What are the Unique and Essential Characteristics of Technology Education in the Primary School? A Study Based in the USA.

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ABSTRACT

The purpose of this modified, rotational Delphi study was to identify the unique and appropriate characteristics of technology education for the primary curriculum in the USA. Two groups of participants in the USA, experts in technology education and primary teachers with some experience of technology education completed three rounds of the Delphi study using an electronic World Wide Web based survey. The results suggest that there are many characteristics of methodology, knowledge and understanding, and skills that both the technology experts and the primary teachers perceive as being important for primary education. However the most unique characteristics identified were those of skills and methodology, with knowledge and understanding featuring to a much lesser degree.

Overall, the participants were asked to rate 27 characteristics of methodology, 22 characteristics of knowledge and understanding and 43 skills. The survey was conducted electronically and the items were rotated around the two groups to prevent fatigue.

The findings suggest that technology education experts and primary teachers in the USA feel that technology education has many characteristics that are fundamental to the primary curriculum. They identified intellectual capabilities, practical skills, design and problem solving as unique and appropriate characteristics of primary technology education. They also identified technological concepts as unique to this field of study.

Many countries have technology education as a core component of the primary curriculum. The instrument for this study was informed and developed from theory and practice of primary technology from some of these countries. It is suggested that the
findings of this study could provide a core of characteristics with which to evaluate and
develop present programmes and policies in primary technology education in the USA.

There is very limited evidence from academic research which demonstrates the
needs and benefits of technology education for primary aged children. However, there is
considerable anecdotal evidence to support its inclusion in the primary school curriculum.
This study suggests that further research is needed into children's learning in technology
education in order to provide a sound basis on which to build national and school policies
and programmes.
Introduction

Technology education is a relatively new entrant to the primary education curriculum for many countries. It can be defined as:

That part of the curriculum concerned with helping learners to become technologically capable: to identify human needs for which technological solutions are possible, design and make appropriate products (physical products or organisational systems), and to evaluate their quality and their potential societal and environmental effects. (Gardner & Hill, 1999, p.104)

It is widely recognised that this adds yet another dimension to what is already, some would argue, an overcrowded curriculum (Braukmann, 1993; Knamiller, 1992). Identifying the characteristics of technology education that are unique and appropriate and to add value to the existing primary curriculum is, therefore, essential if technology education is to be accepted and recognised as an important part of young children's learning.

The Primary School Curriculum

Few people would argue against the need for literacy or numeracy in the primary school curriculum. However, theories and arguments abound about what children should know or be able to do by a particular stage in their lives. Governments, philosophers, psychologists, educators, communities, and individuals all want to influence what children learn, and know if this is taught, during their formative years in primary education. This results in a very broad curriculum being taught in the primary school, leaving too many demands on teachers who have to juggle time and make subjective judgments about what value to place on any particular subject (Osborne & Simon, 1996). Research demonstrates that even with curricular guidance, primary teachers find it difficult to meet the time recommendations for all subjects (Harlen, 1999). Teachers, who are influenced by their competence and confidence to teach a subject (Aubusson & Webb, 1992; Harlen, Holroyd & Byrne, 1995), need to understand how the essential components of a subject can add value to children's learning. They need professional development and guidance as to what is relevant and important for children to learn from any particular subject at an appropriate stage of their education (Mant & Summers, 1995).
It also matters that the subject content reflects an ever-spiraling curriculum (Bruner, 1966; 1986).

**How Children Learn**

Children have their own ideas, which have been constructed because of their experiences in everyday life (Harlen, 1997, 1999, Leach & Scott, 1995). Such findings are contrary to the 'tabula rasa' theory (blank slate), or empty vessel theory, that necessitated teachers feeding ideas that would somehow begin to fill these empty minds. Constructivism, a theory initially developed through Piaget's work in the 1920s, recognizes that children are "active learners who are able to set goals, organize, and revise" (Bransford, Brown & Cocking, 1999, p. 68), and by doing so, organize their own knowledge. Children therefore build on, or assimilate, new ideas into existing frameworks thus developing their own conceptual understanding of the world around them.

