it. Considering the technacy model, he argued that *technologically* such a tank would be difficult to repair out in the bush should it be damaged, and that fibre-plastic technology was much too expensive for the scale of the local economy at his grandfather's camp. *Human* issues included a desire to keep skills in the camp and not have outsiders coming and going all the time to install and repair the tank, leaving no reusable skills behind. *Environmental* issues included the fact that the land at his grandfather's camp was sparse, with little timber, but had plenty of desert sand. He grappled with several ideas and finally decided he wanted to try and construct a ferro-concrete water tank using "bush sand" from the camp site. He had no skills in cement mixing and as a result the educator included in his learning experience a short module dedicated to cement making techniques. The end result was a very functional and locally repairable water tank for his grandfather. The student had commenced his journey of empowerment in holistic technology practice through the production of technologies appropriate to his grandfather's particular context. It should be noted that the student not only gained skills in specific technical processes, but also in the overall organisational skills required for getting the job done in a culturally, technically and environmentally appropriate way (Seeman, 2000:72).

Wellbourne-Wood (2000) argues that 'insights into the cultures of people's interaction with technology offers valuable and useful knowledge to advance understanding of Technology Education' (p. 194). Wellbourne-Wood (2000) asks:

> How does culture impact on our interrelationships and perceptions of technology? How does culture impact the teaching and learning of technology? A critical awareness of our own and other cultures, it can be argued, is a prerequisite in democratic participation with technology. Culture is a piece of the puzzle in building understandings of issues confronting Technology Education (p. 199).

Conclusion – moving forward

When taken together, the diversity of practice in technology and design education has provided the profession with a rich understanding of how learning can be enacted in classrooms. Unfortunately, the practice in classrooms at this early stage in the theorisation of technology and design education, has meant that we do not have a sophisticated approach to building student learning. Rather, the literature has illustrated the diversity and the research has shown the problems that arise in both open-ended and closed learning experiences in technology education. Individual researchers have provided rich examples of students engaged in ethically driven, ecologically motivated, or culturally sensitive pedagogical approaches. However, framing these approaches into a conceptual grid as a tool for teachers has not been considered before.

Figure Two provides a beginning point for making explicit the pedagogical approaches that are possible or that are enacted daily in Australian classrooms and centres. Although each category identified and named is not exclusive (ie teachers can construct pedagogy which takes into account both teacher-centered and child-centered practices within one teaching sequence), it is important to both analyse and name common practices so that we can communicate within and external to the profession about what is taking place. Similarly, we need labels to help us with the important conceptual work that is still needed in what has been described by many researchers, as a 'relatively new field of study'. This being principally so in the early and primary years of education. Wenger (1998) suggests that the reification process (concretising complex processes through the naming of practice) is important for both theorisation and conceptual progression.

The analysis of existing practice in Australia, as shown in Figure Two, draws our attention to thinking about technology education in terms of a meta-pedagogy. That is, examining the balance of pedagogy encountered by Australian students in classrooms and centres. What is important here is ensuring that as a profession we examine both the sequential development of technological knowledge and capability in students, and their exposure to higher order processes in technology and design over the duration of their education. Simply applying one approach, such as tightly framed design challenges devoid of social context, may never give children opportunities for building other ways of thinking in technology education, such as social, ethical and cultural thinking in relation to technology and design. Similarly, only focusing on social issues, may never provide students with important technical skills needed for realising designs.

Sophisticated pedagogy in technology and design education is about teachers being thoughtful about the pedagogy they employ and the balance of approaches they use throughout a school year. This metacognitive approach to technology pedagogy is important for building a range of technological capability in students. If technology is to move forward into the arena of ideas technology - as is being advocated in the Vision put out by the Commonwealth Department of Education Science and Training (www.dest.gov.au/school/te/2012/) by a group of academics and practitioners expert in this area - then a more systematic way of thinking about pedagogy in technology education in Australia is urgently needed. Consequently a further layer of pedagogy and conceptual work should be included in Figure Two which focuses on metatechnology. That is, the movement from artefact and process to agency and metacognition, as shown below in Figure Four. This has the effect of not just teachers working metacognitively in relation to pedagogy, but also for the learners to think metacognitively about the conceptual tools they are developing as a result of technology education.

Figure Four

Metatechnology: Moving from artefacts and processes to ideas technology

Learning Context	Focus	Perspective	Pedagogical Example
Ideas technology	Metatechnology	Agency oriented - Building agency within a globally embedded context	Features include: openness, richness, fostering collaboration, progression with increasing complexity and sophistication, authenticity, independence, multiple cultural perspectives, building individual and community agency, creativity, and foregrounding of ethics, values and critical technological literacy.

The challenge for the design and technology community is to realise these pedagogical features (shown in column four) through imagining teaching scenarios that give rise to a child's technological agency. An individual's agency can only be built at the metacognitive level. What is needed is pedagogy which foregrounds agency so that children can invent ideas that have as yet not been envisaged, are able to move into paradigms not yet conceptualised, build globally responsible policies not yet considered, and imagine futures embedded in thoughtful analyses of values and ethics. Through framing technology education within an agency-oriented approach, new ways of conceptualising pedagogy are possible (Figure Four). These metacognitive technological thinkers will be the graduates we need to build community capacity for peaceful, harmonious, trusting co-existence in a diverse and multicultural global community. Design and technology education that is conceptualised in this way will make a lasting and important contribution to education in Australia.

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Chapter Eleven

Diversity

Innovation Through Diversity: Beyond the Know-How to the Know-Why and Who-With in Cross-Cultural Technology Education.

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And the Beat Goes On: Diversity Reconsidered

Linda Rae Markert

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Innovation Through Diversity: Beyond the Know-How to the Know-Why and Who-With in Cross-Cultural Technology Education.

Dr Kurt Seemann

Southern Cross University

Introduction

This paper explores the critical importance of diversity in technology education for fostering innovation qualities, new knowledge and capabilities among learners for the knowledge economy. It asserts that the premise for increasing participation behind questions like "What does technology have to offer females and minority groups?" is fundamentally one directional and so gives a negative message to minority cultures and groups in technology education. The proposition implies limited understanding of the role and contribution that diversity in technology education makes in helping to improve the quality of technical decisions and educational strategies. The alternative "What do underrepresented groups have to offer technology?" in education is rarely the driver for both enhancing participation and developing deeper knowledge of technology itself.

It is further asserted that the opportunity cost of conservative technology education can reduce innovation opportunities for new knowledge development essential for addressing and redressing the many and ranging lifestyle and economy challenges we face. The paper illustrates its position by way of case examples of technological solutions in remote Indigenous Australian communities and their associated educational issues. The examples highlight the need to develop a deep understanding of the natural interconnectedness of the Tool, Human and Environmental settings and elements underpinning all technical endeavours. This holistic or interconnected understanding of technology teaching and learning for any cultural or gender setting is referred to as technacy education. The technacy approach, initiated by a diversity of cultures itself, has had significant success in raising participation among underrepresented groups due largely to it offering a 'universal glue' for diverse participants to contribute and so participate more meaningfully in technology research, development and education.

In his address to technology educators at the New South Wales forum "Creating World Class Technology Teachers: Qualities for 2010" Walker (a Clunies Ross award recipient) summarised his recent involvement with the Federal Government's Summit on Innovation (Clunies Ross Foundation, 1999). For gearing up Australia's capacities for innovation in the knowledge economy Walker stated, "we have moved from a period of periodic change to one of continuous change where the catch cries of the new age are:

- Don't come up with policies and strategies for issues that have passed by.
- Speed is crucial, cycle times in weeks not years.
- Size is not an advantage.
- No time to contemplate, speculate or procrastinate.
- The value dynamic is moving from hard assets to intangibles like intellectual property.
- Half the jobs of the 21st Century are not yet invented.
- We need to create an acceptance of failure for our CV's"

(Department of Industry Science and Resources, 1999; Walker, 2000).

In a world faced with rapid change, knowledge clusters are forming to compete in ideas development. A whole new age of economic and lifestyle drivers are demanding significantly higher order capabilities and depth. This is not merely in technological information, processes and knowledge but also in contextual understanding, creative flair in problem solving, communication skills and collaborative acumen with various (often atypical) groups and their technological settings. Forming communities of practice through connecting individuals representing unprecedented variety in world views and expertise, knowledge clusters above all rely on maintaining, indeed celebrating, the diversity among their members (Desert Knowledge Australia, 2002; Walker, 2002). In other words, technological developments, solutions and education must increasingly be holistic and higher order in conception in the modern knowledge economy to meet the lifestyle challenges ahead. There are significant adjustments before general technology education. The prospects, however, appear excellent where change is creatively explored (especially conceptually), judiciously embraced and shared by technology educators. There is therefore opportunity in enhancing diversity in technology education like never before.

Ideally, each member of a knowledge cluster maintains their sovereignty but shares a common interest including the principle of effort for mutual value. Significant 'hardware' enablers for such clusters are well known including both new information and communication technologies (ICT) and new and appropriate technologies not ICT oriented. The new significant 'software' enablers for the same are diverse and creative thinkers, doers and increasingly participants of cultures from different settings. Fresh new perspectives and knowledge are everything. In the case of technological developments and designs, dominant culture views of what technologies are or how they ought be advanced to address (or create) wants and needs are no longer safe bets for leading and developing innovations. Some innovations to technological challenges do not use new technologies (things and devices) at all: the innovation is in the actual thinking framework employed to better address or redress and so interpret challenges or problems. The many new tools and devices we may develop are consequential to the real innovation that occurred at the conceptual framework or knowledge level preceding them. New *mental tools* and their applications are the driving commodities in emergent technologies. Seeing how technology education and development can be done better by adopting different values or ways of thinking highlights the significance of diversity as essential to the general wellbeing of the mainstream. Dominant paradigms or homogeneity of values and 'standard competencies' are no longer dependable human or resource advantages in the knowledge and innovation age. Being knowledge agile and linking various setting-diverse expertise together may be better: the *know-why* and *who-with* elements of technology education are unprecedentedly significant (Australian Science and Technology Council. & Jack Hilary and Associates., 1996; Seemann, 2002; Seemann & Talbot, 1995; Walker, 2000).

To illustrate the problems of over conservative technology education (relying too much on set tools and settings in education) and highlight the innovation that can occur by fringe cultures, the setting of indigenous Australians in small and remote communities is presented. Clear efforts by technologists to exchange expertise with remote communities are highlighted by such organisations as the Centre for Appropriate Technology Inc., Alice Springs Australia (an indigenous Board Managed Technology Research and Teaching organisation). The author spent, and continues to engage in, many years of research in cross-cultural technology transfer and cross-cultural technacy education research (CAT Inc, 2002). The new 10 year $90million Desert Knowledge Cooperative Research Centre (DK-CRC) initiative will also be highlighted for its exemplary linking in real time remote men's and women's indigenous knowledge with Western knowledge within which the author is a project leader (Principle Research Scientist) in a theme on housing and infrastructure research and sustainability in the DK-CRC (Desert Knowledge Australia, 2002).

What does research on diversity tell us and what can we take from that research and apply to technology education?

> "Sometimes it is easier to see something when you move outside your frame of reference." (Walker, 2000)

Research in diversity reveals to us what we fail to see in our selves and so of our understanding of the study and assumptions about technology itself. Technology education research on diversity reveals the universal principles (or hidden world) that underpin technological activities. To the extent that a deal of technological knowledge is derived from a desire to effect a solution, it is the setting of the problem that we now understand to be necessarily always socially and environmentally defining of technology choices, designs and evaluations. This realisation that all technical knowledge appears to be mutually defined by a necessary amount of human/social, material/environmental and tool/artefact presence has been elaborated elsewhere in Australian literature since 1989 and the Australian Macquarie Dictionary as technacy education and won't be elaborated here (Australian Science and Technology Council. & Jack Hilary and

Associates., 1996; CAT Inc, 2002; Seemann, 2002; Seemann & Talbot, 1995; Seemann & Walker, 1989; Southern Cross University, 2001+; Walker, 2000). The following example of this necessary, but unfortunately little practiced, holistic understanding of the nature of technology solutions and knowledge is offered by Walker (2000). Let us assume you are an A1 rated mechanic trained in all the best well linked industry standards programs, in all the modern tools and techniques, awarded first class grades and then find you are transferred into a very different social and environmental setting. Will your mainstream competencies be sufficient to teach something new and useful in the new social and/or environmental setting presented below? As a skilled and experienced mechanic what could you teach the owner of this car (Print 1)?

Print 1: Changing Car Transmission (Walker, 2000)

Walker (2000) highlights that unless technology is taught holistically (that is, unless the learning objective is to become more technate rather than only tool or process skilled) most people from mainstream technical training would struggle to offer sustainable benefits especially in transfer situations. The technological setting for many remote indigenous people is fringe to that learned in formal standardised training institutions. Most conventionally trained mechanics in this example regard their skills highly and are keen to teach others. Unfortunately many technical programs are specific and rely on a range of supporting tools and settings (social, tool sets and environmental settings) that reduced capacity to transfer (or adapt to) knowledge gained in different settings.

A national study for valuing technical resources among remote communities for designing curriculum found a great disparity between priority personal tools and priority community service tools (Seemann & Walker, 1989). The disparity is not merely one of 'lack of tools'. On the contrary, the 'tool box' of many was efficient and appropriate for several priority functions (Table 1). The disparity related to very different material value placed on the things that enabled greater personal or social control over functions essential for sustaining a lifestyle appropriate in remote desert (or remote tropical) environmental settings.

Technologies most used by individuals		Technologies most used by the council workshop	
1	Axe or tomahawk	1	Shifting spanner
2	Spear	2	Screwdriver
3	Broom	3	Hacksaw
4	Garbage Drum	4	Socket Set
5	Digging Sticks	5	Tyre repair tools
6	Television	6	Oxy Cutting set
7	Gun or rifle	7	Hammer
8	Fishing equipment	8	Pliers
9	Utility knife	9	Shovel
10	44 Gallon Drums	10	Crow bar
11	Electrical extension lead	11	Spanner set
12	Shovel	12	Measuring tape
13	Hammer	13	Tyre bead breaker
14	Screwdriver	14	Arc welding set
15	Shifting spanner	15	Vice grips or clamps
16	Video recorder	16	Stilson pipe wrench
17	Wood rasp	17	Wood saw
18	Pliers	18	Cold chisel
19	Boat	19	Fixing devices (glue, bolts, etc)
20	Metal file	20	Electrical extension leads

Table 1: Tool Priorities – Individuals Vs Community Council Technical Priorities (Seemann & Walker, 1989)

The above setting for many technologies and education efforts are high unemployment, high health risks and populations that average 106 people (92% of Australia's remote communities contain under 200 persons) who are culturally tied to living in mostly harsh climatic (Environmental), social (Human) and technologically *(Tool)* challenging conditions (Commonwealth Government of Australia, 1996).

Remote community dwellers respond to their largely urban emanated technologies with various methods to accommodate their sustained value of things like cassette recorders, cars and TV's. Studies by the Centre for Appropriate Technology show these people are the inventors for adapting various technologies - using such things as matches to aid electrical connectors, spent bullet cartridges as car fuses etc. Clearly a technology training program in this situation has to cope with few resources, differing concepts, broad multi skilling and low levels of specialisation. Consequently the national Aboriginal Technical Worker (ATWORK) and the national network for Aboriginal Women in Technology (including Women in ATWORK) courses were accredited .

The basic conclusions are that mainstream technologies and technical training standards are only *randomly useful* for sustaining many benefits for Desert and Tropical community settings and lifestyles. Rather than the assumption that the end user needs to change their skills, values or even move to the urban centres in order to maintain 'standard' technologies, there has proven to be a strong case to change the technologies and type of technical skills to better match the social and environmental settings of the end user: to be *purposefully useful.* This concept, as eminently sensible as it appears, flies in the face of much of current policy and technology curriculum design which seeks to fund only 'sameness' or 'conventional standards' to all settings: standardisation is the notion of one size and one shoe fits and suits all. The training input (the curriculum) is standardised at the expense of the educational outcome and in ignorance of the end user human, tool and environmental setting.

The problem appears to omit the option of universal principles in technological knowledge development. The framework underpinning technacy education was therefore employed and continues to be so in an increasing number of technology education agendas and systems. What makes technacy as a concept significant to this paper is that it is itself the product of diversity. When employed appropriately in the curriculum, technacy has helped to effect an unprecedented increase in participation of both women and minority groups in technology education.

What is technology education's competitive edge as it relates to meeting the needs of a multicultural student population?

In short, the answer to this question for Australia is new and significant knowledge, quality of life, wealth creation opportunities and environmental gains. In Australia a huge national and internationally linked research and development program has commenced. Called Desert Knowledge Australia (see http://www.desertknowledge.com.au), the project links several States and private organisations towards a quality of life and wealth creation vision through the production of new knowledge as the new commodity in various technologies.

The underpinning drivers are not merely know-how, but significantly to develop context knowledge for applications in diverse settings (the know-why element). To achieve this the Desert Knowledge Project places a premium on the untapped knowledge of fringe (normally under-represented) groups including remote indigenous men's and women's knowledge, remote pastoral and horticultural knowledge, remote sensing scientific and natural resources knowledge and linkages with empathetic knowledge networks worldwide from Mexico to native cultures elsewhere (the know-who-with element).

The driver for this research and development initiative is the growing global need to consider desert living as a necessary and ideally desirable context as population pressures or climatic shifts emerge in various settings world wide over the next 25 years. From technologies enabling the growing of new market and highly nutritious foods in desert conditions (Print 2), creating employment to better understanding social challenges of extensive unemployment - diverse communities of practice form a rich knowledge advantage in the economy. The untapped knowledge pool among underrepresented groups in technology education and development is regarded as significant.

Print 2: Digging for Bush Potatoes (Source: http://www.desertknowledge.com.au/)

What are the limitations for a profession that is lacking in diversity? What should the profession do to address these limitations?

The limitations may be summarised as risk of becoming increasingly ignorant, arrogant and atrophied. Much of the response for Australia to this critical question is the opportunity cost outlined in the above section. The failure to not reconcile a holistic understanding of technology as a phenomenon in itself can perpetuate mis-educative habits and views leading not only to teachers and learners forming poor judgments in technical decisions and problem analysis, but also disenfranchising under-represented groups in the process. There is a tone of arrogance in much of Western curriculum on technology, which is a turn-off to minority cultures. While ever opportunities to redress technology from a different frame of reference is given only fringe status, there is an increased risk that new knowledge opportunity may be lost and that mono-cultural perspectives of technology may become increasingly atrophied or superceded by other groups that embrace diversity. The latter is a particular risk in the rapid change setting of the knowledge and innovation economy world wide.

The profession of technology educators must redress its perception of technology from being culturally conservative and essentially mechanical in definition to being inclusive and deliberately educational (more liberal rather than vocational) and essentially phenomenological in definition in its argument for technology in the curriculum. In the author's experience, underrepresented individuals and cultures are more likely to seek greater participation if:

- Technology is taught transparently and entirely, that is, holistically. This would help improve participation of women, for example, to the study area
- Technology is presented in the curriculum via universal principles, like those of technacy education initiated by indigenous Australians. This would flag a

universal-glue for many minority cultures for them to contribute and have their knowledge settings validated on equal terms to the mainstream. Other cultures need to *see their knowledge* in a universal or phenomenological view of technology.

What has the profession done to date to respond to the research data?

What successful strategies have other disciplines used to recruit and retain a more representative population of students? Which of these strategies might be applicable to technology education?

To a large extent, the technology education profession in Australia has done very little to redress the gender and cultural imbalance in participation rates by underrepresented groups. It has been a mantra of "we have the correct view of technology, so our job is to see how we can get you participating more in it". While there was an attempt to break down barriers by introducing subjects in secondary schooling such as Design and Technology, (thought to be more gender neutral in content) what has occurred instead was a desire by the existing guard of mostly traditional manual arts and home economics teachers to present new curriculum as little more than cosmetic variations of their original guild. That is, the profession appears to have shown more signs of becoming increasingly (and I suspect unwittingly) ignorant, arrogant and atrophied in the conception of technology education than modernizing and re-inventing technology education. There appears to be minimal evidence in the classroom and in State curriculum that the technology education profession has adopted new mental tools: certainly new physical tools, but little by way of re-conceptualising technology education. This is perhaps not surprising as Australian technology teachers have a generally very poor record for engaging in critical discourse and applied and pure general technology education research.

What factors keep female students and students from minority groups from entering the technology education profession? What strategies might the profession use to address these factors? What does technology offer females and minorities?

In addition to strategies outlined above, one unique and successful approach uses the technacy framework to enhance participation in Technology Education among traditional, remote living indigenous Australian women. The nationally researched and delivered Aboriginal Technical Worker (ATWORK) program mixes traditional Aboriginal technology with introduced technology to address remote community functions. A special arm of this course was created for indigenous traditional Aboriginal women, which has sustained growth and success for over ten years. The course aims to deliver training to indigenous women interested in developing technical, problem solving and design skills in technacy. An offshoot of this access and equity initiative is the

Women in Technology Network (Print 3). The framework allows these women to reconcile their values and knowledge of traditional and hybrid technologies along side introduced ones.

Print 3: Women in ATWORK and Women Technology Network Posters (source: http://www.icat.org.au/)

Conclusion

"For many people technology is a means to an end not an end in itself. In such cases values and culture are very important determinants of how a technology is used. Technical skills in isolation and in particular contexts may be useless." (Walker, 2000). Our new age of technology education increasingly scrambles for knowledge sourced up stream at the know-why and who-with end of the river, rather than for the traditional, long warn and so 'standardised' knowledge sources downstream at the know-how end of the river. This is a particularly important position for diversity to be strongly supported in the new knowledge economy. To extend the analogy, it is through advocating diversity that new up stream knowledge tributaries can be discovered for advancing and enriching technology education delivery downstream. Through strategies that formally celebrate diverse frames of reference in values and technology knowledge settings, technology education must embrace more holistic concepts of itself. By doing so, both women and minority groups such as remote indigenous Australians are more likely to see opportunities to participate and contribute to innovative knowledge clusters and communities of practice. The real risk to Australia not doing this is increased portrayal of its technology education curriculum as ignorant, arrogant and atrophied: a ready position in the knowledge economy to be rapidly superseded and reduced in appeal to diverse groups in society not to mention world markets.

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And the Beat Goes On: Diversity Reconsidered

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The grocery store's the super mart, uh huh
Little girls still break their hearts, uh huh
And men still keep marching off to war
Electrically they keep a baseball score

The beat goes on, the beat goes on
Drums keep pounding a rhythm to the brain
La de da de de, la de da de da . . . . . *Sonny & Cher, 1967*

When people reflect on the past, they have a tendency to recall the events through a nostalgic or sentimental lens. They remember that people in their lives seemed to be less harried, and that scientific, technical and social changes appeared to occur at a much slower pace. In today's society, we are bombarded with marketing phrases like "new and improved," "now, with even more power," and "hurry, offer ends tomorrow." Many of us have become accustomed to this hectic pace of change, but not everyone is able to tolerate it. In fact, a number of my colleagues have uttered phrases like "I don't mind progress, as long as I don't have to change."

While it may be true that change has been the only constant through history, changes are not always as great or far-reaching as we either hope or imagine they will be. In fact, it is often the case that the more things change, the more they stay the same. Although the topic of diversity has been on the technology education profession's radar screen for more than twenty years (Markert, 1981; McLure, Renter & Piel, 1976), the changes have been incremental with regard to the representation of women and minority groups in technology education venues.

Federal legislation directed toward the elimination of sex-role stereotypes in the world of work, coupled with affirmative action requirements, has done much to stimulate research and spirited conversation about the profile of women and members of ethnic minority groups who enter "atypical" careers. Three years before Sonny & Cher's hit single *The Beat Goes On* was being played on many U.S. and international radio stations, the Civil Rights Act of 1964 established affirmative action goals of "equality as a fact and equality as a result." A primary goal of this monumental legislative directive was to create fairness in an otherwise biased society by leveling the playing field, expanding access and increasing inclusivity for marginalized groups, especially women and persons of color.

Five years after this same musical piece became popular, Title IX, a clause of the 1972 Federal Education Amendments, was signed into law. It states "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance."

Coincidentally, I graduated from high school within a week of Title IX's passage, and subsequently entered an academic baccalaureate degree program in Industrial Arts Education wherein 97.7 percent of the students were male. More than thirty years later, statistics for my alma mater department reveal that a resounding 95.1 percent of the technology education majors continue to be male, with very few persons of color enrolled (1.7 percent). Since this northeastern institution remains one of the country's largest producers of technology education teacher candidates, a 2.6 percent increase in female majors over three decades is indeed dismal. Research efforts in our own technology education discipline (Sanders, 2001), and in the allied fields of science, computer science, and engineering (CAWMSET, 2000; Mervis, 2001; Su, 2001; Wolcott, 2001; Wyer & Adam, 1999) depict an interesting array of statistics relative to the participation of women and minority groups in various applied technology career paths (see Figure 1).

Arguably, these researchers obtained their information via a wide assortment of strategies including surveys, personal interviews, and reviews of official government reports. Regardless, the melody and beat portrayed by their data does not seem to be changing all that much as time goes on. In no case is it evident that the numbers of women and minority group members who are working in the applied technology and scientific professions even begin to reflect their actual representation in our country's population.

Figure 1 Female and Minority Participation in Applied Technology Disciplines

Year	Group Studied	% Female	% Minority	Reference
1950	US Engineering Workforce	6.10%		Wolcott, 2001
1950	US Medical Workforce	6.10%		Wolcott, 2001
1973	US Scientific Workforce	7.00%		Mervis, 2001
1973	SUNY Oswego IA Majors	2.30%		Oswego's OIR *
1975	Undergrad Com Sci Degree	13.50%		Wyer & Adam, 1999
1979	Tech Ed Teachers K-12	1.00%		Sanders, 2001
1984	SUNY Oswego IA Majors	6.60%	0.60%	Oswego's OIR
1985	Undergrad Engr Degree	2.20%		Su, 2001
1995	Undergrad Com Sci Degree	20%		Wyer & Adam, 1999
1995	Undergrad Engr Degree	1.60%		Su, 2001
1997	US Sci & Engr Degrees	37%	3%	CAWMSET, 2000
1999	Tech Ed Teachers K-12	10.10%	5.90%	Sanders, 2001
1999	US Engineering Workforce	10.60%		Wolcott, 2001
1999	US Medical Workforce	24.50%		Wolcott, 2001
1999	US Scientific Workforce	22%		Mervis, 2001
2001	SUNY Oswego TE Majors	4.90%	1.70%	Oswego's OIR

* SUNY Oswego's Office of Institutional Research

A variety of formal programs and informal efforts, developed and implemented to attract and ultimately recruit more young women and minority group members into the traditionally white male-dominated fields of technology, science and engineering, have seemingly been just partially successful. This essay, briefly examines what might be labeled the allure of applied technology disciplines for all persons, and further discusses the extent to which the technology education profession's attempts at promoting diversity have been successful over the years.

The Allure of Applied Technology Disciplines

What is it about the fields of technology, science and engineering that students find appealing? More specifically, why do certain students seem to gravitate toward these types of courses, while others either approach them with apprehension or avoid them completely? And third, are there unique aspects about applied technology classes that might respond favorably to the needs of a multicultural and diverse student population?

In almost all instances, students very much enjoy the applied nature of the problem-solving activities they experience in their science and technology courses. Teachers in many disciplines now realize that authentic learning experiences, where there are obvious links to their students' daily lives, represent a much more powerful pedagogical approach than simple chalk and talk lectures. Technology and science educators have known this for decades. Using real world scenarios to challenge their students comes naturally, and the notion of authentic or outcomes based assessment is nothing new to them.

Students at all grade levels look forward to classroom or laboratory assignments where they can get out of their seats and work with their hands as well as their minds. In both my middle school and university teaching experiences, students looked forward to "lab time" and simply tolerated my lectures and equipment demonstrations. Applied technology education assignments enable students to work cooperatively to design solutions to problems or situations they encounter on a regular basis (e.g., outdoor play structures, automobile consoles, highway bridges, bedroom storage/work space requirements, ergonomic backpacks, etc.). Laboratory experiments in science classes require and challenge students to again work cooperatively through a series of inquiry-based steps in order to investigate and ultimately understand scientific principles.

I will never forget the time my son came home from his fourth grade school day and said, "Mom, I had the best day! We actually had a chance to do an electricity experiment with a partner, and now I understand how my bedroom light works when I flip on the switch!" This anecdotal incident is further evident as students proceed to higher grades. Margolis, Fisher & Miller (1999) spent four years interviewing male and female students about their experiences studying computer science classes at Carnegie Mellon University in one of the United States' most reputable computer science departments. These undergraduate students talked about the pleasure in systematic thinking, problem solving, creativity, and logical thinking tasks. They underscored the fact there is an "aha moment" or "rush" that one experiences after working and working on a problem for hours or even days until finally it just works!

Applied technology and science laboratories and courses seem to have a recognized competitive edge over other disciplines when it comes to inquiry-based learning and cooperative problem solving challenges. Today's students live with the reality that advances being made in the fields of energy systems, medicine, information technology, manufacturing, materials science, and genetics are totally re-charting the course of human history and transforming the way human beings live on this planet. Scientific discoveries continue to take place in the abstract world of theory, and technological breakthroughs drive the concrete achievements of sophisticated machines. For certain individuals, there seems to be an allure to being at the cutting edge of a discovery, and being fully capable of having a positive influence on the future course of change in technology, science and engineering.

Why is it then that such a small percentage of currently enrolled high school juniors and seniors from across the United States indicate an interest in science and engineering careers? In a recent national study conducted for Ferris State University's Career Institute for Education and Workforce Development, researchers found that young persons expressed a preference for careers involving human contact and interaction vs. high technology fields (*Decisions without direction*, 2002). Health care is the leading career choice overall and is appealing to all students, but more so to female students than to their male classmates. Education and business professions appeal about equally to males and females, where the law profession and computer industry has more allure for young men than for young women.

Promoting Diversity: Perseverance or Attrition?

When asked to review the current literature related to **diversity** issues, it is difficult to know where to begin. Studies related to diversity span all disciplines including economics, business & marketing, psychology, teacher education, management, religion, and of course, technology, science & engineering. The word diversity is a contemporary buzzword that has actually become a modifier in its own right (e.g., diversity training, diversity management, diversity council, diversity paradigm, diversity action plan, diversity accreditation standards, etc). Over the years, an increased awareness of the absence of diversity in different venues has led to the establishment of professional organizations and enactment of federal law devoted to promoting diversity.

Beyond the legislation mentioned earlier, the Advancement of Women and Minorities in Science, Engineering, and Technology Development Act became law in late 1997, which led to the creation of a federal commission with the same title one year later (CAWMSET). The group was given eighteen months to accomplish four tasks, after which its term would expire. Their mandate was to:

- Study the barriers that women, minorities, and persons with disabilities face in science, engineering and technology (SET).

- Identify and examine the number of women, minorities, and persons with disabilities in these fields to determine where they were underrepresented.
- Research and describe the practices of employers regarding the recruitment, retention and advancement of women in these areas, and make a judgement as to whether or not these practices were comparable to those for men.
- Issue recommendations to the government, academia and private industry.

Their extensive report (CAWMSET, 2000) was delivered to Capitol Hill in July 2000, and its findings and recommendations most certainly augment and validate other current research regarding diversity (Thomas, 1996; Weber, 2001). On the other hand, there were times that the *La de da de de, la de da de da* refrain could be heard while reviewing the commission's assessment of our contemporary SET workforce. In no way should the importance and credibility of national findings such as these be devalued. However, one is tempted to question the extent to which costly studies commissioned on a regular basis have had or will ever yield the positive workforce environment changes they promote and aspire to achieve.

Over the years, we have learned a great deal about the differences and similarities between females and males. Our understandings of the relationship between gender and technology have become clearer as well. Valian (1999) generalizes that girls and boys understand mathematical concepts equally well, but boys are better able to apply their knowledge to new areas than girls are. When asked to solve word problems, males are more skillful at ignoring irrelevant information and devising unconventional solutions than their female classmates. In the field of computer science, males view computers as toys to play with, while females use them as a tool to do things with (Margolis, Fisher & Miller, 1999). Women, to a much greater extent than men, link their interest in computers to other disciplines and emphasize the importance of having their programs do something beneficial for society. In engineering venues, males are more inclined to say they are interested in engineering problems no matter what, whereas women seem to exhibit more enthusiasm if they see the relevance of solving the problems to helping people or the environment (Alper, 1993).

These three simple examples from the research on diversity are cited to suggest that women and men do approach problem-solving tasks differently and they possess a different appreciation of technology, science and engineering as subjects and artifacts. In a similar vein, minority group members bring different cultural perspectives and expectations to the laboratory and the workplace. A number of companies and foundations are visibly sensitive to these and other differences, and are aggressively promoting diversity among their employees and constituent groups. The success and effectiveness of their initiatives give the technology education profession much to emulate.

Aerospace and aviation companies revere diversity in a tightly competitive labor market (Diversity still valued, 2001). Companies like Raytheon Aircraft, United Airlines and Northrup Grumman extend their focus on diversity well beyond race and gender. They have found that the prospects for retention and promotion of female and minority employees are improved when they feel respected and know they are being prepared for their next career move. While the majority of aviation workers are still primarily white male (i.e., only 5 percent of pilots are women and 3 percent are minority), large aerospace firms are taking great strides to promote diversity and retain good workers.

Electronic Data Systems (EDS) is a leading global information technology services company. At all levels, the company has supported its employees in their desire to form diversity network groups, including: The Hispanic Employee Resource Organization (HERO), Unity in Action (UIA, African Americans), Women @ EDS, and Gay and Lesbian Employees at EDS (GLEE). Success stories abound with regard to these support groups, and EDS is an exemplar among U.S. companies with its extension of health benefits to domestic partners, and its provisions for women who are raising young children and also advancing their careers.

One final example of a successful strategy to increase opportunities for minorities is found within the **American Advertising Federation (AAF).** Several years ago, the AAF, together with their educational foundation, convened a Congressional Summit on Diversity in Advertising. Through the course of this event, it became apparent that many clients were not appreciably savvy about the marketing implications of a multi-cultural society. Given the fact that advertisers, the entertainment and news media, and marketing departments play an influential role in shaping society's perceptions about SET careers, this AAF summit session was a significant event. Publicly displayed images of technical workers, scientists and engineers as white men who have above average intelligence and are socially inept and/or absent minded nerds tend to discourage minority groups and women from pursuing any SET career interest they may have.

The technology education profession has attempted to utilize various aspects of all these strategies. During the mid-1990s, both the ITEA and NAIT had acknowledged the importance of diversity via the recognition of women in the "Leaders to Watch" section of *The Technology Teacher,* and the inclusion of diversity in the language of accreditation standards for industrial technology programs. The Technical Foundation of America sponsored a retreat in 1995 for women to develop a strategic plan to increase women's involvement and leadership in the technology education profession. One year later, the Alfred P. Sloan Foundation funded a national symposium for Advancing Women in Technology Education – a primary aim of which was the development of a national plan of action. For a couple of years, ITEA included a Women's/Diversity Special Interest Session during its annual conference; attendance at these pre-conference meetings apparently did not warrant their continuation. From the advertising perspective, ITEA partnered with *TIES Magazine* during the 1990s to prepare a series of superb full color recruitment posters – most of which featured women and persons of color in their artwork.

Despite these efforts, plus the presence of an ever-increasing number of conference breakout sessions devoted to diversity, the beat goes on. And, much of the dialog in our profession unfolds within what Delatte and Baytos (1993) labeled the BOWGSAT environment (i.e., Bunch of White Guys Sitting Around a Table). This oppressive classroom or work atmosphere is difficult for women and minority groups to warm up to and penetrate, which remains a deterrent to perseverance in technology-related disciplines and a major cause of attrition.

The Culture of the Technology Education Profession

One of the Keynote sessions at the 2002 ITEA Conference featured A. Thomas Young, one of the editors of *Technically Speaking: Why All Americans Need to Know More About Technology* (Pearson & Young, 2002). Following his large group presentation, he chaired a panel session for persons who wanted to learn more about the study that culminated with this publication. The small room filled up quickly and I found myself sitting among approximately 75 of my colleagues – only 4 of whom were female. During the question and answer portion of the meeting, I held my hand up to make a statement; Mr. Young had a clear line of sight to me, but I waited a full 60 minutes to be recognized – after at least ten (maybe more) men had been invited to speak. This form of gate-keeping is sometimes called the chilly classroom climate, and it apparently persists in our profession.

Matlin (1993) provided her sense of the chilly classroom climate as a scene where faculty members routinely treat men and women differently in the classroom or laboratory, to the point where women feel ignored and devalued. Persons of color and individuals who have disabilities also experience overt forms of this sort of discriminatory treatment. Quite simply, chilly classroom behaviors may partially explain why there are still so few women and persons of color who are actively engaged in our profession. They may also contribute to the attrition rate among women who do make an attempt to get beyond these and other barriers to advancement in technology-related careers.

There are a number of other factors that operate to discourage female students and minority students from entering technology, science and engineering programs. These same factors are a deterrent to advancement and retention faced by the women and persons of color who do manage to complete a college degree and land a position in an SET field. The CAWMSET (2000) report revealed several issues, several of which include the following:

- Absence of role models – There are often few if any female role models or company role models who are members of the new (often young) person's same racial/ethnic group for them to emulate.
- Isolation – female engineers, scientists and technology faculty members often find themselves the lone woman in their group, both in college and at work. This makes it hard to establish informal support networks. Underrepresented minority professionals experience similar situations.
- Lack of mentoring – influential mentors and sponsors are of vital importance to females and minority group members in the SET profession. It is difficult for women and minorities to establish mentor relationships via the same informal mechanisms used by men, especially since persons tend to mentor others who are very much like themselves.

- Risk-averse supervisors and stereotypes – the notion that it is riskier to promote women vs. men and that women really can not be successful scientists or engineers seems to prevail. The competencies and profile characteristics associated with success in technology fields are commonly viewed as white male attributes.
- Exclusion from informal networks – females are readily excluded from all-male networks especially those that focus on sporting events and weekend outings. Persons of color are also often left out of these opportunities for informal networking with their colleagues away from the work place.
- Work/life balance – Women more so than men remain primarily responsible for family and home care. Even when they work in what might be called "family-friendly" institutions, women express concern that they can not pursue their SET careers and also take family leave without their male colleagues believing they are less committed.

And finally, thirty years after the passage of Title IX, the National Women's Law Center (2002) reported that girls are routinely discouraged from enrolling in certain career and vocational education programs during high school. These researchers undertook a nationwide investigation of the presence of sex segregation in high school vocational and technical programs. Their study, which sought data from every state and the District of Columbia, discovered biased counseling, the provision of incomplete information to students regarding the consequences of their early career preparation choices, sexual harassment of girls who enroll in non-traditional high school classes, and pervasive sex segregation. "Young women in Virginia have also reported that schools are not informing them about opportunities to take technology-related courses, that counselors have steered females away from advanced computer courses, and that the few females who do enroll in technology-related courses are subjected to a hostile environment" (National Women's Law Center, 2002, p. 5). And the beat goes on. . . .

Diversity Reconsidered

The extent to which leaders and young researchers in our technology education profession are able to intervene to both ameliorate and ultimately eliminate these and other barriers to women and minority groups remains to be seen. As mentioned earlier, our profession has taken strides and various groups have allocated resources to promote diverse ideas, perspectives, viewpoints and opinions. Perhaps, as Thomas (1996) implies in his book *Redefining Diversity,* we need to get beyond the "why so few" questions with regard to race and gender. We also need to get past the "women-in" or "minorities-in" syndrome. Reports titled "Women in Technology" or "African Americans in Engineering" only prolong the notion that women and minorities should be spotlighted as one-at-a-time, often exceptional, performers. Instead, their work and contributions should be fully integrated into their respective disciplines as opposed to being illustrated as Bartusiak (1994) portrayed them "like so many ornaments on a Christmas tree, as mere appendages to the scientific enterprise" (p. 6). It is time for us to change the beat and start to sing a new tune.

It is evident we agree that increasing diversity is desirable for any number of reasons. Therefore, our profession must consider new ways to sustain the small but critical mass of women and persons of color who have chosen to persevere in technology education positions. The CAWMSET (2000) study discovered that increased diversity in the work place and in academic institutions underscores a better utilization of talent, increased quality of team problem-solving, higher success in acquisition of grant monies, and greatly enhanced creativity. It stands to reason that a diversity of opinions and insights will yield a richer more powerful anything – you fill in the blank (e.g., curriculum, proposal, solution, design, work environment, government policy, scientific experiment, accreditation review, etc.). We need to reconsider how we promote and value diversity in our profession in such a way that women and minorities are not viewed as tokens of success, or expected to be stellar in their performance.

Thomas (1996) defines diversity quite simply as "*any* mixture of items characterized by differences and similarities" (p. 5). Borrowing a bit from his premise that "diversity refers to the collective (all-inclusive) mixture of differences and similarities along a given dimension" (p. 7), I will conclude with this visual metaphor. Try to envision a glass bowl of Hershey's ® Kisses – all of which are wrapped in their signature silver foil. Next imagine adding to the bowl several of these candies wrapped in green and red foil. If we perceive the green kisses to represent minority group members, and the red kisses to represent women, we are then led to believe these different colored pieces represent diversity. Thomas (1996) argues this is not the case and that diversity is truly exemplified by the new **resultant mixture** of silver, green and red wrapped candies.