How children learn will depend on their individual strengths in a particular mode. Gardner (1983) developed the theory of multiple intelligences: linguistic, logical, musical, spatial, bodily kinaesthetic, interpersonal, intrapersonal, and naturalistic, and recognised that children may have particular strengths within which they may attain optimal learning. Such a theory offers teachers a range of modes to develop concepts and provides a variety of ways of enabling children to exhibit their multiple intelligences (Gardner, 1997).

In addition to multiple intelligences, children were found to have a variety of learning strategies (Siegler, 1996), choosing those that had the greatest advantages for a particular problem. Although these strategies have been identified in young children, increasing strategic development is associated with age and experience within a domain (Lemaire & Siegler, 1995).

Knowing about how children learn, their knowledge construction, their use of multiple intelligences, and their use of a variety of learning strategies enables educators to plan for appropriate and relevant learning. It can inform development of teaching strategies, programs, and curricula that best fit the needs of their children, whatever their age, aptitude, ability, or experience.
Characteristics of Technology Education

The most recent major developments in technology education in England (DFE, 1995), Scotland (Scottish Executive, 2000), New South Wales, Australia, Board of Studies (1993), and USA (ITEA, 2000) suggested a variety of concepts necessary for the understanding of technology education at the elementary stages of learning.

In England the aim of technology education is:

- Pupils should be able to design and make products safely by applying knowledge and skills from the programs of study for technology and where appropriate from other subjects, particularly art, mathematics and science. (DFE& WO, 1992, p.19)

Thus, technology education was seen as integrating knowledge and skills from a variety of disciplines, including technology in order to make products. Conceptual understanding of a technological nature, specifically identified as required for technological capability, includes knowledge of mechanisms, structures, products, and applications (DFE, 1995). The knowledge is framed in general terms, as a means to an end rather than for its own worth.

In Scotland (Scottish Executive, 2000), where a similar process based approach exists, conceptual understanding is seen as a means to an end. The document stated, “the central purpose of knowledge and understanding in technology is to enable skills to be developed effectively and attitudes to be well informed” (p.67). The knowledge and understanding strands are specifically named as: needs and how they are met, resources and how they are managed, (and) processes and how they are applied. (p.66)

Within these broad strands, the more specific concepts of design, technological change, materials, energy conservation and transfer, processes, and control were identified. However, they were couched in general terms for the purpose of designing and making products to meet the needs of "groups and societies, past, present and future" (p.71).

In New South Wales, Australia, Board of Studies (1993), where science and technology are combined for elementary education, it is difficult to decide which of the concepts identified are specifically intended for technology education. However, concepts such as control, forms of energy, consequences of production and consumption,
systems, services, and the effects of technology can all be identified within the prescribed syllabus.

The Standards for Technological Literacy (ITEA, 2000) in the USA demonstrated a different approach to technological concepts. They likened technology to any other branch of knowledge (Rosenburg, 1982), as having "concepts that characterize it and set it apart from other fields of study" (p.32). Out of 20 strands identified for technological literacy, 17 referred to understanding while only 3 referred to skills. More specifically, in Chapter 3, the "core concepts" of technology were identified as systems, resources, requirements, optimization and trade-off, processes, and controls. A continuum of each of the concepts is identified for all grade levels.

Although different approaches to technology education have been undertaken in different countries with some having taken the process-based approach while others appear to have taken a more knowledge-based approach, there is some agreement about the concepts that relate specifically to the technological domain. The commonalities of conceptualization at this stage, although implicit in some cases, appeared to be the concepts of systems, energy use, conservation, and control. In many cases these were stated in broad terms (Board of Studies; 1993 DFE, 1995; Scottish Executive, 2000) but in the case of the USA, the concepts were made explicit and developed on a continuum for all grade levels.

**Reasons for the Research**

Despite the anecdotal beneficial claims being made for children's learning from their exposure to primary technology education, Foster (1997) found that it was "virtually non existent in primary schools in the US" (p. 34). In England and Wales, where a National Curriculum has required primary schools to teach technology education since 1990, "some primary schools are actually teaching less technology than they did before the National Curriculum appeared" (Davies, 1999, p.26). Add this information to the fragmented and limited research base available for this area (Zuga, 1996; 1999), and the picture for primary technology education seems less than favourable. In spite of this, teachers who witnessed the joy of children engaged in technology education (Bottrill, 1996), the organizations, such as ITEA, who have just delivered the new standards for technology education in the US, and the governments which continue to fund changes to try to improve children's learning experiences, all believe that there is a place for
technology education in the curriculum. It is, therefore, critical at this juncture, with increasing pressure being made on the curriculum, that the characteristics of technology education that are unique and appropriate for primary children's learning, be identified.