I support Thomas' (1996) opinion wholeheartedly and suggest it provides a starting point for our reconsideration of diversity in the technology education profession. Like the red and green kisses, the contributions being made by the women and minorities in our field must be applauded and celebrated alongside those made by white males (silver kisses). Since it is far easier to emulate persons whose accomplishments are integrated into the discipline at large, we ought not to idolize women and minority group members as superstars. As stated earlier, young persons today are not overwhelmingly interested in pursuing SET career paths to begin with (*Decisions without direction*, 2002). We need to accept and live with the fact that our recruitment efforts may never yield large harvests. Those few women, persons of color and white males who do make the decision to join our profession represent a collective mixture that may never approximate the percentages reported in U.S. Census statistics, but a mixture nevertheless that is quite diverse. When they are strongly encouraged to persevere and eventually achieve leadership roles in technology-related fields, the look of the mixture in our candy bowl will continue to change – albeit incrementally. In my view, this is both an optimistic and realistic perspective, and one we should promote enthusiastically in our profession.

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Chapter Twelve

Professional Development for Technology Educators

2003: An Administrator's View of Professional Development for Secondary Technology Educators in the United States

Doug Wagner

School District of Manatee County, Florida

Professional Development issues in Technology Education: the changing scenery.

Michael Berry

Education Queensland

2003: An Administrator's View of Professional Development for Secondary Technology Educators in the United States

Doug Wagner
School District of Manatee County, Florida

All systems are go.

Start the final implementation countdown sequence.
10-9-8-7-6-5-4-3 . . . ringgggg, ringggg, ringggg . . .

Control, we have a problem: professional development for secondary technology educators has malfunctioned. I repeat, it has malfunctioned. All operations must be overhauled immediately.

It is widely believed that our human resources (technology educators) are the determining factor as to whether technology education programs succeed or fail. As administrators, we collectively devote much of our time and capital to the recruitment of qualified educators to teach in our high-tech, high-cost, high impact facilities. We all recognize the importance of a well prepared individual at the time of program implementation. However, after the educator is in place, and the program is up and running, the efforts to keep an individual professionally current is virtually nonexistent. Toss in the declining individual participation in professional organizations, participation which at least provides a source for mail--journals, newsletters, and promotional conference information--and the result is a technology educator who is isolated from the profession, as well as behind in the content knowledge necessary to maintain an effective instructional program.

We live in an era when talk about the great transformation of industrial arts to technology education is behind us. The shift within the majority of our programs has taken place. We no longer debate what the new technology education will look like, but rather we discuss how to work with what has evolved. We have new labs, new curricula, and new definitions of what technology education is and can be. In the distant future, historians may look back at this point in time and describe this monumental change as radical, ambitious, and--hopefully--timely and effective. Regardless of what will be said or thought about our actions, one thing is clear today--we need not wait for the future to realize that the amount of planning, effort and resources devoted to the professional development initiative of our technology educators does not adequately mirror the significant changes that have taken place over the last fifteen years of our profession.

For the design of effective professional development, educator concerns about upgrading their own skills and technological knowledge are important considerations (Linnell, 1992). Not only is the profession faced with the need for new teaching strategies to make effective use of new labs and equipment, but there is also a set of new philosophies and of new attitudes that come in response to high stakes testing. Underlying much technology education today is the belief that the educational system is able to do much more with less.

We ask a great deal of our technology educators and our technological understanding. As Mark A. Edwards contends, "Teaching and learning in our schools must possess that same commitment to reflect the changing dynamics of work and life in the next century. We need to develop school cultures that are typified by adult learning. Every employee should accept responsibility for continuously upgrading his or her performance. Every employee must hold himself or herself personally accountable for outcomes that require thinking in a broad sense" (1998, p.34).

The attitude that classroom educators must hold themselves accountable for staying current looks great on paper, but the reality is that with no administrative support, individual success is rarely achieved. Because of large majority of technology education programs at the secondary level and the governance of such programs, this article addresses the issues from the administrative stand point. Two surveys were compiled during the fall of 2002. I worked with an initial target population of state level administrators who oversee three thousand secondary technology education educators, and--for the second survey--with district-level administrators who collectively oversee more than one thousand technology education educators. Both surveys were limited to those serving as top decision-making administrators over technology education. Because of the potentially damaging nature of the findings, the survey was conducted by phone, and participants were assured that individual state and/or district results were not to be published. Only collective group results would be used. Careful attention was paid to make sure results from both small and large states and districts were received and processed accurately.

The Survey of State-level Administrators

At the state level, 100% of responding administrators indicated that their state department of education offers some kind of certification or credentials in technology education. The length of certification varied from five years to a lifetime award. While it is reasonable to assume that much effort went into creating each credentialing system, just as much emphasis seems to be placed on the rules for keeping or upgrading the credentials. The questionnaires showed that renewal of certification depended upon documentation of professional development activities--courses, in-service programs, and conferences. Requirements ranged from as little as six college credit hours in one state to a full masters degree in another. Many states cited a set number of in-service hours needed to keep the credential current (Wagner, 2002). Up to this point, you might be asking, "then what is the problem? It looks as if states have done a good job setting the formal process for the credentialing for educators of technology education. They have even followed up with policies and procedures to ensure that educators keep up with their professional commitments in order to remain in the classroom."

One area of weakness that showed in all the questionnaires, however, was that no specific content was named for these in-service or course requirements. Whereas, all of the responding states required professional development in order for educators to keep certification to teach, not one of the states specified required content.

A follow up survey question asked whether or not a recommended professional development schedule existed. Even though the phrasing was "recommended" rather than "required", all the state respondents indicated that no such formal document exists from their department of education. Some respondents indicated that while no formal documentation exists, they have become the primary provider of professional development in their state: many state supervisors are offering some kind of professional development seminars for their educators to attend.

With this finding comes a clear division between the philosophies of state administrators about who should do what. It seems that some state administrators take it upon themselves to facilitate most of their state's professional development. These respondents cited the percentage of time spent on organizing statewide professional development for technology education at approximately 10%. Personnel in states who viewed professional development as the district or schools' requirement reported that only 2 to 3% of their time is spent on professional development. Administrators in these states indicated that district level personnel organized and conducted virtually all of the professional development, and that their role at the state level was one of brokering information to surrounding districts, or providing information on possible presenters or facilitators for the district's desired programs.

It is important that we focus on the issues as they unfold: first; the majority of responding states across the United States have a detailed certification or credentialing procedure for the educators of technology education; and second; these states require additional courses or in-service activities to maintain or advance that certification or credential. No responding state, however, has an official required technology education professional development plan or schedule in place. Some of the state supervisors take it upon themselves to facilitate professional development for the educators, while others take a supporting role to the district or local administrators. This hit-or-miss approach from the top down, depending on where one lives, has created a fragmented professional development system across the United States.

One question asked of the department of education administrators of technology education was to identify which listed entity contributes the most to providing professional development for the educators of their state; they were to choose among 1) local department agencies, 2) state department agencies, 3) colleges or universities, 4) state associations, or 5) national associations. In the states where the state administrator saw his or her role as the major facilitator the choice was easy; it was the state department agency. For the respondents who did not facilitate professional development at the state level, 75% chose local agencies, 10% chose colleges or universities, 9% chose the state associations, and 6%, the national associations. This diverse pattern of choice highlights the importance of a formal professional development program at both the state and district level. However scarce or restricted the financial resources are at the state level, the facts remain that additional professional development, or in some cases college course credit, or both, should be required to maintain or advance one's certification or credentialing. We all should be concerned with providing new opportunities for educators to advance their technology education content area skills and knowledge.

There is a growing need for a state department of education requirement across the United States for technology education professional development. Yet, here at the start of the twenty-first century, technology education program administrators are operating at a significant reduction of staff compared with just a decade earlier. Budgets have been eliminated, and more than one state has cut this supervisory position entirely, leaving no one responsible to facilitate technology education. It is no wonder that professional development is limited or nonexistent in some parts of the country. If there is a vacancy at the state level, or the administrator in place gives no real support for technology education, it then becomes the district program administrator who overcomes the constraints to recommend new programs, seek funding, provide leadership for new initiatives, and deliver professional development.

One of the more difficult issues connected with professional development is conveying useful information. Gwynn Mettetal (2001) speaks to this problem as she admits that, "Most teachers take graduate courses to maintain their licensing, and they participate in staff development to improve their teaching. Such professional development often takes the form of workshops on various topics, usually offered during teacher in-service days or after school. Teachers often complain that these workshops are irrelevant, one-shot efforts and that they rarely lead to actual change in the classroom" (p.108). Technology educators are in desperate need of information, and pedagogical skills as curricula and equipment change rapidly. Yet the current governmental emphasis in the United States is on improving students' scores on high stakes testing rather than on improving the quality of instruction within every class. The current debates over holding school systems accountable for student results in such testing has shifted many of the decision-making powers away from departments of education and into the hands of local educational organizations. "The message in many schools seems to be 'increase test scores however you can' rather than 'here are the instructional approaches we understand can improve achievement" (Fisher, 2001, p.67). It is this shift, plus the significant changes that have taken place in our profession, that have left implementation of professional development with little or no voice, and limited resources.

The Survey of District-level Administrators

The second survey was conducted with district administrators (sometimes known as local supervisors; in small districts, this position may be held by the school principal). A small school district might have one or two technology educators; large districts such as Florida's Miami-Dade might have several hundred, with the average number being ten to twelve technology educators in a district. This fifteen-question survey was administered by phone, to school districts with a full-time administrator with decision-making authority for technology education. Results showed that while 90% of those responding had professional development as a part of their duties, only l0% indicated that a set number of professional development opportunities were required each year (Wagner, 2002). Like the state administrator, the local supervisor has no guidelines as to how many events to offer, or what topics to cover. As Susan Reese (2002) notes, "Ensuring that career and technical education programs of the highest quality are available to all students is a huge undertaking requiring the participation of many individuals, but a dedicated, actively involved administrator can do much to help in achieving those goals" (p.26).

The survey results showed that during the 2001-2002 school year, the top five topics of professional development for technology educators were:

5. The Standards for Technological Literacy
6. The Technology Student Association
7. Computer numerical control
8. Computer aided design
9. Module management

Offering these current, timely topics demonstrates that administrators are working to move the profession forward. The survey also indicated that 20% of all professional development at the district level is contracted with an outside vendor, which is a worthwhile expenditure, bringing in experts to promote new ideas and knowledge. While technology education administrators may not be required to provide a set number of professional development opportunities, the survey showed that district opportunities varied widely; they ranged from one to twenty-nine each year. The average was five distinct technology education professional development opportunities over a twelve-month period. (These technology education opportunities are in addition to the staff development offerings in each district. Additional topics might focus on classroom management skills, reading strategies, and ways to meet state level requirements for special populations.)

Another question on the survey asked how much time a year administrators spent on planning, developing, coordinating and handling paperwork for professional development. Figures ranged from 5 to 25%, consistent with how many activities were offered; the average was 6.7%. Professional development in terms of time as well as actual dollars is not free. In the words of Bernadette Marczely (1996), "Money, or more to the point, the lack of, has always been a problem for educators . . . It is essential that the principal use traditional and creative ways to secure the dollars needed for effective professional development programs and projects. Like any other CEO, the principal must accept the raising of capital for development as an integral part of the administrative mission" (p.103).

The survey also asked about sources of funding for professional development in technology, and found that most funding came from grants and special projects. Allocations from the Carl D. Perkins Vocational and Technical Education Act of 1998 were commonly used, as were resources from the staff development departments used to fund content area technology opportunities.

The reality found across the responding states is that funding for professional development does not have its own budget line from the district general funds. With the annual reduction of financial resources for education being the norm rather than the exception, plus the focus on funding initiatives to support high stakes testing achievement, funding for comprehensive content area professional development has all but evaporated.

"While staff development is an integral ingredient for encouraging school reform, there may be little funding in district budgets for professional development. Without specific goals and a guiding vision, teachers are often left alone to find classes they need for professional growth or recertification, which may not match the focus established in their school" (Applewhite, 1999, p.50).

According to the survey, most district administrators have a single source of money, from which all professional development funds must be allocated. When pushed to estimate the amount spent on each technology education educator for the 2001-2002 school year, administrators gave figures ranging from $0 - $1000, with the average being $300. These figures were not surprising. As Bullard and Taylor (1993) found a decade ago, most school districts spend less than l% of their budget on training. Their statements were much less dramatic than the emphatic contention of W. E. Deming, that "In its underuse and abuse of talent, America is the most underdeveloped country in the world" (1986, p. 6).

When asked what incentives are used to get staff members to attend professional development activities, administrators agreed on the following strategies:

1. If during work hours, cover the cost of substitute teachers
2. Cover the cost of workshop registration
3. Cover the cost of meals, miles and lodging if necessary
4. Provide in-service points
5. If outside work hours, pay a stipend for participation

To the untrained eye, this list might suggest that all educators would try to participate in professional development opportunities. However, administrators are quick to point out that many educators do not take advantage of any such opportunities. Across districts, the most effective educators are those who stay current: they are the trendsetters and the leaders. Teaching is their passion and they devote l00% of their time and effort to ensure that their knowledge and skills are up to date. The surveys showed that they are the educators who are in the high column of the "levels of teacher commitment." Those educators who do not participate in professional development are viewed by their administrators as being in the "low level of commitment."

Levels of Teacher's Commitment		
Low	Moderate	High
Little concern for students	Some concern for students	High concern for students and other teachers
Little time or energy expended	Energy expended sporadically or only in certain areas	Extra time and energy expended
Primary concern with keeping one's job	Primary concern varies according to circumstances	Primary concern with doing more for others

(Glickman, 2002, p.85)

Educators considered to be in the "low level of commitment" appear to have limited subject knowledge, and are sometimes considered lazy by their peers. This detrimental stereotype can be found across the country. In these two surveys, the question that asked about educator participation in professional development was answered emphatically; administrators see their least effective educators as non-participants.

Discussion

The survey results indicated the need for equitable funding for professional development. There is a direct correlation between the perception of which educators are effective and which are ineffective that might be erased through a quality, adequately funded professional development program. As Sullivan, Shulman, and Glanz state, "It is necessary for not only leaders to be trained for individual initiatives; all parties involved in developing leaders, from schools of education to school districts, must focus on the administrator as instructional leader . . . . Systemwide reform is necessary to develop and maintain educational leaders" (2002, p.474).

Technology education administrators at the state and the district levels must come together to solve this problem. No longer can we just discuss the issue and hope for a better tomorrow. The United States Department of Education, also needs to realize that technology education professional development is essential.

Since 1996 the United States Department of Education offers a national awards program for model professional development, to highlight and recognize schools and school districts with exemplary professional development programs. During the years that this program has been operative, no award has ever been given for technology education; in fact, technology education is not even mentioned in the program abstracts.

Considering all these points, it is clearly time for action. We cannot stop the clock from ticking. Our administrators need professional development about ways of effectively designing and implementing professional development programs that would benefit all technology education educators. Most administrators are working from knowledge learned years ago in university level graduate programs, before significant changes transformed industrial arts into technology education. In a recent study by Margaret Grogan and Richard Andrews, these educators contend, that "the new conceptualization of school-site and district leadership, as put forth by the academy and by the National Association of Elementary School Principals, the National Association of Secondary School Principals, and the American Association of School Administrators and research on leadership require something other than a traditional course delivery of knowledge, values, or a compendium of skills" (2002, p.249).

Recommendations

What constitutes effective professional development for technology education in the twenty-first century is a perplexing question that must be addressed in order to move our profession forward. The question, however, needs to be addressed and supported by the group that has the largest impact on the profession (the administrators).

The roles of our elementary and secondary schools, universities, and professional associations in professional development are all very different but in a perfect world should fuse to provide a complete professional development program for the educator. It is common knowledge that the vast majority of technology programs are located at the secondary level. Focus must be concentrated on this group in order to achieve the most effective results. Elementary technology programs are non-existent in most states (most programs are about educational technology and do not cross over into technology education). The university in which an effective technology education program is still in existence is one of the best sources for professional development. However, it is unrealistic to think that all U.S. educators would travel across the state or the country to take a three-credit course. If this were the case, we would see an increase of university programs as opposed to the current decline in programs.

The surveys found that no state administrative body has an effective model for professional development in the twenty-first century. There are pockets of examples of model professional development programs currently being practiced nationally in the profession by such organizations as the International Technology Education Association (ITEA), and the Technology Education Division of the Association for Career and Technical Education (ACTE). However, with declining membership in such organizations and even less participation at the annual conferences, using this approach we will not reach the majority of our programs. (Some states even have little or no participation at all in the national organizations). If we put all of our efforts into professional associations, then educators must attend events to receive professional development. This hit-or-miss approach depending on one annual conference has helped to create the current state of affairs where membership in professional development organizations is in a nosedive and, therefore, so is professional development because educators are not attending conferences.

I recommend that local and state administrators work together to develop a sample effective professional development plan, focused on participation in these available national groups that could serve as a model. The strategies for delivering effective professional development are, first; to get educators to attend. Results have shown that just because something is offered does not mean it is well attended. A case in point:

National conferences and university offerings are coming nowhere near reaching the masses of technology educators. Effective professional development must start with the local administrators serving the educators and building a program around the interests of the clients. Both beginning and experienced technology educators have different expectations which must be addressed. Then and only then, will participation start to grow, and real change occur.

The survey showed that professional development is, for most, a part of continuing teacher certification across the country. The method used to achieve this certification requirement is voluntary for the educator, and using non-technology education in-service has become the norm rather than the exception. Availability, cost, location and effort to attend all come into play. Most of the schools in the country have on-site professional development for the teachers, ranging from conflict resolution to classroom management. Such offerings at the school site make it easy for educators to obtain re-certification but have created a technology educator who is behind in the current knowledge and skills needed to advance the profession.

I recommend that the professional development agenda for the technology education profession be developed by administrative leaders who have a clear vision of the current state of affairs. Universities and professional associations need to be a part of the discussion, but they need to understand that current programs accessible at this level are not reaching the majority of the current technology educators in the United States. Participants who would establish this agenda need to be clear about where we are today and understand that anything less than perfection (reaching one hundred percent) would be unacceptable.

A national standard in professional development must be developed and supported by the profession. State administrators would monitor and assess the effectiveness of the program by offering a highly sought-after credential for those who could achieve such a level. This model of professional development would be attractive to external funding agencies that understand that the content delivered in our technology programs is directly affected by the skills and knowledge the educator possesses.

Sample Professional Development

The professional development example below is from a school district which is home to 39,000 students, with a career and technical education department consisting of just over 300 staff members, educators and administrators. Technology education is part of this department with just under two-dozen full time educators teaching at 14 secondary schools. The past administration had not kept up with the commitment to offer a wide range of professional development opportunities, funneling any available funds into new equipment for the labs (a good choice for expenditures, however, after an initial survey of the educators in this district, is was determined that little Personal Development has been offered in the last few decades). The full professional development program was implemented to provide many opportunities for the educators so that the catch-up process could begin. Most of the opportunities listed on the next page could be offered around the nation. This sample professional development is not meant to be a solution, but rather to be used to promote ideas and action to move this issue forward.

Appended is a synopsis of the technology education professional development opportunities that were offered during the 2001-2002 school year in Manatee County, Florida. The program is being provided to start ideas flowing in other districts, as one model that addresses the need for high-quality professional development for our educators. The funding was provided from a number of different sources such as grants, state money, federal funds, and local funding.

- **August 2001** - Technology Teachers Back-To-School Meeting (2 inservice points, hourly pay)
- **August 2001** - Digital Camera Workshop (3 inservice points, equipment, hourly pay)
- **August 2001** - Institute of Electrical and Electronics Engineers (IEEE) Electric Motor Workshop (2 inservice points, equipment, hourly pay)
- **Any Day Throughout The Year** - Local Programs & Practice (6 inservice points, travel expenses, sub, hourly pay)
- **Any Day Throughout The Year** - State Programs & Practice (6 inservice points, travel expenses, sub, hourly pay)
- **October 2001** - Technology Student Association (TSA) New Advisors Workshop (14 inservice points, travel expenses, sub, registration, hourly pay)
- **October 2001** - Florida Technology Education Association (FTEA) Annual Fall Conference (7 inservice points, travel expenses, registration, hourly pay)
- **October 2001** - Project Lead The Way (PLTW) Fall Workshop (7 inservice points, travel expenses, sub, hourly pay)
- **October 2001** - Technology Student Association (TSA) Leadership Training Workshop (21 inservice points, travel expenses, sub, registration, hourly pay)
- **November 2001** - Technology Education Educator Meeting (6 inservice points)
- **December 2001** - Plotter Workshop (3 inservice points, stipend)
- **20 Different Days Throughout The Year** - Workforce 2020 (6 inservice points, sub, registration, hourly pay)
- **February 2002** - Standards for Technological Literacy Workshop (6 inservice points, travel expenses, stipend)
- **March 2002** - Institute of Electrical and Electronics Engineers (IEEE) Anclote Power Plant Workshop (4 inservice points, travel expenses, sub, hourly pay)
- **March 2002** - Computer Numerical Control (CNC) Workshop (6 inservice points, sub, equipment, hourly pay)
- **March 2002** - Workforce Development Conference (6 inservice points, hourly pay)

- **March 2002** - International Technology Education Association (ITEA) National Conference (21 inservice points, travel expenses, sub, registration, hourly pay)
- **April 2002** - Technology Student Association (TSA) Advisors Breakfast (1 inservice point, food)
- **April 2002** - Digital Camera Workshop & Visit (3 inservice points, sub, equipment, hourly pay)
- **April 2002** - Technology Student Association (TSA) State Conference (21 inservice points, travel expenses, sub, supplies, registration, hourly pay, stipend)
- **May 2002** - Technology End of Year Meeting/Dinner (2 inservice points, food, stipend)
- **June 2002** - Integration of Technology Workshop (6 inservice points, stipend)
- **June 2002** - Standards for Technological Literacy Workshop (42 inservice points, registration, equipment, stipend)
- **June 2002** - Camp Tech Prep (28 inservice points, stipend)
- **June 2002** - Teachers In Industry For Educational Support (TIES) (60 inservice points, stipend)
- **June 2002** - Technology Student Association (TSA) National Conference (45 inservice points, travel expenses, registration, equipment, supplies, stipend)
- **July 2002** - Florida Association for Career and Technical Education (FACTE) Summer Conference (21 inservice points, travel expenses, registration)
- **July 2002** - TechKnow Project Workshop (28 inservice points, travel expenses, supplies, equipment, stipend)
- **July 2002** - Project Lead The Way Educator Training (66 inservice points, travel expenses, registration, supplies, equipment, stipend)

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Professional Development issues in Technology Education: the changing scenery

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Education Queensland

Introduction

This paper briefly examines two recent professional development activities in Queensland and considers how these relate to the literature about desirable features of professional development. It also looks at a new 'capacity building' model of professional development which is being developed by Education Queensland to support the implementation of the Years 1 to 10 Technology syllabus during 2003 - 2007.

Finally the paper describes a composite set of principles derived from literature on contemporary professional development programs for adult learners and proposes some recommendations about how these can be used to guide the design of effective professional development programs in Technology.

Background

All professional development and change is contextualised. It occurs within a changing political, social and educational context. It is captured within a certain time and space.(Cuthbert and Schultz, 2000) It has its own set of constraints and underpinning professional boundaries. It draws upon a certain, and often, a very limited pool of funding and attempts to influence a particular target audience, which have their own unique set of collective characteristics. The National Staff Development Council, (NSDC) take up this point recognising that no single "ideal" model exists that meets every school/districts needs and requirements. A diversity of cultures and unique concerns need to be acknowledged and valued (SERC 2002). Yet Guskey & Huberman, (1995) cited in SERC (2002) suggest that a set of guiding principles and beliefs are consistently evident in successful professional development. These principles can be identified and used to guide and evaluate:

- completed professional development programs,
- the design of professional development programs, and
- employed as a reflective tool to evaluate potential professional development ideas.

'Never before has there been a greater recognition of the importance of professional development for teachers' North Central Regional Educational Laboratory (1996). To be effective the design and implementation of professional development has to meet the professional as well as the social needs of those it is designed to help - the teachers (Grossman Smagorinsky, Valencia, 1999).

A brief examination of the Queensland context

In many ways Technology Education is still in its infancy in Queensland. After four years of development the Queensland Studies Authority (previously known as the Queensland School Curriculum Council, the Queensland Board of Senior Secondary Studies and the Tertiary entrance Procedures Authority) is reaching the final stage in the development and printing of the Years 1-10 Technology syllabus for Queensland. The finalisation of these document, and its suite of support materials, will mean that for the first time teachers from across years one to ten will be expected to deliver a cohesive, and sequential course of study which provides students with the opportunity to develop and demonstrate learning outcomes in the key learning area of Technology.

Prior to this teachers in the early secondary years taught a range of practical subjects such as Industrial Arts, Home Economics, Business Studies, Agricultural Science and Computer Studies which provided some students with some knowledge and skills associated with technology. However, without general systemic support pockets of technology education have been the exception rather than the norm in Queensland secondary schools.

Teachers in Queensland's primary schools have undertaken a range of practical, problem-solving activities which have, at times, aligned to the aims and goals of technology. However on the whole these programs have been, ad hoc, with many teachers confessing little or no real understanding and recognition of the Technology key learning area.

The introduction of the new Years 1-10 Technology syllabus therefore represents a major new initiative for Queensland and one that involves many potentially significant professional development challenges. One of the most significant of these will be the need to provide professional development learning opportunities to primary and secondary teachers on the nature of technology, the intent of the syllabus, and the epistemology which underpins its practice.

The Queensland Experience - learning and reflection on recent experience

During the early nineties the Federal government launched the National Professional Development Program (NPDP) initiative that was designed to promote professional and curriculum renewal of teachers over a three-year period. While the mechanical processes and underpinning design of the national program together with its underpinning political agenda, are in themselves worthy of examination the individual professional development programs which were eventually initiated through this funding provided significant opportunities to plan and manage sustained professional development learning at a state level.

Allocation of funds to each state and then to each subsequent professional development program were based on competitive grants and involved the submission of professional development program submissions which demonstrated collaboration between universities, educational institutions, industry groups and professional associations.

While Queensland secured a range of funding amounts during this time two sequential, and interconnected, professional development programs for teachers in the area of technology education are of particular interest, *Teacher Professional Development for the Delivery of technology education - stage 1 and stage 2*. Stage one was funded for the modest amount of $50 000 and culminated in the design and development of an education kit consisting of a video containing a series of 4 case-studies and a written set of materials drawn from upper primary and lower secondary school classes. Much of the initial grant was issued to the 10 or so schools who participated in the professional development activities or was used in printing and production costs for the kit.

Due to the relatively small amount of funding offered in stage one of the project it was decided to focus the funds on a relatively limited number of schools, develop some high quality practice and document this through written materials and video resources. Replication and distribution costs were achieved using systemic funds. Five hundred kits were eventually produced and used as a key resource for the second, more extensive, part of the project.

The second stage used a budget of $200 000 and involved 11 regional coordinators operating across Queensland to run a series of school-based and cluster workshops using the resource kits from the first stage as stimulus material. Each regional coordinator for Technology nominated the number of workshops they could manage and determined the number of kits they needed from the central pool, depending upon their regional needs and conditions. The coordinators were in control of the process, exercising local decision making (SERC, 2002) in terms of the content and mode of delivery for their schools. While the coordinators planned and ran the workshops independently they typically used the video kit materials to stimulate discussion about classroom practice in technology. This was based on the notion that 'teachers are the best teachers of teachers' (SERC, 2002) and that professional growth can be modelled as a culture (Cuthbeth &Shutz, 2000) and communicated best by teachers. By comparing and contrasting a couple of video case studies to determine the common elements in their practice and relating this back to their own current classroom practice, teachers were able to gain an appreciation of the processes and practices of technology rapidly and critique this through discussions in small learning teams (Grant). The authenticity of the practice came from the recognition that the practices on the video were the lived expertise of classroom teachers who were themselves only recently introduced to the learning area of technology.

At each workshop participants were provided with a copy of the video kit to take back to their school and share with other teachers and administrators. This also provided participants with the opportunity to view the rest of the video case studies. All workshop participants were offered the opportunity to apply for a limited amount of funding through their regional technology coordinator to undertake a classroom action-research project in the area of technology. This aspect of the project was designed to enable participants to negotiate a research project in alignment with their interests and current knowledge. The idea was to 'dip their toe' in the water and try out some ideas in the area of technology before it became a mandated area of learning. This concept was explained early in each workshop and provided a context for the active engagement and motivation of teachers. The amounts of funding directed towards individual school projects was very modest for two reasons – firstly, this meant that the money could be used to involve the maximum number of participants and help build the critical mass of individuals needed within the project to support its continuation. Secondly, and perhaps more importantly, it meant that while teachers were provided with the resources to undertake an initial classroom action-research project, a similar project could potentially be funded using school funds in subsequent years. This process enabled teachers to undertake guided (mentored), workplace embedded tasks that catered to their own professional interests and capabilities in the area of technology. These teachers became a resource and support person to other staff within their school. Other teachers were able to visit their classroom and see first-hand a technology project in action as it evolved.

The principles of 'professional choice' and 'ownership' were important and re-occurring elements at all levels of the project. The grant provided the teachers with a professional opportunity to explore the technology key learning area through a small self-organised action-research project supported, and approved by the regional coordinator, acting as a mentor or supporter of the process. This meant that the regional coordinator had a pool of interested, motivated and committed teachers undertaking a range of self initiated action-research projects across the region. These projects provided participating teachers with the opportunity to explore the ideas that they had seen in the video and discussed in the workshop within the 'safety' of their own classroom across an extended period of time.

With five hundred kits distributed by the regional coordinators and nearly 800 workshop participants state wide, over 500 minor projects were initiated and undertaken in primary and secondary classrooms across the state.

Sustainability

Parallel to the workshop/action-research process a second video of 4 case-studies was produced in partnership with a limited number of 'focus' schools. These further examined classroom issues and practices relating to technology. The two videos were incorporated, together with a book of 55 brief case studies (5 selected action-research projects from each of the 11 regions) into a second kit for distribution to interested schools. This process enabled regional coordinators to capture and document some of the most innovative 'action-research' projects from across the regions and disseminate these through the kits. The aim of this second kit was to develop a more comprehensive set of materials that could be distributed as a 'stand alone' resource, independent of any formalised in-service process. Kits were distributed to individual schools on the basis of an 'expression of interest'.

Contemporary Queensland Experience – A ‘capacity building’ model for schools and systemic change

The imminent implementation of the Technology Syllabus provides us with a new opportunity to reflect upon past and current practices and consider how the changing political, organisational and professional development issues surrounding schools and the schooling system may evolve into a new model of professional development. More than ever before there is a recognised need to devolve and share decision making with schools and districts in a partnership. This changing social and political dynamic has seen the evolution of a 'capacity building model' of curriculum development whereby the central authority works in close collaboration with districts, clusters of schools, and partner organisations to build expertise and networks across clusters of schools and districts to enable locally designed, developed and implemented change programs.

Gone are notions of ‘top down’ models of curriculum implementation characterised by a ‘one size fits all’ model of curriculum change. No longer is it acceptable to 'impose' pre-designed curriculum materials upon schools or districts through a central authority. Rather, a flexible framework which focuses on building expertise or capacity for change at the school and district level is being initiated. This model places a strong focus on the abilities of the systems, district, school and ultimately the classroom teachers to become active members of the change process. To do this they need to work as networked communities of practice, building and sharing their expertise while at the same time being supported and enabled through the actions of the other partners. There is a focus on ‘enabling’ local activity which is 'self-designed' and 'self-implemented' through guided action-research projects. Such a methodology is not only driven by an economic rationalist imperative but by some of the underpinning philosophies mentioned below. In particular the notions that:

- Teachers and schools should be the focus of professional change and that a strong culture and support network for change can be build and sustained at the school and district level,
- authentic and contemporary classroom expertise exists at the classroom level, for this reason one-size-fits-all programs imposed in inflexible ways on staff are being relinquished in favour of a model that sees teachers as ‘partners’ and mentors for other teachers,
- One day ‘in-service’ programs are generally short term and have very limited impact on teacher’s long-term classroom practice,
- Change needs to occur in a sustained manner, across a number of sites simultaneously and that this can only be obtained through the active engagement and enrolment of teachers in learning communities.

- Resources and change management programs may be more appropriately designed, developed and sustained in partnership with districts and schools where different needs and resources can be accommodated or capitalised upon.

Under this plan a small and 'strategic' group of partners at the central level will be responsible for the design of the overall framework of the project in collaboration with districts and schools. They will also collect data to confirm the project's level of success focusing on network building and 'enabling' the actions of schools and districts. This is very much a model where the integrity of the school, its supporting network, and its ability to self manage are paramount to the eventual success of the program.

This model presents many opportunities but also presents many difficulties. While it preferences the support for local needs it is also a very outcomes-driven model, one where accountability is shared amongst the partners. It places the focus of the change process where the most change is expected to happen, at the school and district level. Such a model requires all parties involved to recognise and value their relative roles and responsibilities. All partners need to understand the change management processes and have a common set of expectations. On the other hand schools will have greater autonomy in terms of the design and customisation of their own in-service programs, the ability to draw on a range of potential resources and sources of information rather than those simply endorsed or developed centrally.

At a systemic level this individualisation is difficult to monitor and evaluate in terms of the success of the implementation. There is no minimum level of resourcing to each school (eg. kit of materials issued to all schools). Hence, concerns about the quality of individual district and school implementation may arise. Such a devolved model also supposes that schools know what they want and know how to get it. In the case of Technology education they may not. For example, resources could be directed towards 'information and communication technology' training rather than supporting the implementation of the Technology learning area.

Phases within a 'Capacity building ' model of technology implementation

Given the environment in which the technology syllabus is to be implemented, the nature of the key learning area, and the current level of understanding and awareness in schools, what might an implementation model look like? How might it be successfully structured and supported by the central authority?

The proposed model has 4 overlapping and dynamic phases.

- Awareness phase
- Networking phase
- Interconnectedness phase
- Ongoing practice phase

Phase characteristics

Awareness phase

The awareness phase aims to promote the key messages of the syllabus and its intent to a wide range of audiences using a range of different modes and strategies. This phase involves creating a shared, systemic and community understanding of the nature of the key learning area of Technology.

Networking phase

Selection of a limited number of self-nominated schools (incubator schools). This will involve forming close working relationships with staff and districts from these schools to nurture their expertise in the implementation of technology at a school level. This process involves creating networks between partner organisations, professional associations, districts and schools to promote capacity building at a local level.

Interconnectedness phase

Focuses on utilising and connecting 'incubator' schools to work as a source of information and inspiration for other schools within their clusters and districts. This phase of the project involves supporting districts through financial grants to plan and implement a range of customised services and processes to implement the syllabus more widely across their districts and across the state.

Ongoing practice phase

This phase involves the promotion of best practice across the state through the identification and publication of materials developed by schools and districts during the implementation process. It also involves the development of processes to sustain networks and practices in districts to promote an understanding and capacity to implement the Syllabus.

Principles of effective professional development

The following is a composite list of professional development principles drawn from a wide range of research papers and the projects undertaken in Queensland schools through the National Professional Development Projects One and Two.

Professional development programs for teachers of technology should:

- be classroom based and focus on an action-research methodology
- be lengthy and sustained rather than one day events
- be collegial and promote professional networking, and discourse
- model the types of practices and processes to be used with students
- think big, but start small (Guskey, 1994)

- enable teachers to shape and direct their own learning programs
- be flexible and contextualised to the needs of the learners
- promote professional leadership roles for teachers
- recognise formal and informal learning

Principle 1: Professional development should be classroom based and focus on an action-research methodology

The action-research model of the NPDP projects, particularly Stage Two demonstrated the power of engaging teachers in self initiated research projects which are guided and mentored during their development. Such activities provide opportunities for teachers to initiate classroom research that explores issues and ideas important to their own learning within the context of technology. Guskey (1995) and Knowles (1985) in particular stress the importance of embedding teachers learning as 'problematic' within normal classroom activities of day-to-day teaching. Using this approach professional growth and practice are seen as continuous (NPEAT, 1999) and achieved within the classroom environment.

Principle 2: Professional development should be lengthy and sustained rather than one day events

Change is a long term process. Providing follow-up, mentoring, and monitoring (Guskey, 1995) are important if learning is to be seen as a sustained and long term process (NCREL, 1996) The impact and ability of one day programs to change teaching practice effectively is challenged by the Northern Central Regional Educational Laboratory (NCREL, 1996) They suggest that a program which enables teachers to undertake sustained learning opportunities in collaboration with other teachers is more likely to promote sustained professional change and learning than single day events 'imposed', at irregular intervals on teachers.

Principle 3: Professional development should be collegial and promote professional networking and discourse

Teachers communicate best with teachers. 'The craft of teachers is best transmitted by teachers' (SERC, 2002) Professional development programs should be designed to build on the experiences and knowledge of classroom teachers. They should enable teachers to construct and reshape their understandings of their practice actively through a constructive process of reflection and learning. Such learning is often best promoted through the use of learning communities (NCREL, 2002) such as on-line learning communities or learning circles. Hence the NCREL suggest that effective and sustained professional growth is promoted when teachers form learning networks rather than work in isolation.

Principle 4: Professional development should model the types of practices and processes used with students

Programs which promote and model processes which are similar to those used with students help to demonstrate and embed these understandings in teachers' practice enabling them to explore how others are able to 'practice what they preach'. Evidence suggests that much of this learning is unconsciously assimilated (Grossman, Smagorinsky and Valencia, 1999) by the teacher enabling them to develop an understanding of the rationale and associated teaching practices being presented more actively.

Principle 5: Professional development should Think big, but start small (Guskey, 1995)

Starting with the early innovators is often the most effective method to create maximum impact. These teachers pioneer the practices, sharing their ideas and providing a springboard of information and approaches for other teachers to follow. Such an approach relies on intensively supporting a 'few' teachers rather than attempting to focus across the entire cohort. The practice of these early innovators is then used as a dynamic model of authentic practice which other teachers can use as a springboard.

Principle 6: Professional development should enable teachers to shape and direct their own learning

Nearly every set of adult learning principles stresses the need for the learner to play an active role in helping to shape and direct their own learning programs. Often this is with the notion of teachers helping to set the agenda for a one-day workshop. Nevertheless this idea can be extended to longer-term initiatives involving communities of practice. In the case of the NPDP projects attending teachers were offered the opportunity to undertake their own research projects through the grants scheme.

Principle 7: Professional development should be flexible and contextualised

A one-size-fits-all model of 'training' teachers is unlikely to yield effective results, given the diversity of factors which they need to accommodate when planning and implementing classroom curriculum. Rather, a model which promotes individual and diversified practices, accommodating a range of teaching styles, and recognising the individuality of each teacher's learning environment is far more likely to produce effective and sustained change.

Principle 8: Professional development should promote professional leadership roles for teacher's leadership

Teachers are natural curriculum leaders. Providing avenues through which teachers can further develop and share their ideas with others is an important aspect of catering to the professional development and growth needs of teachers. It provides a way by which early innovators can share and partner in the process of change, building a critical mass of potential change agents and assisting other teachers to grow professionally in a range of flexible ways.

Principle 9: Professional development should provide continual contexts for formal and informal learning (Grant)

Both informal and formal learning should be recognised as contributing to the learning and professional growth of teachers. In fact, learning in non-formal settings, ie. that which occurs beyond the direct intervention of the 'instructor/mentor' probably provides a more personalised and often more contextualised opportunity for teacher to reflect upon and internalise change.

Additional organisation Principles to consider:

Self sustaining Professional development

Professional development programs should be engineered in a manner which maximises their sustainability. This may involved the structuring of a process to generate revenue which is then fed back into the curriculum change process i.e. the marketing of resources or services to others, or through the development of sustainable resources such as books, media resources or a web site which provide a stream of revenue to support further growth.

Building capacity and independence

'Building capacity' involves shifting the focus for decision making and management from the central authority to the district and school based level. It involves the establishment of self-supporting networks and communities of practice which are able to manage and further evolve the initiative to meet both the centrally determined outcomes as well as local needs. To do this genuine and strategic partnerships needed to be established and nurtured over a sustained period of time until a critical mass of interest and professional understanding is established.

Conclusion

> Schools must become places of intellectual challenge, learning and growth, settings which nurture qualities of thinking that set the stage for a lifetime passion for learning. For this to occur, teachers must be provided with rich, varied and empowering contexts for their own development, through formal and informal means of professional support. (Grant,(n.d), Professional Development in a Technological Age: New Definitions, Old Challenges, New Resources, [Online].)

Continued professional development must be a key focus for any department interested improving the teaching and learning practice of their workforce. A continual process of workforce renewal and training based on a range of flexible models and underpinned by principles of adult education and training is fundamental to achieving successful change.

The old 'roll-out' models based on a 'one size fits all' process where one day workshops are used in a hit and miss fashion, with teachers as the targets, must be superseded by the notion of a learning organisation where sustained professional networks and conversations are used as tools to support collective teacher change and professional growth. This represents an organisation where teachers, schools and districts are enabled to build the capacity needed to guide and determine their own professional growth through productive partnerships and rich professional networks.