**Purpose of the Study**

The purpose of the study was to identify the characteristics of technology education that are unique and appropriate for children's learning in the elementary school in the USA. It was designed to seek answers to the following specific research questions:

1. Which technological knowledge and understanding is unique and appropriate for children's learning?
2. Which technological skills are unique and appropriate for children's learning?
3. Which methods should be used in the teaching of technology education in the primary school?

In order to find answers to these questions, the study used the experience gained by two groups of educators: experts in the field of technology education in the United States of America (USA); primary teachers in the USA, with some experience of technology education.

In an effort to address the research questions, it was decided that a Delphi survey of experts in the field of technology education and primary trained teachers with some experience with technology education, would provide opinions that addressed both policy and practice. It was assumed that traditionally the experts in the field, professors in technology education, would have influenced policy decisions about what should be included in a curriculum for technology education. Primary teachers traditionally would have been expected to take these policy decisions and the ensuing curricular guidance and translate this into practice in their classrooms. The decisions to use these two groups was to see: (a) whether a consensus of opinion could be established about which characteristics of technology education are unique and appropriate for primary children; (b) whether the opinions of both groups are similar or different; and, (c) to see if either group would influence the other in the final outcomes.

The technology education experts were nominated by professors in the field known to the researcher. These experts nominated further experts and primary teachers whom they knew were active in technology education in their primary schools. All of the
participants for both groups, the technology education experts and the primary teachers, came from the USA.

Research suggested that for policies to be successfully applied, practitioners and policy makers need to work together from the beginning of the decision making process (Burgess, 1993). The result of this study may suggest a way forward.

**Current Available Research**

Although there is limited research in technology education (Cajas, 1999; Layton, 1993), and even less research in primary technology education (Foster, 1997; Zuga, 1995; 1999), there has been a considerable amount of agreement in the academic world about what the current general education should encompass. Suggestions include "student motivation, hands-on learning, community and career awareness, (and) practical and applied academics" (Foster, 1997, p.4). As early as 1923, Bonser and Mossman (1923) were asking the question: "Is there not also a body of experience and knowledge relative to industrial arts which is of common value to all, regardless of sex or occupation?" (p.20). The research available in primary technology tends to be highly specific (Foster, 1997; Zuga, 1999) and focuses mostly on teaching methods (McCormick, Murphy & Hennesy 1994) and student attitudes (Raat & De Vries, 1985; McHaney, 1997; Thomson & Householder, 1993; Wright & Thomson, 1998), "without a strong connection to specific ideas and skills that have been identified as part of technological literacy" (Cajas, 2000, p.2). Other research on children's conceptual and skill development in science and mathematics through design based learning (Hmelo, Holton & Kolodner, 2000) may be relevant to technology education or, at least, may suggest a way forward(Cajas, 1999).

**The Nature of Technology Education in National Primary School Programmes**

Established primary technology programmes in various countries provide models, systems and reflections which can be used to inform developments in countries without such programmes. For this reason primary technology programmes from a number of countries were analysed in order to inform and develop the instrument for this study. Analysis of the technology programme in England and Wales provided items on design, problem solving, creativity and assessment:
England and Wales

Very few countries have technology as a compulsory component of the primary curriculum. England and Wales, which were the first countries to include technology education as part of their primary curriculum, introduced it as a statutory component for all children aged 5 to 16, in September 1990. A rationale for the inclusion of a technological learning area as part of the curriculum was suggested by the Secretary of State in 1984. One of a series of discussion papers, Curriculum Matters 2, sought ‘broad agreement about the objectives of the 5-16 curriculum’ (DFE, 1985, p.30). The working party set up to look at technology education as part of the National Curriculum asked the question: "What is it that pupils learn from design and technology activities which can be learnt in no other way?" (DES & WO, 1988). It suggested: "In its most general form, the answer to this question is in terms of capability to operate effectively and creatively in the made world” (p. 3).