Recommendations

- Professional development programs should be underpinned in their design and development by professional development principles and practices drawn from research.
- Professional programs should be designed to meet the local requirements of the systems and culture in which they are going to be used. Professional development programs are highly contextualised (Guskey, 1995). They need to be adapted to the dynamic characteristics of specific contexts.
- Professional development programs which run as single day events or even short courses are unlikely to have the same impacts as sustained conversations, supported by workplace learning, based around the notion of teams working together to address common issues and concerns. Such professional development is sustained and significantly based on relationship management and partner building.
- Professional learning in technology should, in many ways, reflect the type of learning being sought in the technology classroom. One where professional decision-making is important, one where multiple solutions are valued and recognised, and one where innovation is actively supported and natured.

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Chapter Thirteen

Shaping the Profession's Image

Shaping the Profession's Image

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Shaping the Profession's Image

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Introduction

This paper argues that the technology education profession is not a single entity and that technology educators see their role in one of two significantly different ways. Many consider that technology education is principally concerned with the transmission of subject specific know-how. Others associate technology education with a more holistic approach characterized by a core of transferable knowledge and processes.

Each construct is examined and a conclusion is drawn that the professional must embrace a holistic approach if it is to adequately prepare young people for life in the Information Age. To some extent, the impacts of fragmentation on the profession's image are explored.

The paper draws on developments in Australia, and more particularly in New South Wales, over the past 15 years and the resulting issues of identity faced by local technology educators.

The identity we, as Technology educators, ascribe to ourselves can be related directly to the curriculum we deliver. If our curriculum is a collection of loosely connected subjects that compete with each other for priority and popularity in a wider curriculum, the notion of technology education has little value other than to define a boundary. On the other hand, if our curriculum specifies a core of transferable knowledge, capacities and values that are recognized by all and that take precedence over subject specific content, the term 'technology education' may encapsulate the very essence of what we teach.

Those who identify with the 'loose connection' construct will seek to find value in fragmentation and will argue that there is strength in choice and diversity. Those who argue that technology education should be based on a defined core of 'transferable knowledge, capabilities and values', will regard fragmentation as a destructive quality or, at best, a passing phase in the development of a united and powerful area of learning.

At this point, the situation in New South Wales reflects a mixture of both constructs. Mandatory courses for primary and junior secondary students contain a strong core of transferable learning based on design processes. Elective courses in secondary schools fall into the 'loose connection' construct. Few secondary teachers identify with broad notions of technology and technology education.

To consider both positions one must first ask the question: what is technology? Like many important concepts, the word 'technology' has many layers of meaning. The New South Wales *K-6 Science and Technology Syllabus* states that technology "is concerned with the purposeful and creative use of resources in an effort to meet perceived needs or goals. It extends beyond the tools and technical inventions of society and involves the application of human skill, knowledge, techniques and processes to expressive and practical problem-solving situations in all aspects of human life." p1 The national document, *Technology – a curriculum profile for Australian Schools* states that technology "involves the purposeful application of knowledge, experience and resources to create products and processes that meet human needs" p2

These and other definitions used by Australian education systems suggest that 'know-how' is central to the concept of technology. Such know-how tends to define what we are as humans. It is evident in our capacities to adapt and shape our environments to meet the diverse spectrum of human needs.

Know-how is most evident in products, systems, services or environments that are new and different. In common usage technology is associated with new fields of endeavour such as genetic technology, space technology and computing technology. While we are comfortable associating know-how with things that are new, technology is equally a part of those things that are not new. It resides in the everyday products, systems, or environments, i.e., the things we use regularly and that surround us. There is 'know-how' in the pegs we use to keep clothes on the washing line, in the sandwiches we eat for lunch, in the homes and other buildings we construct, in the gardens we create, etc.

What is the "technology education profession?"

As a generalization, technology educators can be said to work in one of two paradigms.

1. Technology education exists for the purpose of transmitting defined areas of know-how, e.g. how to make things out of wood, how to make things out of textile materials, how to use computers. (Referred to as the 'transmission approach'.)
2. Technology education exists to develop students' capacities to create and apply technology and to develop understanding of its role across a wide range of contexts. (Referred to as the 'holistic approach'.)

Technology education – a transmission approach

Traditionally, Australian secondary schools have provided subjects that clearly existed for the purpose of transmitting specific types of know-how. Mostly these subjects were made available as options or electives. The NSW curriculum continues to include secondary subjects such as:

- Textiles and Design
- Technics
- Technical Drawing
- Sheep Husbandry and Wool Science
- Agriculture.

Syllabuses for these subjects contain lists of specific knowledge, skills, values and attitudes that are to be taught.

Prior to the 1990's these subjects were not explicitly identified as technology subjects. Teachers were (and still are) grouped under banners such as Home Science and Industrial Arts. Traditionally such subjects were regarded as non-academic. In many cases their image and professional status reflected the fact that many teachers were recruited directly from trade areas with minimal levels of tertiary education.

Problems of the transmission model

If we define technology broadly, we face a profound issue: of the myriad of technologies that humans have developed, what technologies should we teach our young people? How do we identify and prioritise the types or forms of technology that will be of value to young people over the course of their lives?

Traditional approaches attempted to address these questions, most commonly through separate 'subjects'. To this extent, fragmentation is a characteristic that technology education has inherited from its forebears. It is a product of its history and traditions. The approach generates ever-increasing boxes of know-how, each seeking a higher priority in a crowded curriculum and each struggling to remain current.

But our traditions are more deeply embedded. Technology teaching in Australia has its roots firmly planted in the society and culture of the Industrial Age. Parts of the curriculum and the pedagogy that underpins its delivery can be related directly to the age of mass production, i.e. the Industrial Age.

Education and training for the Industrial Age aimed to create a workforce that would keep the wheels of industry grinding. Workers required:

- a predictable set of technical skills
- a capacity to follow instructions (mostly in an unquestioning fashion)
- precision and accuracy.

More importantly, qualities of creativity and innovation were actively discouraged. The empowerment of workers was seen as a danger. Social and environmental responsibility was not associated with the role of workers.

While Australian and New South Wales Technology curriculum has undergone considerable reform, the profession's image is a reflection of the experiences parents and community members encountered during their own schooling. Few parents fully understand the reasons for a holistic approach to technology education. Many see value in the making of cookies, pencil boxes, teapot stands, etc. They regard computing as a natural extension of a menu of technical activities.

Currently, the profession's image reflects the characteristics of the transmission model. The characteristics are summarized in Table 1 below.

Table 1

Characteristics of the transmission model

Role/aspect	Perceived characteristic
Teacher	sees self as the source of most/all expertise personal expertise is narrow but in-depth values the currency of own technical skills avoids areas of technology not regarded as own domain uses set projects as the prime vehicle for teaching and learning.
Learner	conforms to set procedures practices accuracy and precision values the development of personal technical skills works individually.
Curriculum	states specific technical content suffers from the need for constant revision to maintain currency.
Pedagogy	models physical (how to do) processes frequently separates theory and practice focuses on the performance of individuals.

Technology education – an holistic approach

C. Hooker (1988) states that a

> "central function of education is to prepare students for the future, including both their societal and their personal futures. An education system can only be successful in this aim if it correctly identifies the sources of change in its society and adapts its curriculum accordingly." p2

The young people entering our schools today will live through a period of unprecedented change. If we are to prepare young people for the future we must recognise that specific technological know-how will develop and change at a dazzling pace. Technological knowledge and skill that is of high value today may be of limited or diminishing value tomorrow.

If technology subjects are primarily concerned with the transmission of existing knowledge and expertise, how do we prepare young people for a future in which the most powerful know-how is yet to be developed?

Up to the period of the mid 1980's, Australian community embraced an approach based on the transmission of know-how. However, at this time policy makers, educational leaders, and influential elements in the community, started to question the value of this approach. This questioning was the result of:

- poor economic conditions
- a perception that Australian industry was not responding to rapid development in information technology
- evidence of degradation of the environment
- reports of global warming.

There was a realization that the transmission approach is not one that will best prepare young people to live in a future that will be characterized by ongoing social, environmental and technological change.

So, what of the future?

Freeman Dyson of Princeton University provides the following scenario for the development of technology in the next 50 to 100 years:

> "Try to imagine a world where people get energy from fields of trees that have been genetically engineered to secrete liquid fuel from their roots into underground pipes. In an adjacent field, other trees might grow silicon chips in the same way they grow flowers. Surgeons no longer use knives but inject their patients with purpose-built viruses that seek out and eat damaged cells and organs. Roads are constructed out of engineered organisms in the same way that coral polyps make reefs. Cities are smaller, as the majority of people choose to live in small communities, yet wherever they live everyone is connected by a mature Internet that is truly global.
>
> And every day home made spaceships are hurled into space by giant lasers, on a pay per throw basis, the occupants perhaps on a journey to visit friends living beyond Pluto in the Kuiper Belt on collections of comets that are lashed together like junks once were in Hong Kong Harbour."
>
> As reported in a review of *The Sun, The Genome and the Internet* on the Radio National Science Show (30/10/99), (http://www.abc.net.au/rn/science/ss/stories/s638/0.htm)

While Dyson's scenario may sound fanciful, the change he anticipates is no greater than the change many of us have experienced during the 20th Century. The detail may not be accurate but the rate and nature of technological and social change can be foreseen.

In his book *Futures for the Third Millennium*, Slaughter (1999) lists six new factors with future impact as:

- The human genome project and synthetic organ replacement
- Research on the control of aging
- The forging of new person/machine links
- The development and application of nanotechnology
- Universal digital communications systems
- High-tech terrorism using miniaturized weapons.

The February, 2000 edition of *Wired*, reported on the work of Kevin Warwick, Professor of Cybernetics, University of Reading, UK. Warwick has implanted silicon chips in his own body in order to communicate with a computer via radio waves. His research program will explore further applications of cybernetics including the communications of emotions via the Internet. He argues that 'thought to thought' communication is a feature of cybernetics that may be important "as we face the distinct possibility of being superceded by highly intelligent machines". In conclusion, Warwick states that "since childhood I've been captivated by the study of robots and cyborgs. Now I am in the position where I can actually become one. Each morning I wake chomping at the bit, eager to set alight the 21st century – to change society in ways that have never been attempted, to change how we communicate, how we treat ourselves medically, how we convey emotion to one another, to change what it means to be human and to buy a little more time for ourselves in the inevitable evolutionary process that technology has accelerated" (p.151)

If teaching students what we already know has only a limited benefit, what type of technology education will empower them to deal with or shape the type of world described by Dyson, Slaughter and Warwick?

Orientating technology education toward the future

De Bono argues that our "excellence in working with 'what is' has meant that insufficient attention has been paid to the 'what can be' side of thinking…. The 'what can be' aspect of thinking is concerned with design rather than analysis, with value rather than truth.

You can analyze the past but you have to design the future " p 277

More recent approaches to technology education require that students learn through design processes and learn to use design processes to create products, systems and environments. Design is concerned with the formulation of ideas or concepts in advance of production. Implicit in the word 'design' is the creation of something that will exist in the future and with which people will interact in the future. We shape the products, systems and environments that will be used in the future, but equally those products, systems and environments influence how we behave, what we believe and who we are.

Technologies service our designs and, conversely, our designs stimulate the development of new technologies.

As we have moved away from a transmission model, curriculum developers in New South Wales have attempted to develop a core of transferable knowledge and capacities. The new holistic approach requires that we must:

- teach students how to create and apply technology to serve their own purposes and to serve other people. This requires that they develop skills and capacities to design.
- teach students to consider the appropriateness of the technologies they use and how their use of technology may impact on other people and the environment.
- provide learning experiences in which students consider futures and the types of actions we must take today to produce futures that we may desire.
- provide a broad range of technological experiences and frequent opportunities for students to transfer their learning to new contexts.
- encourage students to think broadly about technology and to appreciate its role and impacts in the wider community.

- provide students with experiences that develop confidence and enthusiasm for learning about technology. (Learning to learn 'technology' is a critical skill for all young people. It would seem that those who continue to learn about technology will be the ones who shape technological change into the future.)
- teach students to value the human ingenuity and creativity that has produced the products, systems, services or environments that are part of all cultures.

In NSW, the introduction of mandatory studies in the primary and junior secondary years also acknowledged that if we are to prepare young people adequately for life in the changing technological world of the 21st Century, they must learn both the processes and content of technology in a systematic and focussed way.

It is important that, in time, the profession's image develops to reflect the characteristics of a holistic approach the technology education. These characteristics are summarized in Table 2 below.

Table 2

Characteristics of the holistic model

Role/aspect	Perceived characteristic
Teacher	sees self as a process guide sees self as an architect of learning experiences during which students seek knowledge and expertise from a range of sources identifies broadly with design and technology is interested in contemporary issues of design and technology values innovation and creativity embraces change and anticipates a professional life of learning.
Learner	enjoys creative activities and learning about different forms of technology evaluates and critiques own work and the work of others sees technical skills as a means of realising designs and plans is curious about technology and emerging developments in technology relates technology to human contexts.
Curriculum	defines processes and transferable ideas is expressed in the language ideas and concepts contains a futures focus accommodates flexible approaches to programming
Pedagogy	models cognitive as well as physical processes integrates theory and practice recognises a progression of learning uses negotiated tasks and activities places importance on social context uses both individual and group work .

It should be noted that such an approach does not devalue technical skills and capacities but rather seeks to teach these in a social context. It challenges teachers to design programs that address technology that is valuable in daily life; those that may be useful in paid employment; and, that will impact on us as part of a global community.

The technology education profession

Central to the notion of 'profession' is an idea of what the professional does. Professions are valued for the importance of the work they do and for the qualities they bring to the task. In education, our professional image is a reflection of:

- what we teach
- what we tell others about the purpose of our teaching
- what students perceive as their learning and its purpose.

The value of what we teach is reflected in the priority it is given in the curriculum.

In New South Wales (if not Australia), the Technology profession's role in education and its image is unclear. Technology educators are drawn between the two approaches to technology education described above. At this time technology educators do not share a common and clearly articulated purpose. There is a significant gap between the rhetoric and the reality of technology education, between the stated curriculum and the practice of teaching and learning. As one would expect, the general community's understanding of technology education is equally confused.

While this may be the case, the Australian Government has now recognised the importance of the new approach. In the recent publication entitled *The Knowledge Economy*, the Commonwealth Department of Employment, Education and Training stated that the "emerging society and economy based on ideas, not objects, will require different educational forms and priorities. Educators must employ strategies to effectively build the 'wetware' that their students will use to engage in a knowledge economy, or risk being obsolete.

If the vision statement articulated in the Technology Education Action Plan (2002-2006)

> is realised, technology educators are poised to play a crucial role in determining Australia's future. The technological processes, systems, creativity, higher order cognitive skills and future-orientation that technology educators can bring to the classroom will become increasingly significant tools. Technology – above all other learning areas in the current school curricula - has the potential to imbue many of the 'life skills' required to actively participate in the information society." p7

What are some strategies the profession should follow to develop a common philosophy and a more positive image?

The brief for this paper tends to suggest that the profession will develop and change from within and, subsequently, communicate its (new?) vision and mission to the wider community. Experience in NSW would suggest that it is difficult to affect change from within. Our experience would also suggest that it is very difficult to impose change from outside the profession. Change processes have been most effective when the technology education community has engaged with the wider community to determine its direction and when debate has focused on the future needs of students.

In the past, there has been movement towards a shared philosophy of technology education when policy-makers (politicians and bureaucrats) have set an agenda for change and when they have expressed interest in, and strong support for the profession. This support is essential as it signals to the profession that the planned changes are valued, that new priorities will be conveyed to school administrators and that essential resources will be available to support the change.

While policy-makers may set agendas for educational bureaucracies, their policies are a generally a response to public concerns and perceptions. In NSW, change processes have stalled during periods when we have failed to clearly communicate the benefits of a holistic approach to the technology education to the wider community.

It should be noted that during the early stages of curriculum change in NSW, the profession formed strong alliances with natural allies, e.g. academics in disciplines such as design, engineering, architecture and computing science, professional institutes, industry associations. These individuals and organizations contributed to and expressed strong support for a new direction in technology education. However, their support eroded when the change was undermined by factions within the profession or was not implemented effectively in the classroom.

In retrospect, a key requirement for effective change in the profession is strong leadership. There is need for leadership that has vision, that communicates effectively with influential groups in the community and that elicits the commitment of practicing teachers.

What are some of the barriers that must be overcome?

One of the most basic barriers to change is a perceived conflict between the needs of teachers, as professionals, and the needs of students. Industrial conditions and agreements, promotion pathways and existing school organization and facilities impact greatly on the willingness of teachers to embrace change. These factors are part of the culture of schools and are aligned with the transmission model of technology education.

At different points teacher unions have intervened to obstruct changes that are not endorsed by union members. Some teachers see the change as devaluing their existing base of teaching expertise.

Another profound barrier to change is the nature of the education system. In New South Wales, few technology educators have found their way into senior positions in the bureaucracy; the positions that influence priorities and determine the allocation of resources.

Within the profession, the most difficult barrier is that of pedagogy. In general terms, secondary technology teachers are most comfortable operating in the transmission mode. Their teaching is characterized by the processes of demonstration, i.e. showing students how to make things or how to complete technical operations. The holistic approach, described above, demands a significant transformation: from teacher-directed to students-centred learning. In essence, teachers are required to confront the paradigm in which they operate.

Is it time to consider a name change?

Whether or not the words "technology education" accurately conveys the notion of our identity is subject to considerable discussion by Australian technology educators. Some groups that have been assembled under the banner of technology education actively campaign to retain traditional titles such as Industrial Arts and Home Economics. These subject names play an important role in the organisation of secondary schools and in the marketing of subjects. The popularity of subjects ensures their continued existence in the curriculum of secondary schools

Others argue that the title 'design and technology' better describes the essence of what we teach and what we want to be. From a personal perspective, I see considerable merit in this option as the combination of design and technology represents a desireable balance between the content of technology education and characterizing processes of technology education.

In NSW, it is unlikely that the profession could achieve consensus on a name change.

It may be more useful to question whether secondary subjects are part of technology education if they fail to address technology in a holistic way or if they fail to address an agreed a core of transferable knowledge and processes.

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Shaping the Profession's Image

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Introduction

Shaping the profession's image is a complex societal issue that transcends throughout the evolution of technology education. When I first began thinking about this issue, it seemed rather simple; position technology education so that society places value upon its rewards. In other words, find a way to change the image of the discipline so others view it as essential in educating our youth. If technology education is valued, the image would naturally be enhanced. Sounds logical, but from my study it is a much more complex and diverse issue. I have found no direct correlation between image and value when it comes to educational expectations. In the commercial world it is often said that image is everything and that with a brand name and marketing you can sell anything.

Lest we create the impression that technology education is valued by other professions simply by marketing an image, the image of technology education is shaped by its past successes. With a history of success in industrial education, it should not come as a surprise that the change to technology education has not changed the image in the minds of many within the profession or general public. The first element in assessing technology education as a profession is to analyze the culture of its past successes. This is not unique to professional associations or educational disciplines. There are many examples of how corporate culture has nearly bankrupted companies throughout the world.

Take for example the story of IKEA. IKEA is not only one of the largest firms in Sweden, but one of the largest retail furniture companies in the world today. The mission of IKEA is to create a better everyday life for as many people as possible by making beautiful, functional items for customers' homes at the lowest possible price. It launched its first catalog in Sweden in 1951. Since then, it expanded into 22 countries across Europe, North America, Southeast Asia, and Australia. In 2000, IKEA had sales of nearly $9 billion dollars.

IKEA understood positioning in the global market. However, IKEA's successful strategic map failed miserably on two specific items when it expanded into the United States: beds and bed sheets. When IKEA began its U.S. operations, it shipped low-priced moderate-quality, metric-sized beds and bedding to all of its U.S. stores. It advertised how wonderful the beds were especially at a full two meters in length! IKEA expected the same great success in the U.S. that it had enjoyed in Europe.

Unfortunately, sales did not go as well in this new market. IKEA's management was forced with facing the results that the image it had created throughout the world was not working in the United States. Not believing that this could be possible IKEA's management decision was simply to increase advertising. More advertising would surely bring customers into the stores and sales would increase. As you can imagine the metric beds and bedding quickly became category failures. Local stores and regional managers tried to communicate to corporate headquarters in Sweden that metric-sized beds and bedding would not sell in the United States despite the fact that they were priced lower than the king, queen, full, and twin sized bedding found in competitors' stores.

IKEA's senior managers were blocked by their own corporate image. Anders Dahlvig, CEO of IKEA, is quoted as saying "Whether we are in China, Russia, Manhattan, or London, people buy the same things. We don't adapt to local markets." (Nicolas George, "one furniture store fits all" Financial Time, February 8, 2001, p.11.) Finally, after two years of disastrous sales, IKEA discounted metric-sized beds in the U.S. market and declared that "metric was not king" —king was king; queen was king, and twin was king in the U.S. market!

Until we recognize that people's vision for the need for change is blocked by existing mental images that argue for past success and against future change, we will continue to fail in breaking through the barriers of change.

Clearly resistance to change is not a new concept. In fact, resistance to change seems to be a biologically inherited trait. We are programmed not to change. Although plants may evolve and survive through random variation and natural selection, people do not. We do not generate random variations in behavior and let nature take its course, selecting and deselecting those who fit and do not fit the environment. We are wired to resist random change and, thereby avoid random deselection. We are wired to survive, so we hang onto what has worked in the past. This intricate action happens in all aspects of human endeavors.

In our personal life, how many of us have a set route that is traveled everyday to and from work? Day after day, week after week, it soon becomes so natural that we do not even think about the route, it becomes a mental map. Then one day on the way to work you are rerouted because of construction. You follow the detour so you are aware of the change, and the next day you follow your same mental map only to find yourself at the same detour. Finally, on the third or fourth day you remember and start to change your mental map of how to get to work and avoid the detour.

Although likely frustrating, the fact of the matter is that no matter how good we have been at leading change in the past, the future will depend on a new type of leadership—one that helps people redraw their mental maps in new paths.

So what does change have to do with the shaping of the image of technology education? On the surface not much except that the richness from these simple examples lies within the history and development of the profession.

Shaping the professional image of technology education lies within each of us. In some ways we have been our own worst enemy. An unclear vision and separation of values have caused distrust within the profession and a distraction for the image of technology education. Even today, two decades after the official name change in the

United States from industrial education to technology education, there is not consensus on the foundation, pedagogy, or content of technology education.

Shaping the profession's image is a commitment to exemplary leadership. Influencing organizational change is about how well the profession mobilizes those within the profession to want to do the extraordinary things necessary to move the organization. It's about the practices of those in leadership roles to transform values into actions, visions into realities, separateness into common unions, challenges into opportunities, and risks into rewards. Leadership creates the climate in which the culture lives.

The discipline of technology education has certainly had its challenging opportunities. In these extraordinary times, the challenges seem to be increasing, and through our responses we have the potential to change the way we live, work, and learn.

Many circumstances in our society have influenced the way we respond to change; school violence, the horror of September 11, 2001, uncertain economic trends, new educational directions at state and federal levels, and the rapid influence of technology in the way we live and educate students.

Being globally connected means much more than it did just ten years ago. With access to information only a keystroke away, how do you provide leadership for technology education where the hierarchy has become totally irrelevant? How do you define a discipline that now has applications in all sectors of the education enterprise? And how do you lead a diffused network of people with varying degrees of knowledge and experience in technology education? Even more than that we have to recognize that the profession is going through a dramatic demographic change.

Today we have a new generation of teachers with values and virtues that embrace technological change as a way of life and are not rooted in the history of industrial education.

With all these questions, there are countless opportunities to make a difference and to shape the image of technology education—opportunities to use the tools of technology to our advantage in creating a network of human capital and connection; opportunities that build a sense of increased understanding and leadership among a diverse cohort of professionals in technology education. Now, more than ever there is a need for people to capture the moment and lead our profession into the next century.

Shaping the future of technology education cannot be done by a few dynamic individuals that have earned recognition within the ranks of academics. It will only be achieved when the profession brings forth the talents and passion from all people within our profession. People make extraordinary things happen by recognizing the leader within everyone.

In 1984, I accepted my first teaching position in a small town in northeast Wisconsin. Realizing that I was the first teacher hired in a three person department in over 20 years, I knew there was history embedded into the attitudes of the staff and community. I was fortunate to work with two fellow teachers that understood and appreciated my efforts to transition a successful industrial education curriculum into a contemporary technology education program. It was an enlightening and successful journey. With new classes and the infusion of technology content, the program flourished. In just three years, over

80% of the student population had been enrolled in technology education.

From the surface, many saw a very successful transition and believed that technology education was here to stay. I share this story not because I am proud of what we accomplished at this particular school, but to make a point about empowering leadership within the entire profession. Even with all our success, it only took three years after I left the district for the technology education program to revert back to a woods, metals, and drawing industrial education program.

Sustaining the drive and committing to the vision of technology education is critical to shaping its future. The profession must embrace the strengths of all our ancestry roots and commit to a national effort of professional development and resourceful mentoring. I believe that overwhelmingly teachers want to stay current and understand the need for technological literacy.

This example is not uncommon, it happens in many disciplines as well as in technology education. Shaping our profession's image is dependent upon how well we address the leadership challenge within our profession.

Another element to consider when examining our profession is "what do our customers really think of us?" In the business world customer satisfaction is primary to the overall financial success of the company. In business there are many ways to analyze the impact of customer opinion. In education we struggle with the age old question of "who are our customers?" To avoid that debate for the purpose of this discussion, I will simplify the question of "what do others think of us?" It is a well known fact that there is great confusion regarding the difference between technology education and other disciplines that have a technology dimension. In a recent search on the internet, I discovered over 600 listings under technology education. While many were justified websites representing our profession, some were clearly not.

Educational technology, science and technology, information technology, and technical education were some of the most frequent listings. This confusion would cause one to wonder whether technology education is a recognized discipline at all. It would serve the profession to isolate the core mission of technology education and align with disciplines that have similar core values. In the spring of 2001 the International Technology Education Association commissioned the Gallup organization to research American citizens' knowledge of and attitudes about technological literacy. One objective of this Gallup Poll was to determine if the public's perception of what technology is and what should be taught is congruent with the opinion of national experts in the fields of technology, engineering, and science. This is an excellent survey of public opinion and provides some interesting elements that impact the professional image of technology education. An opinion survey measures how the public feels, the information that it has, and how it reacts to particular events, ideas, or proposals. It is a snapshot of public opinion at a given point in time. While this survey draws many conclusions regarding public opinion on a variety of aspects of technology literacy, there is strong support of the need for what we call technological literacy and that technological literacy should be part of the school curriculum.

The survey also suggests that the public has a somewhat narrow view of what technological literacy represents. Not surprising, computers came to the minds of 67%

of the public when the word "technology" is mentioned. This narrow understanding of technology places our profession at odds with the general public. The technology education community embraces a much broader understanding of the word technology, one that is building consensus around the definition of "changing of the natural world to satisfy our needs."

The purpose for raising this question is to challenge the profession to reflect on the opinions and values from outside the profession. Shaping our professional image is dependent upon how well we understand the environment in which we interact.

Another interesting issue that came out of the Gallup Poll is the relationship between technology, design, engineering, mathematics, and science. The public views both engineering and science the same as technology. This could certainly add to the case that a clear core mission for technology education is needed. When asked what they think of when they hear the word "design" (a term that is often used when describing the profession and is presented as a major element in the standards for technological literacy, as a creative process for solving problems) fifty-nine percent responded to the term "design" as relating to blueprints and drawings from which you construct something. Forty-one percent think of "design" in relation to the creative process for solving problems.

It is well known that technology education in the United States as well as other countries has had a focus on "design." The relationship between design and technology is closely related and may be an appropriate alignment for the discipline. What is not clear is if design is intended to become the core content or focus of the discipline. Technological design involves practical, real-world problem solving and is basic to technology. Design is one type of problem solving, but not all technological problems are design problems. Technology includes other types of problems and different approaches to solving them—troubleshooting, experimentation, invention and research, and development.

The engineering profession has a similar relationship with design. Engineering has a recognized set of design principles that provide a systematic approach to design.

How does an image impact the profession? People associate the profession with what they see, hear, understand, and value.

Traditionally, technology education has been aligned with educational programs that are elective options. Art and design education, vocational education, and technical education are examples of where technology education is currently positioned within the education community. Much of this can be attributed to the alignment of the core mission of industrial education. When industrial education transitioned to technology education it was not clear to the public that the core mission also changed. The name changed but the image stayed the same primarily because the profession did not realign itself within the education community. Similar to the example cited earlier of IKEA, efforts to increase the professional position of technology education will not be achieved by simply increasing the number of teachers and programs, investing more in marketing the program, or creating curriculum that emphases science and mathematics.

The international community must begin to realign the profession with disciplines that reflect the content of technology. Over the last decade technology education has attempted to persuade the educational community that technological literacy is general education and should be considered a separate discipline required for graduation and on the same plane as mathematics and science education

If this is to happen, we must understand the powerful influence that the existing image has and how to break through some of the mind barriers history brings with it.

Aligning technology education to better position the teaching of technology will take a dramatic new mindset. A mindset that no longer positions technology education at the center of technological literacy, but as a contributing discipline that adds value to the students' knowledge and skills; a core discipline that shares the responsibility of technological literacy with mathematics, science, and the humanities.

Shaping the professional image of technology education is rooted in the debate over where it appears in the educational pecking order. Technology education is often referred to as an applied science or contextual math—it's as if we are justifying the relationship between math and science to add value to technology education. Technology has been around as long as there have been people. Technology, like language, ritual, values, commerce and the arts, is an intricate part of a cultural system. It both shapes and reflects the systems' values. Even with this basic and evolutional understanding of technology the discipline has suffered from the constant struggle for recognition.

The professional image and growth of the discipline will be dependent upon a new alignment of the core value of technological literacy. Such an alignment would remove technology education from the center of the technological literacy model and embrace symmetry with science.

According to the 1990 report *"Science for All Americans – Project 2061"* the component of technology most closely allied to scientific inquiry and mathematical modeling is engineering. In its broadest sense, engineering consists of constructing a problem and designing a solution for it.

Engineering, the systematic application of scientific knowledge in developing and applying technology, has grown from a craft to become a science in itself. In today's complex technological world, science and engineering can scarcely be separated.

This new order of innovation and design has changed the way we must think about education. Citizens must use knowledge of science and technology, together with strategies of design, to solve practical problems. This interplay between science and technology is not limited to contemporary practice. Rob Larsen and Susan Dunn comment in their book *"Design Technology – Children's Engineering"* that those concepts draw on long traditions of educational thought going back to John Locke, Jean-Jacques Rousseau, and a series of British educational reports dating as early as 1882. Americans can best understand it by linking it with the best of American progressive educational traditions like that of John Dewey.

The alignment between the philosophy of engineering education and technology education are strikingly similar, in many cases it's difficult to recognize any difference at all. Take for example the message that is inherent in the introductory statements describing the overall purpose and mission of the Triangle Coalition for Science and Technology Education. The triangle coalition describes its mission in focusing action in three major areas: advocacy, communication, and programmatic efforts to advance science, mathematics, and technology education. The triangle coalition is comprised of more than 100 member organizations with representation from three primary sectors: business, education, and scientific and engineering societies. In this example, one might ask the question "what is the closest natural alignment between the educational disciplines identified by the coalition and the members that make up the organization?" "Is technology education assimilated with business, education, or scientific and engineering?" Of course, most people in technology education would suggest science and engineering.

This is just one example of the challenge the profession faces when trying to describe its relationship with other professions. One of the determining factors in deciding on how the profession will be shaped in the future is how society defines and embraces "technological literacy."

Technological literacy adds additional characteristics to the discipline of technology education and creates a separate and unique identity from that of technical or vocational education.

Technological literacy involves understanding the nature and history of technology as well as having the capabilities and critical-thinking skills to consider its development and use. A recent report by the National Academy of Engineering and National Research Council calls for a broad-based effort to place the issue of comprehensive technological literacy front and center on the national "home page," with a goal of increasing awareness and skills in this area among all segments of the population.

The report states that learning about technology should be emphasized throughout a student's education. Technology content should be infused into curricula, teaching materials and student assessments and all educators should be better prepared to teach about the subject. The report goes on to say that at the federal level, the National Science Foundation and the U.S. Department of Education should encourage publishers to include technology content in new textbooks about science, social studies and other topics. Likewise, agencies with a technological focus such as NASA and the National Institute of Health should support the development of curricula for teachers for all subjects and grades.

Technological literacy is a concept that must be rooted in all dimensions of education. It is unrealistic to think that any one discipline will be able to stake a claim in delivering technological literacy independently.

Technology education's contribution to the advancement of technological literacy would be enhanced by establishing a formal academic connection with engineering education. Likewise the technology education profession would grow substantially by building a partnership with the engineering profession.

Engineering is a broad field of study that has many disciplines and multiple levels of application. Engineering itself is the art of applying scientific and mathematical principles and experience to design processes and systems. Engineering technology applies knowledge of mathematics and natural sciences to create new products. In comparing the two distinct fields of technology education and engineering, it is easy to see that there is a natural relationship between the two professions. It is from this philosophical relationship that I draw my conclusion to the challenging issue of "Shaping the Profession's Image."

Inspire leadership within the technology education profession to see beyond the shadow of our past mental images of technology education to a new and responsive vision that leverages the values of society and education is critical to the future growth of the profession.

We must listen closely to the needs of society and prepare our profession for fulfilling a new role in education. Technology and technological literacy should not be viewed as the domain of just one discipline, it is essential in all aspects of our education systems.

As technology continues to be the driving factor shaping the society in which we live, it will influence all content areas in a much greater way. Consider the rapid impact technological literacy has had on our lives in consumer economics, entertainment, literature and human and societal needs. Technology is a foundational building block to all aspects of society.

The future domain for technology education rests in the development of content within the academic discipline of engineering. The International Technology Education Standards for technological literacy's content for the study of technology studies states that "Engineers are the professionals who are most closely associated with technology."

The future of technology education rests in its identity. The profession should assess the implication of a name change that includes engineering as its base.

Engineering technology serves as the bridge between the two fields of study, pure engineering and technology education, while clarifying the content and purpose of teaching about technology.

While the challenges would be many, the field is experienced in transitioning. By developing a strategic plan that includes alliances with the engineering profession, the engineering education profession, and related industry and professional associations the potential for success is high.

As indicated throughout this paper, the fundamental content and purposes of technology education align well with the engineering discipline. This alignment creates a smooth transition because much of what has been established through the transition from trade and industrial education to technology education would be very applicable in transitioning to engineering technology.

The International Technology Education Association along with other national organizations such as the National Science Foundation, the American Society for Engineering Education, and NASA, should assess the climate for such a change by surveying the profession on at least three fronts: administrators and teachers of technology education, engineering profession, and related education and government organizations.

The results of the environmental scan should serve as the basis for decision-making in future development.

The nation is calling for leadership in education reform. By serving as champions of enriched academic and technology driven curriculum, the profession would reposition itself in both the education community and the engineering profession.

Engineering education is not limited to the college experience. Increased connections with K-12 education will increase cultural and political factors that shape the image of the profession.

Engineering technology is a discipline that is identifiable by students, parents and community, business and engineering professions, and other education technology professionals. When considering such a change in the profession it is imperative that all factors be taken into account.

As noted by the National Research Council in the publication *"Engineering Education: Designing an Adaptive System"* (1995), the health of the engineering profession is dependent upon a wide range of factors:

> The nation's engineering education system includes not just higher education, but also K-12, community colleges, and continuous (life-long) engineering education.

The engineering community would benefit from a systemic engineering discipline beginning at the K-12 level and continuing through professional post graduate education. To promote technological literacy through engineering will shape the profession and encourage all students to embrace and understand the value of the study of technology.

Shaping the profession's image should be thought of as a journey on the walk of progress. As the needs of society continue to challenge the way we prepare citizens through education, the future of technology education is hinged on how well it adapts to change and responds to societal needs. It will require a new type of leadership, one that empowers the teaching profession to create a new vision for technological literacy.

By embracing a new philosophy centered in engineering technology, the profession will inherently reposition the discipline within the education community and achieve professional respect. Shaping the professional image lies within each of us. It is an evolution of a discipline that has been fundamental to building a productive society. The future is limited only by our ability as humans to cooperatively envision a new mental image of the educational enterprise.

The transition from industrial education to technology education has ignited an enthusiasm within the profession—one that recognizes technological literacy as essential in our global society.

The challenge for the profession is in recognizing the need to continue that evolution. Repositioning and realigning the discipline for systemic professional growth will meet resistance from many fronts. Ultimately, it will be the empowerment of leadership within the profession that determines the future of technology education.

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Chapter Fourteen

Implementing Change in Technology Education

Implementing Change in Technology Education: New perspectives, new questions, new model

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New perspectives, new questions, new model

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Introduction

As long as humans have recorded time, change has been a force at the forefront of efforts to survive. As in the past, change is constant in today's world. Because everything we once knew and depended on is changing, it can often be overwhelming. While much has been written and thousands of authorities, books, and seminars have weighed in on the change debate one single factor that remains constant is that change affects people. When major change occurs, people have similar reactions of fear, anxiety, self-doubt, and a lack of control. The difference in change rate that occurs in change initiatives within learning organizations can be attributed to how individuals respond to change. Senge, Kleiner, Roberts, Ross, Roth and Smith (1999) argue that the challenge of fear and anxiety in people is the most frequently faced challenge in sustaining profound change and the most difficult to overcome. To better understand why sustaining change is often so elusive and why implementing change often leads change agents into a hall of mirrors that extends to infinity, this paper will examine some fundamental issues that when understood, can assist leaders in adopting a new perspective for sustainable change efforts in technology education. Furthermore, this manuscript will offer a model for sustainable change in technology education and review its critical elements.

Framing Change, Implementation, and Time

Getting a new idea adopted, even when it has obvious advantages, is often very difficult. Implementation of a change initiative actually occurs when an individual or other decision-making unit puts a change effort into motion or use. Until the implementation stage or deployment of the change initiative is reached, the change idea or process is strictly a mental exercise. Herein lies a fundamental problem. Implementation involves overt behavior changes as the new idea is actually put into practice. It is one thing for individuals or an organization of decision-makers to decide to adopt a new idea, but quite a different issue to put the new innovation or idea into action. Problems of implementation are compounded when the adopters of a change initiative are organizations like schools rather than individuals. In an organizational setting like schools, a number of individuals are usually involved in the decision process and the implementers are often a different set of people from the decision-makers. Using an industrial setting as an example, change initiatives are viewed as tasks or a structure of tasks that are managed towards implementation (Hall and Hord, 1987).

In education and in specific technology education it is the belief of the author that we could be better served by thinking less like managers of change as in an industrial setting and think more like biologists. Thinking like biologists requires that we examine all systems and variables that interact and influence our change initiative. For example, schools and indeed technology education are extremely vulnerable to pressures from different constituencies. So if members of a school board or a cadre of parents say that a school ought to have a gifted and talented program or a new writing program, school boards have a hard time saying no. This is so especially critical because there is often a lack of scientific evidence that shows that one kind of educational intervention is clearly superior to another.

For technology education to achieve sustainable change it is important to recognize, like biologists, that over time most change initiatives follow a generic life cycle where the amount of unrealized potential of a change initiative increases as time increases. Therefore, sustaining the effort or the "buzz" that surrounds the new initiative is time sensitive and critical (Tarlow & Tarlow, 2002). Framing time as a variable in implementing change is important to maximize change potential and reduce unrealized potential. This time potential relationship is shown in figure 1. Figure one further illustrates the importance of sustaining the change initiative over time. When studying the simple line figure below, the weight of carrying a change initiative can almost be felt if one has ever been at the forefront of such an initiative. As time passes, an effort's unrealized potential grows. The reality of the change time potential curve is further compounded when individuals or isolated organizations are driving the change.

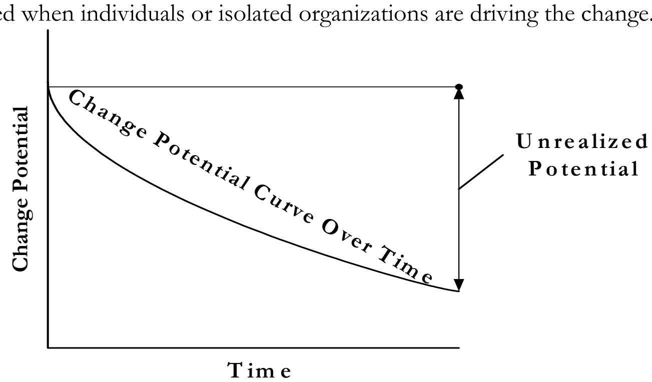

Figure 1

Time potential curve

Understanding the human side of change and transition as a biologist.

When technology education is framed as a content area of study within an organization called school, it becomes important to differentiate between change and transition. Change is situational. It is the event, such as a new school, a new job in a new lab, or the loss of a program that produces tangible change. School curricular change can be influenced by a situation. For example, the focus on science education in American schools during the early 1960's was a result of an event, the launch of Sputnik into outer space by the then Soviet Union. On the other hand, transition is the psychological process one goes through in adapting to change. Unless a successful transition occurs, change will not occur. Since change is an event often beyond our control, it is important to focus on how individuals respond to change, or make the transition. Therefore, the framing and examination of the transitional process could serve as a better tool towards advancing transition in technology education (Havelock & Zlotolow, 1995).