As a result of this report, technology education was organized under four attainment targets for all pupils aged 5-16 and each of the targets, AT1-Identifying needs and opportunities, AT2-Generating a design, AT3-Planning and making, and AT4-Evaluating, were assigned a series of programs of study for each level of attainment. The scheme was so complex that over six years, there were seven publications with "each attempting to clarify the situation for teachers" (Barlex, 1998, p.140). After a series of reports from 1990-1993, a review of the inspectors’ findings 1993/94 reported the following for technology in the primary schools (OFSTED, 1995). Main findings:

Standards of achievement by pupils in specific lessons at Key Stages 1 and 2 are generally satisfactory, but overall standards of achievement in primary schools in design and technology are often low. Frequently pupils fail to progress in their development of design and technology capability. This is often linked to teachers' lack of subject knowledge and practical expertise in the range of design and technology activities, poor and cramped accommodation, large class sizes, and insufficient resources to enable pupils to have a sufficiently broad range of experiences. (p. 3)

Inspectors found that standards achieved in technology education were unfavourable in comparison with other subjects and that the technical vocabulary was
"inadequately developed". They found that standards were low where designing skills were not developed and that children had insufficient knowledge and skills to handle tools "safely and effectively". They pointed out that the lack of resources limited opportunities for children to develop their capabilities over a range of activities.

On the favourable side, inspectors found that when teachers set challenging tasks, children were talking about products and their functions, achieved high standards, able to design over a range of activities, and to select and use tools appropriately (OFSTED, 1995).

As a result of the review process, a new order was published in 1995 which was "much more manageable" (Barlex, 1998). It featured a new mission statement, “Pupils should be taught to develop their Designing and Making skills with knowledge and understanding in order to design and make products” (SCAA, 1995, p. 5).

Only two attainment targets remained: AT1 Designing, and AT2 Making, and the performance was described at each level in a simple paragraph which teachers could understand (Barlex, 1998). However, after all the changes and simplification, it seemed that teachers were still finding difficulty in organising the statutory orders into appropriate classroom activities. An exemplar scheme of work was produced for schools in 1998 (DFEE, 1998) and provided teachers with the resources to assure progression of design and technology activities in the primary curriculum. After more than a decade of experience of primary technology, questions about its worth still continue. A recent review suggested that there were falling standards and asked the questions, "What do we want? What do we really want?" (Wilders & Pitt, 1999, p.198).

Analysis of the Scottish programme suggested similar items to the English and Welsh programme but emphasised the need for technological capability:

**Scotland**

Although there was mention of the need for primary technology in 1985, “teachers in primary schools should be encouraged to introduce technological activities” (CCC, 1985, p.25), it was not formally introduced into Scottish primary schools until 1993. The technology guidelines developed as a result of the 5-14 Development Programme (SCCC, 1989), were not statutory and were embedded within the area of the curriculum known as Environmental Studies (SOED, 1993). They were not based upon research but
on current good practice within the country's schools. The resulting technology outcomes consisted of knowledge and understanding, skills, and attitudes organised in the form of progressive statements of attainment for children aged 5-14 years. In 1996, somewhat belatedly, the 5-14 Guidelines were followed by a rationale for technology education, A Statement of Position, highlighted the need for capability in four areas: perspective, confidence, sensitivity and creativity (SCCC, 1996). Technological capability was defined in the document as follows:

Technological capability encompasses understanding of appropriate concepts and processes; the ability to apply knowledge and skills by thinking and acting confidently, imaginatively, creatively and with sensitivity; the ability to evaluate technological activities, artefacts and systems critically and constructively. (SCCC, 1996, p.7)

For many teachers in primary schools in Scotland, technology education, was a new area of the curriculum which posed a number of problems; they lacked personal experience of the subject; they had limited knowledge and understanding in this area; and, as a result, they lacked the confidence to teach technology and its accompanying processes to their pupils (Holroyd and Harlen, 1996). The research that looked at the competence and confidence levels of teachers, reported that only 2% of teachers felt highly confident to teach technology education at the primary school level. Levels of confidence were not found to correlate with levels of competence (Holroyd & Harlen, 1996). Since then, a further piece of research demonstrated that teachers' confidence levels had risen, albeit slowly and marginally (Harlen, 1999).

In addition to this research on teachers’ capabilities to teach technology education, a review of technology education within Environmental Studies in Scotland was carried out in 1998 (SCCC, 1998). As a result of this review, teachers requested a simplification of the Guidelines. The new documentation (Scottish Executive, 2000) was similar, but reduced in complexity.

Analysis of the New South Wales documentation suggested similar items to the British documents, with a greater emphasis on links with science. There was also more emphasis on the need for technology to be taught through contexts and for children to be engaged in reflection.
New South Wales, Australia

In larger countries where the education system was organized by the state or province, it was more usual to find programs of technology education organised in the same way. For example, New South Wales in Australia has a "Syllabus and Support Document" (Board of Studies, 1993) for Science and Technology K-6. In this document, science and technology were very closely linked for purposes of the primary curriculum because they formed "the learning area in which all students learn about the natural and made environments by investigating, by designing and making, and by using technology" (p. 1). However, they did define science and technology separately, stating "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 skills, knowledge, techniques and processes to expressive and practical problem solving situations in all aspects of life" (Board of Studies, 1993, p.1).

In addition to defining outcomes, unlike the British Guidelines, the New South Wales document, provided guidance on methodology and "units of work" which demonstrated a contextualised delivery of technology education and its three stages of knowledge, understanding, and skills. There was also particular attention paid to "students' prior learning". It suggested that the evaluation of students' prior learning "can be used when identifying suitable objectives for a class or group program and when evaluating its effectiveness" (Board of Studies, 1993, p.55). Of all the national documents reviewed, the New South Wales document is the only one to identify reflection as an essential component of learning in technology education. It gives teachers information about the need for reflection and suggested strategies for its implementation. In addition, the document provided detailed information on skill development for both the investigation and the designing and making processes.

Analysis of the South African approach suggested items mainly linked to methodology which is not surprising since teacher development was the initial focus of the technology programme:

South Africa
In South Africa, the major strategy for introducing technology education into the curriculum had been to develop teachers and was accomplished through a national training program. Learning outcomes for children had been framed within activities in which teachers had been trained. Trained teachers, who had been centrally trained, were moved around to other schools and trained other teachers by working cooperatively with them within the classroom setting. Unlike other programs, there had been a wider recognition of the need to train teachers in technology education in order to allow them to become competent with specific learning goals before setting levels of achievement for children. By doing this they hoped to develop teachers who would feel confident with developing children’s learning in what, for them, was a new and additional subject of the primary curriculum (e-mail, 1999).

There was a considerable amount of literature from the USA which focused on the content of technology programmes. Although items similar to the British and Australian were evident, many knowledge and understanding items were identified from the American programmes:

**United States of America**

One of many countries without a national program for technology education at the primary stages is the United States of America. Unlike the aforementioned countries, the responsibility of producing such programs remained not with the government but with the professional bodies (Wright and Thomson, 1998). This has resulted in a variety of bodies producing documents that proposed standards for technology education (AAAS, 1993; ITEA, 2000; NRC, 1996). Within these documents, there were benchmarks for scientific, technological, and mathematical literacy (AAAS, 1993), standards for evaluating science teaching and programs (NRC, 1996), vignettes to help teachers interpret the standards (ITEA, 2000; NRC, 1996), and technology standards with an example of an articulated curriculum in technology education in the context of the topic for Grades K-12 (ITEA, 2000).

The most recent standards for technology education in the USA defined technological literacy as "the ability to use, manage, assess, and understand technology". In order to become technologically literate, it is suggested that students need to meet benchmarks for knowledge, understanding, and skills in the following areas: the Nature
of Technology, Technology and Society, Design, Abilities for a Technological World, and the Designed World. However, within the document it emphasised,

These standards do not attempt to define a curriculum for the study of technology; that is something best left to states, provinces, school districts and teachers. (ITEA, 2000, p. vii)

It is also recognised that producing standards is only the beginning of a long and arduous road to technological literacy (ITEA, 2000). Considering what has happened and is still happening in other countries, the USA will need to develop teacher training programs and resources to support any programs developed as a result of this national initiative in technology standards for such programs to be successful.