How teachers view change has a great impact on the transition. Often advocates of change at the legislative, government department levels, association levels and institutions of higher learning focus on the change they are trying to produce and fail to realize the learning capabilities and collaboration necessary between those involved in achieving the transition target. Typically, individuals view change and the requisite transition as either opportunity or loss. According to Rogers (1995) how individuals faced with making the necessary change transition view implementation of the transition is dependent on several factors that include the following:

- The number of change events occurring at once. Individuals can only handle so much change. The greater the number of changes occurring simultaneously, the more likely they will be viewed negatively. Multiple changes require multiple transitions that take time and increase unrealized potential.
- The pace at which change is occurring. The faster the changes come, the more difficulty we have in adjusting transition to them and the more likely we are to view change as loss.
- An individual's perception of change. The greater the meaning one places on the change, the greater the sense of loss or opportunity the transition represents.
- The amount of control in times of change. The greater the involvement individuals have in making change transitions, the greater their sense of control. The greater the sense of control, the more likely the transition will be viewed as an opportunity.

To advance a sustainable change transition, it is imperative that individuals, professional associations, government departments and school leaders recognize the transition cycle and assess their progress within the cycle. For example, when people involved in school transition view it as a loss, they must actually go through a grief process in order to effectively make the transition. Kubler-Ross (1970) identified five stages in the grief cycle that impact the transition process towards change. Understanding this cycle could help leaders in technology education frame change as a natural cycle and less as an event.

Transition cycle.

Kubler-Ross identified the initial stage in the transition process as shock and denial. In this stage, people are numb and often deny that a change event has even occurred. They blame others and do not recognize the need to make transition decisions. Once shock wears off, people enter a second stage of anger, frustration, and anxiety. So much energy is placed in negative emotions at this stage that there is no energy to make critical decisions. This is an important part of the grief process, but how the negative emotions are played out should be watched carefully. The third stage is depression. At this stage, individuals experience an overwhelming sense of "the blues" and a lack of energy to be put forward towards the transition. Because of the energy spent in negative emotion in the previous stage, there is no energy at this time to make decisions for one self. This is a stage where individuals need the help of colleagues, leaders, and friends. Once individuals enter the dialogue and bargaining stage of the grief cycle, they are more open to exploring alternatives. At this time they need to gather information and consider options. The final stage is the acceptance stage. Entering the acceptance stage does not mean individuals necessarily like the transition, but rather they are beginning to accept that it has happened and are willing to work it into their lives. At this time, they feel empowered and in control of their lives, but things will never be the same. Transition has occurred.

Unfortunately, individuals within school organizations do not go through the grief cycle in a neat, step-by-step fashion. Rather, they move back and forth between the various phases. The important matter for transition leaders to recognize is that the various stages of the grief process are normal and to be prepared for what each stage has in store. The danger lies in "getting stuck" in any one phase, especially the anger or depression phases. Although change is often beyond our control, understanding the psychological process of transition can arm a leader in technology education with the view of the transition cycle ahead much like a biologist views the life cycle of a moth.

Models of Successful Transition

Learning From Nature

A blue whale is the largest mammal on earth. An adult blue whale is the length of over three city buses, weighs more than a fully loaded 747 and has a heart the size of a Volkswagen Beetle. It is so large that it takes at least three minutes for it to make a turn of 180 degrees. A strong parallel can be drawn between blue whales and our schools, technology education, businesses and even communities. It just seems to take forever to transition and change direction. But a school of sardines consisting of a greater mass than a blue whale can turn almost instantly. How do they do it? Is it ESP? Could it be GPS? The Internet? (Info Savvy Group Consultants, n.d.)

If you take a careful look at a school of sardines, you'll see that the fish appear to be swimming in the same direction. In reality, there will be always be a small group of sardines swimming against the flow causing friction with the rest of the school. But when this dedicated group of 'committed sardines' reaches a critical mass of only 15 to 20 percent, they induce the rest of the school to suddenly turn and follow their leadership. If we conceptualize this model in the psychological process of transition behavior, isn't that what happened with our societal attitudes towards drinking and driving, and to our feelings about smoking. They were changes of direction induced by a small group of people who were truly committed to change, to go against the flow, to cause discomfort, and to challenge the normal direction.

The field of technology education can learn from this lesson from nature. The whale in this story could represent schools and the school resistance to transition while the sardines could represent the community of practitioners in technology education. However it could be argued that the community of practitioners in technology education, to exceed the mass of a school or the educational system could never meet the mass example of sardines that exceeded the mass of the whale. Faced with the reality of lack of sufficient mass of practitioners to match other disciples like science or mathematics, technology education must turn to new ways of conceptualizing transition to implement change in a collaborative fashion.

Collaborative Change Model

Creating profound change in technology education requires investment of time, energy, and resources. Most organization professionals agree that investment in change efforts should focus only on areas that will result in the most beneficial and sustainable change. Typically, this means establishing some type of activity to address the fundamental problems that prevent an organization from achieving the objectives necessary for continued existence or profitability. Such change efforts do not approach these issues as a finite problem, but as difficulties symptomatic of deeper structural concerns requiring focused activity. Senge, et al (1999) suggest that the real problem in creating transitional change is not the obvious need to fix something, but the forces that keep people from doing anything about it in the first place. The success of fundamental change depends on the ability of organizational participants to collaboratively rethink and clearly articulate their basic assumptions, purposes, and processes. Goldratt (1990) postulated that people are unable to solve problems because they have no method, place or forum for verbalizing their intuition. Both Senge et al. and Goldratt agree that lasting organizational change results from a clear goal; a strategy for achieving the goal; and the use of theories, methods, and tools to guide knowledge towards practices that support the goal.

What has become clear in studies of educational transformation is that all professionals create working knowledge that they use when practicing their profession. Simply put, researchers, teachers, policymakers all generate a knowledge base for themselves premised on their experience with knowledge generated by others assimilated into it. For instance, professional communities, such as teaching or researching in technology education, use knowledge generated from outside themselves by first transforming it into working knowledge through the outside knowledge's interaction with the varying processes used by the technology education community. Examples of such processes are teaching, administering, managing, and researching. Thus, all communities involved in the technology education enterprise are knowledge producers, knowledge transfer agents, and knowledge users. Therefore, the proposed collaborative change model in this paper is designed as a principled collaborative change system, which will consciously, with intent and cohesiveness, view all stakeholders as experts in the production, transfer, and use of knowledge related to technology education. A collaborative change model for technology education can act as a transformation agent by bringing individuals together from varying agencies, institutions, governments, and departments around the world to establish the processes that recognize how each contributes to the generation of knowledge and expertise that when made available to the entire enterprise forms a mass equal to any single institution, department or individual's contribution.

This collaborative change model for technology education must be grounded as a "principled" collaborative change system premised upon the overriding principle that a person's change in behavior--not the transmission of tangible outcomes *per se*--is the primary goal of the system.

Defining "principled" collaborative change for technology education.

A "principled" collaborative change system for technology education can be organized around four guiding principles:

- Building and maintaining continuous communications from research phases through implementation phases at the classroom level among all participants in the production, transfer, and use of knowledge
- Building and maintaining social networks as compared to concentrating on developing the capacity to produce and transmit tangible outcomes
- Building and maintaining a collaborative transformation planning and implementation strategy which accounts for transfer as a developmental process moving with patience and purpose from knowledge which enables potential users to commit to change to knowledge which enables them to implement best policy/practice
- Building and maintaining multiple, simultaneous strategies because of the importance of redundancy in a system which focuses on persons, recognizing that these persons and the groups to which they belong change at different rates, times, ways, and so on

Thus, the principled collaborative change model for technology education strikes a balance among user-driven responsiveness, targeted dissemination, and social networking, organizing itself around three basic, interacting, and mutually reinforcing functions:

- Knowledge distribution (shared among all stakeholders at all levels)

- Knowledge acquisition (assisting in the accessing of knowledge, for example, a technology education resources database)
- Knowledge collaboration (multi-way flowing of knowledge, as with electronic discussion groups, collaborative research and dissemination projects and best practice benchmarking)

Each of these components uses a varying blend of several approaches to accomplish its tasks. Such techniques include database development and use, information brokering, publications, marketing/promotion, direct interpersonal linkages, policy and legislative information and electronic communications.

An example of how a similar integrated collaborative change system element for marketing could operate for technology education is the National Center for Research in Vocational Education and National Dissemination Center for Career and Technical Education dissemination programs. For example, multiple, simultaneous strategies are used by the program staff, introducing necessary redundancy into the program's marketing initiatives. A new NCRVE or NDCCTE publication is simultaneously marketed through their newsletter; electronic resources such as NCRVE's World Wide Web server, gopher server, internet discussion groups and bulletin board systems, conference display booths, targeted marketing flyers and presentations that all participants have access to in the function of their roles.

A similar collaborative change model for technology education would permit all participants to communicate and identify problems that require change and share solutions, foster broad participation in the change effort, spark innovation and creative thinking to deal with the problem, and encourage collaboration among diverse groups and ensure implementation by providing people with the freedom to take action. Many have different formulas for sustained success, but there is a common thread across each; communicate early and often with people affected by the change and involve them in the process from the start. That way, when you roll out your proposed change, you'll have cheerleaders and not adversaries.

A collaborative change model for technology education would contribute to the international educational infrastructure, offering to its constituencies a consistent, reliable method of translating and brokering R&D-based knowledge, practitioner-based knowledge, and policy-based knowledge in ways useful to and usable by these persons. The activities of the collaborative would encourage the development of social networks among all stakeholders, again, so that knowledge is distributed and exchanged in useful, usable ways with the ultimate goal of changing persons' behaviors.

Technology Education Collaborative Change System

Participants and Behaviors

Usually when we think about change we focus on the need to create a vision and strategy for the change. But even more challenging is what follows the strategy and vision; this is the implementation itself, which involves three broad roles of those who participate:

- change strategists-the early work, identifying the need for change, creating a vision of the desired outcome, deciding what change is feasible, choosing who should sponsor and defend it
- change implementers: these "make it happen" by monitoring the progress and process of change; they must respond to the vision from above and the responses from below
- change recipients: the largest group including those who must adopt, transition, and adapt to the change; they determine whether the change will hold

It is the implementers, the teachers and teacher educators in technology education who have the challenge of wrestling with the complex, real-time issues day after day in a changing turbulent environment. What makes this worse is that they often receive too little authority from above to make change happen entirely on their own and from below the more the "recipients" balk at the decisions implementers make, the more frustrating the task then becomes.

For a collaborative model for change in technology education to be successful we must extend the invitation to all who participate in our enterprise to contribute in extending our collective distributed expertise. In every specific area of activity related to technology education, there are already change strategists, implementers, and recipients in the form of researchers at work in our universities, teacher educators, teachers in classrooms, program managers and administrators, legislative activists, curriculum specialists, and advocacy groups. There is already a growing body of experience that can help us all determine the feasibility of applying a variety of different complex collaborative approaches to advancing and sustaining meaningful change in technology education as a unified system. However, these groups and pockets of experience are diffused, scattered and not accessible to all in the field, therefore, in the next stage of this endeavor we will require much more help.

Research in the study of complex systems in education have already identified at least the following kinds of experience and research expertise as important to the success of any effort not only to study educational change, but to initiate and support it. The organization and identification of expert institutes distributed around the following themes could serve as model for technology education to make more accessible to all the resources to support and sustain meaningful change or transition (Zaltman and Duncan, 1977). The important elements of the collaborative must include:

- Scholars in the field of testing, assessment, and its uses and wider implications for education policy and society that impact technology education;
- Curriculum experts who have studied examples of successful and unsuccessful educational innovations and schemes for curriculum change;
- Historians of technology education who are able to communicate our past contributions to education and relate them to our future;
- Administrators and directors with experience of current government and corporate, organization, and workplace models of employee education and human

resource development directed at increasing the capacity of our implementers to achieve meaningful transition and change;

- Professionals who work within the context and agendas of professional organizations in the field of technology education, such as teacher organizations, national associations, etc.
- Researchers who work with and are advocates for marginalized and disenfranchised groups, including the physically challenged, diverse populations, low school completion rates, etc.;
- Researchers and teacher leaders who work with private foundations that study and promote educational change;
- Economists, political scientists, and sociologists with interests in the role of technology education in society;
- Science and education journalists
- Researchers in comparative education and those who have studied educational change in other parts of the world;
- Specialists who study learning in non-school or informal educational institutions;
- Scientists who specialize in the study of the impact of technology on social institutions;
- Leaders in higher education who have worked on educational reform and curriculum innovation in colleges and universities, and those with research expertise in this area.

Representation from all these categories, in addition to experts in science and mathematics education, educational technology, curriculum studies, elementary education, and educational policy studies will be needed to judge the feasibility and chart the most promising course for the future of technology education. To date, no model or initiative in technology education has defined a collaborative that unifies the experience and expertise of the field to aid in knowledge distribution that can be shared among all stakeholders at all levels, knowledge acquisition, dissemination and assisting in the accessing of knowledge. For example, a technology education resources database, or knowledge collaborative serving as a multi-way flowing stream of shared information, as with open web based electronic discussion groups, collaborative research and dissemination projects, and best practice benchmarking of standards based exemplars in schools.

Defining the System

Participant constituents of the technology education collaborative change system (TEC²S) can be defined as any person in the system of public and private schools and colleges that offer students formal education from kindergarten to college graduation. Ultimately the system must be defined by our analysis of its dynamics: which institutions and social practices, which sources and users of information and material and human resources are tightly enough coupled and interdependent in their behavior that they must be included within the system?

If we examine all the source institutions that contribute to students' understanding of particular topics within the technology curriculum, we must include informal educational institutions such as science museums and information sources and learning sites afforded by mass media, print publishing, and interactive communication technologies. If we look at resource constraints and decision-making bodies, we will add school boards and trustees and state education authorities. If we include ourselves within the system, we will consider our roles as teachers and researchers, and the relationship between research institutions and sponsors and the communities that make use of research results. The TEC^2S must be made up of identified contributors around the world who have defined expertise, knowledge, and experience in fields or topics that are driving change. The knowledge and expertise of the system participants must be made public and accessible to all within the enterprise. Participants of the system can no longer afford to attempt to address issues confronting the whole by going it alone. For example, their identified area of expertise will associate institutions in the TEC^2S. It is conceivable that organizations will specialize in specific areas of research, teacher education, administration and policy analysis, or graduate education. Whatever the case, information must be made available and accessible to all in alignment with the principles that define the system.

Drivers of the System

The drivers for advocating a collaborative change model are many, however if change within technology education is to be driven internally and not driven by responding to external threats, we must lead the field in a collaborative effort to sustain meaningful change in areas that perhaps we have not experienced or questioned. We must consider how the educational system in which we participate in as a whole is driven by external events and pressures such as advances in scientific understanding, the increasing complexity of problems addressed by communities and societies, changing technologies, and public demands for reform. How is educational change in technology education constrained by resource limitations, standardized curricula and testing, or deeply held cultural beliefs? How can educational changes in technology education be enabled or made possible by bringing new kinds of people into contact with one another or utilizing new technologies? How would educational processes be affected by creating new feedback loops, such as research data, which systematically describes outcomes back to teachers, students, and parents? Or new spontaneous networks, such as online communication groups of teachers within a school, across the country, and around the world, affect the rate of change? These are just some of the questions and conditions across the educational landscape that we in technology education must prepare for. It will only be through a collaborative effort that we be able to confront such issues, present solutions, and make meaningful progress into the future.

Roles of Testing and Assessment

From a collaborative perspective, we must be engaged in the issues that confront education and be proactive in framing and responding to issues that impact technology education. For example, we might consider the role of high-stakes standardized testing and assessment schemes in the present educational system as imposing an artificial fitness landscape that pulls the system toward behaviors that maximize test results rather than deep conceptual understanding. As a collaborative, committed to sustainable change, we could pose questions about whether or not it is reasonable to expect that the same assessment system could be optimal for both the purposes of diagnosing and providing feedback on learning to individual students and for the purposes of comparing overall performance of programs, schools, districts, and states, or colleges and universities.

To bring about significant and meaningful change we can work to devise multi-dimensional assessments, reporting a large number of outcome measures and indices, that could be complemented by distinct and specialized schemes for re-weighting component measures in different ways to optimize different final single-valued scores for different social purposes. How might we specify such vectorial measures and their dual-vector weighting schemes so that one derived composite might indicate a student's level of technological literacy, readiness for a new program or for advanced study, another his or her qualifications for a particular job; still another be more appropriate for program comparisons, another for budget incentives to departments or schools, and yet another for year-to-year or state-to-state aggregate comparisons? We need to broker collaborations between researchers with long experience studying the relationship between testing and the educational system as a whole and those who can help formulate these issues within a common framework in which research results can be connected to studies of other aspects of the educational system.

New Channels for Interaction

It is a common phenomenon in collaborative systems designed to implement change like that presented in this paper that the system behavior is limited because some elements are decoupled from others; interactions that might otherwise be expected to occur are blocked or strongly buffered. There are many examples of this in the present educational system and each one offers an opportunity to unleash educational change by providing a new channel for interaction.

Schools today have very limited and controlled forms of interaction with other schools, programs, surrounding community and even with students' families. Technology education programs are rather insular and not linked with other programs, and the interaction between colleges, universities, faculty, policy-makers, funding agencies, professional associations, and other key constituencies that contribute to sustained change are limited. There are many researchers in the field of education who are studying various experiments in closer school-community collaboration and new ways in which constituents can participate in the life of schools. Technology education can benefit from such studies.

How can we in technology education learn from and enhance these studies to examine the potential of such new forms of interaction for accelerating reform in technology education? How can we focus on system change and push the envelope of creativity in learning about technology in different ways? For example, within the school, there are two classic forms of segregation barriers: those between disciplines and those between grades. In technology education, the current framework evidenced by the recent release of the *Standards for technological Literacy: Content for the study of technology* not only supports this form of segregation barriers but promotes it throughout the organization of the standards (ITEA, 2000).

What are the actual functions and consequences within the system of these barriers to mixing? Are any of the purported or historical functions on how we deliver learning in technology education still necessary or valid? Apart from complete random mixing, what other forms of organization across disciplines and between age-grades make educational sense for the study of technology, and what would be the likely system consequences of large-scale interaction between teachers of different subjects and students at different ages? Again, there do exist research programs that have examined inter-disciplinary curricula and cross-age learning; the experiences of these researchers can provide valuable data and perspectives for models of change in technology education that focus on creating new couplings between existing educational components. Such new channels for interaction can be advanced through a collaborative change model in technology education.

Changing Roles and Relationships Among Participants

Another potential approach to the dynamics of system change in technology education would look at the effects of shifts in the definitions of roles and the distribution of the kinds of people filling them. In the case of teachers, what are the new definitions of teachers' changing professional roles, and the kinds of preparation and training appropriate to such new roles? What happens when teachers become teacher-researchers, student advocates, or paid curriculum authors? What do teachers need to know in order to use new technologies in the classroom effectively? What then are the implications of these new technologies for teacher education programs in colleges and universities? What impacts does new technological knowledge and technologies have in the recruitment of teachers, the pay they receive, school budgets, and community taxation? How do such new roles guide the hiring of teacher education faculty and the resources needed by doctoral programs preparing future faculty? How do we model the interactions in just this part of the system? In a collaborative change model for technology education, the responsibility to take up these challenges and questions can be undertaken by interested experts around whose charge would then be to educate, inform, and contribute to the TEC²S.

Conclusion

Yes this paper and even textbooks present a tidy pattern for change but this rarely happens; no matter how much preparation, organizations are rarely well prepared for major change. The literature on change often projects a very unrealistic view of sequential change and unless those hoping for change understand the difficulties, the change will fail. By making change seem like a bounded, defined, controlled, and discrete process with guidelines for success, the writing on change misleads those who will find the reality far more daunting than they expected. Rather than a controllable process, we find chaos.

Change does not occur by following a well-defined path; rather it is a laborious journey on hands and knees toward an elusive goal with many wrong turns and missed opportunities. Only rarely does an organization or community of practitioners like those in technology education know exactly where it is going and how to get there. No matter how much thought has gone into the change effort, there will be unforeseen external, uncontrollable and powerful forces that will have a profound impact on the success of the change effort.

The TEC²S model presented in this paper was offered as a different way to proceed towards change in technology education. The model requires fundamentally different roles for those currently practicing in technology education, the inclusion of others often not thought of as having something to contribute. The proposed model envisions qualitatively more effective results emerging from existing programs and initiatives if they can learn how to interact productively with one another towards implementing meaningful and sustainable change. An independent projects approach takes advantage of individual creativity and sensitivity to local needs, but it rarely leads to a whole that is more than the sum of its parts. Top-down coordination and central planning assumes an ability to reckon with the vast scale of the educational system which technology education resides in, this is essentially unrealistic. It should, however, be possible to discover what kinds of networking, information sharing and collaborative planning among individual projects produces more than proportional effects. We need to understand better what researchers, educators, and administrators need in technology education in order to more effectively develop structures of coordination 'from the bottom up' and at each level of organization of the system as a whole. How can funded research initiatives and policies promote more effective networking and collaboration among projects? How can we effectively investigate the preconditions for cross-project synergies and emergent structures of coordination?