The Delphi Technique

The Delphi technique is a systematic, rigorous, and effective methodology used by policy makers, politicians, bureaucrats, and university academics looking for making critical decisions. The technique is particularly recommended for stakeholders in education (Clayton, 1997). Critical decisions for this purpose are those involving personnel, program developers, management, and resource allocation, and require careful consideration (Rasp, 1973) since they "can positively or negatively effect the overall functioning of an organization" (Clayton, 1997, p. 375). Such critical decision-making requires human endeavors and intellectualizing that goes beyond normal daily, routine activities (Clayton, 1997).

Delphi Background

The term 'Delphi' is a derivation of the 'Delphi Oracle' relating to the ancient Greek myth suggesting that one person, a 'chosen one', was able to predict the future with infallible authority. The technique was originally used to forecast the future technological developments; thus, the association with the oracle.

The Delphi technique has been used to set priorities, establish research goals, and to forecast educational needs (Finch & Crunkilton, 1993). Educational purposes for which it has been used include curriculum development (Reeves & Jauch, 1978; Harman, 1981; Blair & Uhl, 1993; Volk, 1993; Wells, 1994; Klutschkowskii & Troth, 1995); institutional planning (Uhl, 1983); determining educational effectiveness (Roberts et al, 1984); forecasting expectations relating to the condition of emotional disturbance/behavior
disorder (Carpenter, 1985); forecasting effects of de-institutionalization and necessary educational services (Putnam and Bruininks, 1986); identifying conditions most likely to encourage full participation in non-formal education programs (Spencer-Cooke, 1986); identifying features of effective in-service practices (Van Tulder et al, 1988); vocational education and training (McCampbell, 1989; Hakim and Weinblatt, 1993); teacher effectiveness (Stivers and McMorris, 1991); issues in interactive media education (Raker, 1992); identifying competences (Clayton, 1992; Cannon et al, 1992; Smith & Simpson, 1995; Thach & Murphy, 1995; Scarcella, 1997); distance education (Miller & Husmann, 1994); nurse education (Hartley, 1995); preparation of students for the 21st century (Gagel, 1995); investigating future directions in education and inclusion for students with disabilities (Putnam et al, 1995); and the future of adult education (Leirman, 1996).

More pertinently for this study, the Delphi technique has been used to identify critical issues and problems in technology education (Wicklein, 1993); and quality characteristics for technology education (Clark, 1997).

The Delphi technique was used because the problem under investigation was appropriate for "subjective judgments on a collective basis" (Linstone and Turoff, 1975, p.4). It requires a larger number of individuals "than can effectively interact in a face to face exchange" (Linstone & Turoff, 1975, p.4), and these individuals were so widely dispersed that distance and "cost (made) frequent group meetings infeasible" (Blair & Uhl, 1993, p.109).

The modified rotational Delphi technique was engaged to reduce attrition of panel members due to fatigue. Attrition is known to have a negative effect on the reliability and validity of results (Hill & Fowles, 1975; Hakim & Weinblatt, 1993; Scarcella, 1997). All survey techniques are known to have an optimal length for the population that was nominated (Crowl, 1996) and cooperation and interest were seen to diminish with length (Christensen, 1980). Since the panelists only had to respond to a subset of the instrument in the first two rounds, this reduced the length of the survey and, thus, amount of time that was required for a response. Crowl (1996) recommended that an instrument should have a limited number of items, 30 or less, in order to reduce errors due to interpretation.

Since the field of primary technology is very comprehensive, a large number of items for knowledge and understanding, skills and methodology were necessary for this
survey (Appendix 1). The rationale for using electronic communication to collect data was to increase response time and to reduce the administrative time associated with the sending, receiving and returning of surveys. It was also being used as an appropriate means of communication for contemporary society, especially for experts and teachers in the field of technology education.

**The Modified Rotational Delphi Technique**

Three rounds of the modified rotational Delphi were conducted. Each round, consisting of an electronic survey, was presented to the participants, group (a) experts in technology education, and group (b) primary teachers, via the World Wide Web. The participants completed the surveys and returned them to the researcher via the World Wide Web. The responses were analyzed and used to design the instrument for the subsequent round and to obtain the final results.