These are some of the questions that require solutions in order to facilitate sustained change in technology education. We will remain in a state of paralysis, relegated to continued efforts of marketing or selling technology education rather than advancing the substantial contribution that technology education provides to school learning and human development.

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Implementing Change in Technology Education

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Introduction

In this paper I begin with an overview of the NSW school context and then provide three examples of the implementation of change in technology education in NSW public schools. Each example provides a background to the broad initiative and then a study of one aspect of the initiative. The examples have been selected to provide a range of approaches to bringing about change and to highlight some of the features that contributed to success. The paper concludes with some generalisations about the factors that have been significant in achieving change in technology education in NSW public schools.

Background To The NSW Context

In New South Wales it is compulsory for all children to be provided with schooling from 6 to 15 years of age. Most students attend government or non-government schools from approximately 5 years to 18 years of age. Primary schooling occurs from Kindergarten to Year 6 and secondary schooling occurs from Year 7 to Year 12.

The Board of Studies NSW is a statutory body with responsibilities including the development of syllabus documents for the school curriculum and the conduct and regulation of the School Certificate (Year 10) and the Higher School Certificate (Year 12).

Primary schooling includes six key learning areas of study; English, Mathematics, Science and Technology, Human Society and its Environment, Creative Arts, Personal Development Health and Physical Education. Secondary schooling includes eight key learning areas of study; English, Mathematics, Science, Human Society and its Environment, Languages, Technological and Applied Studies, Creative Arts, Personal Development Health and Physical Education.

Technology education in NSW schools

In NSW public schools the study of Science and Technology is mandatory in each year of primary schooling. Technology education is particularly evident in the syllabus in the learning processes of designing and making and using technology and in the content strands of built environments, information and communication and products and services.

Design and Technology is a mandatory course studied for approximately 200 hours, usually in Years 7 and 8. The course involves the study of technology through design and project-based learning. Students gain a breadth of technological experiences by developing design projects in agriculture, built environments, clothing and accessories, engineered systems, food, health and welfare, information and communication, leisure and lifestyle, manufacturing, transport and distribution. Students explore resources, human impact and personal, commercial, industrial and global domains.

In Years 7-10 students may elect to study further technology subjects including agriculture, computing studies, design and technology, food technology, technical drawing, technics and textiles and design. According to Board of Studies statistics in 2002 there are 95,452 Year 10 enrolments in these subjects.

In Years 11-12 students may elect to study technology subjects including agriculture, design and technology, engineering studies, food technology, industrial technology, information processes and technology, software design and development and textiles and design. Other industry-based vocational subjects include construction, information technology, metals and engineering, primary industries and tourism and hospitality. According to the Board of Studies NSW statistics in 2002 there are 62,345 Year 12 enrolments in these subjects.

The NSW Department of Education and Training

The NSW Department of Education and Training delivers education and training services from early childhood education through to post-compulsory education and training. In doing so the Department meets the learning needs of children, young people and adults, and addresses industry and community training needs throughout the State.

The Department provides education for around 70 per cent of all school students in NSW at over 2,200 locations throughout the State. More than 750,000 students from a diverse range of backgrounds attend NSW Governments, including pre-schools, primary schools, central schools, high schools, colleges and specialist schools.

Schools are organised into 40 geographic districts across NSW, with support provided from 40 district offices. The Department has numerous state office directorates with specific roles in the support of schools. Professional Support and Curriculum Directorate leads and coordinates the development and provision of curriculum support and professional development services and resources in NSW public schools.

Case Study1 – The New HSC

Background

In 1995 the New South Wales Government made a commitment to reviewing and reforming the Higher School Certificate (HSC), the Year 12 exit credential for NSW students. By mid 1999 the NSW Board of Studies released a new standards-based assessment approach to the HSC and new syllabus documents for all Years 11-12 subjects. Schools were required to implement this new approach with Year 11 students in 2000. The first cohort of Year 12 students, over 62, 700 candidates, undertook the new HSC in 2001.

In 1999 the Department of Education and Training implemented a support strategy for teacher professional learning to prepare teachers for the introduction of the new HSC. Training, attended by 950 secondary and TAFE teachers, was provided for district teams to establish school-based professional learning teams. The Department also conducted 738 training workshops across the State, including subject specific workshops. This was supported by further information provided to all teachers through the Professional Support and Curriculum Directorate quarterly publication entitled *CURRICULUM SUPPORT*. Each edition nine publications are prepared, one for primary school teachers and eight secondary publications, one for teachers in each learning area. A web site was established to provide teachers with additional information and support through a single site. Support for teachers continued in 2000-2002 through a range of subject-specific and general assessment workshops, video, print materials and CD-ROM resources.

The Government committed substantial resources, $24 million plus salaries and infrastructure, to the development of the curriculum and implementation of focused system-wide support. Change was concurrently implemented across all HSC subjects and led to support initiatives being shared for both government and non-government schools. The breadth of the change enabled a whole-school focus to professional development and efficiencies were gained because most secondary teachers were involved. The critical mass of teachers within each school and within teachers of the one subject area across the state engendered high levels of professional discussion and support.

The HSC is a high stakes, publicly accountable credential, where access to student performance data continues to act as a strong motivator for schools and teachers, year after year.

Walking the talk with teachers

The Technology Unit of the Professional Support and Curriculum Directorate has responsibility for supporting the implementation of eight technology subjects in the new HSC; agriculture, design and technology, engineering studies, food technology, industrial technology, information processes and technology, software design and development and textiles and design. Technology teachers typically teach between one and three of these subjects.

Consultation with teachers and professional technology teacher associations overwhelmingly indicated that the curriculum resources most sought were sample teaching programs and assessment programs and assessment tasks for each subject.

In the preparation of teaching programs two expert teachers for each of the new syllabus documents were brought to a training workshop. Following professional development and discussion about expectations and different approaches to the task the teachers went back to their schools to prepare a teaching program suitable for their students. Another expert teacher reviewed these programs to ensure all syllabus requirements were met. These teaching programs were then published on the *New HSC* website and used as a resource for discussion in professional development workshops that occurred across the state.

Whilst this professional development opportunity was of great value to the sixteen participating teachers, and the resources were evaluated as very useful by teachers who attended the 50 syllabus familiarisation workshops held across NSW, it became evident to the Technology Unit that the most valuable aspect of the resource development process, professional dialogue, had not been captured.

The follow up resource development activity involved preparing assessment programs and assessment tasks that demonstrated how teacher assessment practices for the HSC could move from norm-referenced to a focus on outcomes and standards-based assessment. Once again two expert teachers were selected for each of the new syllabus documents. The teachers were each given a different role. The first teacher was to develop an assessment program and sample assessment task, suitable for use in their school and that met all the Board of Studies syllabus-specific and general assessment requirements. The other teacher was to act as the critical friend, asking questions, making suggestions and ensuring all requirements were met. The teachers were asked to record all queries and issues raised during the process.

Articles were written up together by the teachers and the Technology Unit and were published online and in the Unit's publication to technology teachers, *CURRICULUM SUPPORT*. Through this rigorous process of professional dialogue, the curriculum resources were quality assured and refined and issues of concern in that subject were identified and articulated.

The articles and website publications showed the sample assessment programs and tasks and importantly documented the issues that were encountered by the teachers in the process and how these issues were resolved. Teacher feedback on these articles indicated that the teacher discussion was most helpful, especially when the teachers encountered similar problems.

There were other unexpected benefits for the Technology Unit of working so intensively with teachers. The activity was very cost-effective. The process paralleled an action research model. It provided a useful evaluation tool for identifying key implementation issues for teachers and for planning future professional development strategies. It directly informed the content and strategies that were targeted in professional development workshops. The effectiveness of the approach in targeting teacher needs was later demonstrated by the highly rated evaluations of the professional development workshops.

In summary the features of this initiative that promoted change include:

- Valuing professional dialogue as a tool for learning
- Using teachers and curriculum experts as 'critical friends' to support, challenge and advise practitioners during implementation
- Valuing and documenting authentic site-based teacher experience of implementation
- Using authentic site-based teacher experience of implementation to plan the development of curriculum resources and professional development
- Credibility provided to professional development activities based on authentic experience and to workshop facilitators who have an in-depth understanding of the subject-specific issues faced by teachers.

Case Study 2 – Meeting Workforce needs for Technology Teachers

Background

In so many ways the future of technology education in NSW is very bright with a strong and growing demand from students to study technology subjects in NSW government schools. The future of technology education however is reliant on the availability of high-quality, trained teachers and since the mid 1990's the shortages of trained technology teachers across Australia has become an increasing concern. The looming retirement of significant numbers of "baby boomer" teachers, combined with reduced numbers of teachers trained through traditional tertiary teacher education programs will add to these workforce shortfalls. The adequate supply of technology teachers is proving to be a challenge.

Since 1996 the NSW Department of Education and Training has implemented a variety of innovative new technology teacher training programs to meet workforce needs. These programs include:

- existing trained teachers being paid to undertake additional specific training in technology subject matter and pedagogy (University of Sydney)
- suitable graduates and trained industry personnel being sponsored into existing technology teacher education programs (University of Newcastle, Australian Catholic University, Southern Cross University and Charles Sturt University).
- scholarships of one, two, three and four years duration for students to complete preservice technology teacher education programs.

Mentoring new technology teacher

These technology teacher training programs are intensive and rigorous courses of study however technology teaching is a demanding profession and significant amounts of learning needs to take place over time on the job. Experienced technology teachers have had the opportunity to reflect on their practice, to experiment with teaching styles and strategies and learn what works for them.

Technology teachers who have been sponsored by the Department through these technology teacher training programs agree to teach in schools in western and south-western Sydney and non-coastal rural NSW for a minimum period of three years after completion of their training. Some of these newly appointed technology teachers may be part of a large supportive faculty. Others can be appointed to small schools in remote and isolated areas. In these situations they may be the only teacher at the school with this subject expertise.

The new teacher may lack the confidence, the networks or the time to be able to seek collegial support when it is most needed. For these reasons the Department is increasingly recognising the importance of mentoring in supporting newly appointed teachers. All sponsored technology teacher-training programs offer formal mentoring opportunities as part of the teacher's professional development program.

The newly appointed teachers select or are allocated an experienced technology teacher as a mentor to support them in their new school. The mentor shares expertise in the same subject areas. The mentor is not a supervisor but has a collegial support and guidance role. The mentor is generally not teaching in the same school as the mentoree.

What is mentoring?

Mentoring generally involves a process where someone with more experience and expertise provides support, counselling and advice to a less experienced colleague. It is a shared experience between a mentor and a mentoree.

In practice a form of mentoring often occurs in schools that involves a two-way, informal and equal relationship between colleagues, each helping the other to succeed.

Mentoring happens when a relationship of mutual trust, support and benefit exists between two colleagues in the workplace. Informal mentoring occurs, in part, by chance. "Being in the right place at the right time" and can result in an effective professional relationship of support occurring in a school. Many teachers can identify one or two colleagues who have played a significant mentoring role in their career.

Research on mentoring highlights that effective mentors are people orientated and secure. They like and trust their mentorees. Successful mentors take a personal interest in their mentoree's career, share power and expertise, encourage their mentoree's ideas and help them gain confidence.

Professional growth of newly appointed technology teachers is complex and multidimensional. It involves changes in knowledge and beliefs, in addition to a growth in skills. The process of professional growth is enhanced by guided support from both within and beyond the school. Newly appointed technology teachers reported that their professional growth was increased in situations where head teachers and faculty staff in their school:

- worked collaboratively, particularly with programming
- encouraged innovative teaching practices
- assisted the teacher to extend their skill base
- recognised the professional status and responsibilities of the new teacher
- structured opportunities for professional learning.

(NSW Department of Education and Training unpublished evaluation report June 2001)

Newly trained teachers' reported needing help with discipline and classroom management, curriculum and lesson planning and school routines. Most of all they felt the need for moral support, guidance and feedback.

Formal evaluations of the technology teacher training programs have consistently supported the value of mentoring for the newly appointed teacher. The following comment from a mentoree in an evaluation report was typical of respondents:

> The mentor program saved my life. I had someone to turn to who was not in the school – who could be objective and who knew me and had observed me operate in the classroom – who supported me with skills and projects.

Mentors and mentorees have been in agreement that the program is a fundamental component of the teacher training programs (NSW Department of Education and Training unpublished evaluation reports 1996-2002).

How is the mentor supported?

The Personnel Directorate of the Department conducts professional development for mentors to provide an understanding about mentoring techniques and to plan support for their mentoree. Mentors receive an initial allocation of four days' relief to enable them to participate in the professional development activity and for the mentor to provide the necessary support to the newly appointed teacher.

In the retraining program evaluation conducted in 2001, mentors reported that they found mentoring to be a very rewarding professional experience and that they benefited from the training provided by the Department. Mentors frequently reported that the benefits of their participation in the mentor program were:

- increased job and personal satisfaction
- opportunities to demonstrate leadership skills
- opportunities to use and share their own skills and experience
- an enhanced feeling of self worth as a result of assisting in a colleague's professional development
- opportunity to reflect on one's existing skills and practices
- challenging discussions with people who have a fresh perspective
- development of a new network.

No mentors reported being 'burnt out' as a result of their mentoring commitment.

The Department has implemented an expression of interest process to ensure that the pool of mentors available to support newly appointed retrained teachers continues to grow. This process ensures that new mentors can be involved in the program each year and spreads the role among a larger pool of experienced teachers.

Teachers interested in further study about mentoring may also apply to participate in a formal Certificate of Mentoring offered by the Department. This course provides advanced standing into University post-graduate teacher education programs.

In summary the features of this initiative that promote change include:

- Formal recognition of the value of mentoring
- A systematic approach to ensuring all newly appointed teachers have the opportunity to be mentored
- Formally valuing and drawing on the skills and knowledge of individual experienced teachers
- Professional support that is responsive and flexible; is driven by the learning goals and needs of the individual, deals with solving problems in their particular context, provides time to explore, share and apply new ideas
- The expansion of a pool of experienced teachers who understand and value the new teacher education programs and can act as advocates for the newly-appointed teachers.

Case Study 3 – K-6 Science and Technology

Background

The current Science and Technology K-6 syllabus was first introduced in 1991 for implementation from 1992. At this time professional development programs were provided to support the implementation phase. Since that time primary school curriculum has moved through a cycle of review and redevelopment in the other key learning areas, with professional development being focused in the newer syllabus areas such as English, Creative Arts, Human Society and Its Environment and Personal Development Health and Physical Education. Literacy, numeracy and computer skills have also been important priorities in primary schools.

A limited evaluation of the Science and Technology K-6 syllabus in 1996 by the Board of Studies NSW indicated significant concerns about the implementation of the syllabus. In 2000 the Board of Studies released new syllabus outcomes for Science and Technology and in 2001 the Department decided to establish a program of support for Science and Technology from 2002 to 2004. This program included the appointment of 20 district-based K-6 Science and Technology consultants. The goal of the support program is that by the end of 2004 there will have been significant improvement in the quality and profile of Science and Technology teaching in NSW public schools. The twenty district consultants will play a key role in achieving this goal. Each of the consultants is responsible for supporting two districts covering as many as 110 schools.

The consultants are supported by staff of the Science Unit and the Technology Unit of Professional Support and Curriculum Directorate. The consultants are encouraged to work in-depth with those schools that have targeted Science and Technology as a priority area for improvement. The K-6 Science and Technology Team is working strategically to achieve the following:

1. School leadership - School executive in primary schools understand the nature of, and facilitate conditions in schools to achieve quality science and technology teaching and learning.
2. Teaching practice - Quality of Science and Technology teaching improves in schools where teachers participate in a substantial program of professional development.
3. Whole-school planning - Primary schools provide students with a systematic and explicit program of Science and Technology learning experiences designed to ensure access to the staged syllabus outcomes.
4. School community - The school community is aware of the nature of Science and Technology education in the school and its contribution to student learning.
5. Infrastructure support - The decisions and activities of state office directorates and districts of the Department are supported by an understanding of the conditions that facilitate quality Science and Technology teaching and learning in primary schools.
6. Strategic partnerships - Opportunities to access and or shape local, state, national and international educational initiatives and resources related to Science and Technology education are evaluated and explored to best meet the needs of NSW public schools.

A Quality Teacher Program, nationally funded professional development resource is currently being trialled by the consultants with schools. The resource focuses on assisting teams of teachers in a primary school to undertake whole-school planning to achieve a systematic progression of student learning across the seven years of primary schooling. The finalised professional development resource will be an interactive CD-ROM providing teaching materials, video footage and student work samples and will be available to all schools early in 2003.

Strategic research partnerships

One of the objectives of the K-6 Science and Technology Program involves the Department actively seeking opportunities to establish partnerships to best meet the needs of NSW public schools in Science and Technology education. In line with this objective the Department has been successful in a partnership for Australian Research Council Linkage (ARC) funding for a project titled *Researching the design and implementation of systemic, sustainable, school-based teacher professional development in K-6 Science and Technology* *using e-learning approaches.*

Dr Lyn Schaverien, University of Technology, Sydney and officers from the Professional Support and Curriculum Directorate and the Strategic Research Directorate of the Department developed the project submission. Dr Schaverien brought to the partnership an electronic tool called the *Generative Virtual Classroom* (GVC) which she has used extensively in pre-service teacher education. Essentially, the GVC comprises a series of video clips of classroom activities that are accessed via the Internet. The students and their supervisor discuss the classroom scenarios electronically over an extended period of time, contributing to the discussion at their convenience.

The Department brought to the partnership substantial expertise in student learning in Science and Technology and in professional development as well as access to schools, teachers and students and the infrastructure to support the project.

The ARC funded project will research the use of the e-learning mediated tool and a generative research approach to deliver effective and sustainable professional development to teachers across NSW. The project will explore the nature of the content of the e-learning mediated tool and the mechanisms needed to bring about effective professional development. The project content will focus on teachers gaining a deep understanding about how students can better achieve *designing and making* and *investigating* learning outcomes in Science and Technology.The district consultants, in collaboration with teams of primary school teachers within selected districts, will provide authentic classroom video clips of students learning Science and Technology. The video will provide the stimulus for innovative web-based professional discussion and training about how students learn Science and Technology and will assist teachers to select strategies and make judgements about how they can best support students to progress.

In summary the features of the Science and Technology program that promote change include:

- Clear and agreed vision for the program
- Substantial resources and infrastructure support for the program
- Strong and diverse Science and Technology district and state office team
- The use of email, web boards and teleconferences to establish and maintain a team located across 41 diverse geographical locations
- A focus on moving primary teachers to a deeper conceptual understanding of science and technology through professional development that is grounded in research, trialed in specific school settings and is based on improving student learning
- Actively seeking partnerships and strategic alliances in the community to advance science and technology in primary schools
- Exploring innovative uses of electronic learning tools for professional development, with a particular focus on equity for teachers in remote areas.

Conclusion

In this paper I have selected three specific examples that highlight some of the important factors that can bring about change in technology education and in student learning. Working in the NSW Department of Education and Training, in support of public schools, the commitment of the State Government and the strategic support of the community, industry and the tertiary education sectors are crucial. Establishing strategic partnerships to undertake projects of mutual interest such as research or resource development allows organizations to undertake and achieve projects that alone could not be done.

The importance of strong, resilient, dynamic and collaborative partnerships with expert teacher practitioners to trial curriculum ideas in their school setting, develop resources, document processes and prepare effective professional development should not be underestimated. Such arrangements are of mutual benefit as the teacher's thinking, ideas and strategies about practice are challenged and extended whilst the curriculum developer is likewise challenged and extended about theoretical models and professional development approaches. Testing models and ideas at the micro level of authentic everyday teaching situations enables guidelines, resources and advice to be practical, high quality and credible for teachers. Developing and promoting professional dialogue as a systemic learning tool needs to be further explored.

Valuing the skills and understandings of expert teacher practitioners by identifying them as mentors and providing them with the training and support needed to be effective mentors not only provides inexperienced technology teachers with access to much-needed and flexible expertise but also serves to motivate and refresh the mentor. Where innovative models of teacher training are being implemented mentoring serves to reassure experienced teachers about the new teachers entering the system and enable them to advocate for the new teachers.

More classroom-based research into how students learn in technology education settings, the steps students progress through as they become more sophisticated in their learning and the teaching strategies and approaches that enhance such learning is crucial. It is only through an in-depth understanding of how students progress in their ability to design and to be technologically capable that a significant advancement in technology education can occur.

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