**Identified Areas of Technology Education for Survey within this Study**

The literature reviewed revealed four major areas of characteristics pertinent to the area of technology education in the elementary curriculum. These four areas were knowledge and understanding, skills, attitudes and values and methodology (ITEA, 2000; SOEID, 2000). In one study (Foster, 1997) technology education is analyzed three different ways; as content, as process and as method. However, most countries, which have a recognized programme for technology education in the primary curriculum, include all of these areas to a greater or lesser degree. In parts of Australia, New South Wales, Board of Studies (1993) and England and Wales (DFE & WO, 1995), the latest document would seem to put most of the emphasis on skills, whereas in Scotland (SCCC, 1996; SOED, 1993, there is a clear balance between knowledge and understanding and skills. In the USA, the new standards (ITEA, 2000) would appear to put considerable emphasis on knowledge and understanding. Curriculum, Rationale, Benchmark and Standards documents from the USA (ITEA, 2000), England and Wales (DFEandWO, 1995), Scotland (SOEID, 2000), New South Wales, Board of Studies (1993) and South Africa (e-mail, 2000) were reviewed to identify possible knowledge and understanding, skill and methodological characteristics for this survey.

The literature on the constructivist theory suggests a way of learning but does not prescribe a way of teaching (Fosnot, 1995). Although methodology is an issue, countries
with programs for elementary technology have resisted the need to prescribe methodology preferring to give teachers some ownership of this area (SOED, 1993; ITEA, 2000). However, a recent review of research literature from the USA (Bransford, Brown, Rodney, & Cocking, 1999) and Great Britain (Harlen, 1999) suggests that how children are taught will influence how they learn. In both cases, suggestions for acknowledging children's previous learning, learning styles, assessment, classroom ethos and depth of learning, are developed. This specific literature, in addition to other literature reviewed, has been used to identify possible methodology for this survey.

Although some countries recognise the need to include attitudes and values as a major area of technology education (SCCC, 1996), assessment of these characteristics is a sensitive issue. A section on attitudes and values was not included in the research instrument since these characteristics were not included in the Standards for Technological Literacy (ITEA, 2000) in the USA. However, the section on methodology inevitably considers some of these issues in relation to learning styles and it was considered important to review the literature on children's attitudes towards technology education in order to inform the methodology debate.

Finally, the issues raised at a recent research conference (AAAS, 1999) which reviewed research in the area of technology education and made recommendations for further research, was used to inform the survey for all three areas of the study: knowledge and understanding, skills, and methodology.

**Electronic Survey**

A web-based survey (Test Pilot, 2000) was used to design and construct the modified rotational Delphi survey. It was accessible to the participants through a World Wide Web address; access was controlled through the researcher by means of a personal ID and password. Only the researcher could view the participants’ responses, thus maintaining a high level of security.

The complete instrument containing all possible items (Appendix 1) was designed for piloting purposes. From this complete instrument, a subset of the instrument was designed for the technology experts and the primary teachers for Rounds 1 and 2. Round
3 was a composite round consisting of non-consensus items and the section on skills. Each instrument subset was given its own address on the World Wide Web.

**Biographical Details**

Distribution of participants by state is presented in Table 1. The most obvious feature is that the experts in technology education are more widely distributed than the elementary teachers. Although there would appear to be links between experts and teachers in Idaho and Virginia, no other links were particularly obvious. Two of the teachers teach in the same school.

**Table 1**

**State Residence and Number of Participants**

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<th>Technology Education Experts</th>
<th>Frequency</th>
<th>Elementary Teachers</th>
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The most noticeable feature of this sample of participants is that while only 33.3% of the technology education experts are female, 93.3% of the elementary teachers are female (Table 2). Of the female experts, there were small numbers in comparison to the male experts, who averaged over 20 years experience. There are more female experts with experience at the 10–20 year range and there are equal numbers of females and males with experience of 5-10 years. The overall trend is a reduction in the number of male experts at the lower levels of experience. The elementary teachers were mostly female and had between 5 and 20 years of experience.

The age profile was such that 83% of the total population was over 40, with the experts in technology education having the older profile; this was expected since most of the experts had experience over a long period of time. However, the age profile of the elementary teacher is also skewed to the upper age categories, with 73% being over 40 years old.
Table 2

Age and Experience of Participants

<table>
<thead>
<tr>
<th>Years of Experience:</th>
<th>Experts</th>
<th>Elementary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Under 5 Years</td>
<td>5</td>
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</tr>
<tr>
<td>5-10 Years</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10-20 Years</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>More Than 20 years</td>
<td>3</td>
<td>2</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Age:</th>
<th>Experts</th>
<th>Elementary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 - 30 Years</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>30 - 40 Years</td>
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<td>3</td>
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<tr>
<td>40 - 50 Years</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Over 50 Years</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Results of the Survey

The panel, made up of technology education experts and primary teachers with some experience with technology education, reached consensus on 97.8% of the items representing the characteristics of technology education. Analysis and interpretation of the results demonstrated progression towards consensus over the three rounds.

In analysing for unique characteristics of technology education, it was decided that items which reached complete consensus (interquartile = 0) and which were rated at the very high level, would form these unique characteristics. The unique characteristics were found to consist of 7 items for methodology, 1 item for knowledge and understanding, and
12 Items for skills. Of the other items, 69 reached consensus at the high rating and were, therefore, perceived as important by the participants. One item received a medium rating and was not perceived as important. Two items did not reach consensus by the end of the three rounds. Since this was a policy Delphi, these non-consensus items were used to inform the debate (Clayton, 1997).

**Technological skills which are unique and appropriate for children's learning.**

The balance of characteristics is skewed towards the skills, which is ironic since countries which have had a core curriculum for the last 5-10 years have moved to this process led approach (DFE, 1995; SOEID, 2000). There were proportionately more skill characteristics (27.9% skills, 25.9% methods and 4.5% knowledge and understanding) meeting complete consensus at the very high rating than any other characteristics. The constructivist theory would favor this approach to learning since it would see children constructing their own knowledge from a variety of experiences (Fosnot, 1995).

The primary education teachers reached consensus at a very high rating on more skills' characteristics than any other characteristics, which suggested that they would expect to see a technology curriculum that was skill based. Technology education experts' results showed consensus for only 1 skill characteristic item. This item, #1090, is in line with the primary teachers' results and read, "Technology education should enable children to work as part of a team to design and make a product to solve a problem or need". Such teamwork encourages children to share their ideas with their peers and their teachers thus enabling the scaffolding that Vygotsky (Van de Veer and Valsinger, 1994) sees as essential to children's learning.

**Technological knowledge and understanding which is unique and appropriate for children's learning.**

Only one of the characteristic items for knowledge and understanding reached complete consensus at the very high rating. This item, #450, "Technology education provides a unique opportunity for children to gain knowledge and understanding of the technological concepts”, is directly in line with the ITEA (2000) initiative for technological literacy. However, the results would suggest that the emphasis should not
be on knowledge and understanding that is in contrast to the same standards. This raises the debate about what will happen with the new standards ITEA (2000). Teachers who believe in methodology and skills as most important are going to find it difficult to deliver all the knowledge and understanding stated as necessary in the document.

**Technology methodology characteristics which are unique and appropriate for children's learning.**

The results of the rotational Delphi identified 7 methodology characteristic items as being unique. All except one of these items is "unique" to both the experts in technology education and the primary teachers. Although the results of the primary teachers identified more methodology characteristics than the technology education experts at complete consensus and at the very high level, the experts had 7 of 8 of their "unique" items as methodology characteristics. This suggested awareness by both groups of the need to provide appropriate methodology for primary children. It is interesting to see that the items chosen were perceived by the panel as being unique to technology education, especially when the first one reads, "Technology education should be taught to develop children's intellectual capabilities", which, presumably, is the main reason for teaching any subject.

The characteristic items which achieved the "unique" results included developing children's intellectual capabilities, enhancing children's general education, helping children to gain access to their own problem solving strategies, bringing authenticity into the classroom through real world objects, involving children with hands-on tasks, and providing a reassuring and supportive atmosphere. The study confirmed as important, these items identified by Harlen (1999). It is also worth asking the question about whether technology education is unique to one or more of Howard Gardner’s multiple intelligences (Gardner, 1983).

**Discussion**

This small scale study demonstrates that technology education experts and primary teachers in the USA believe that skills and methodology are more important than knowledge and understanding at the primary school level. Whereas national trends tend toward the more academic side of the curriculum in technology education (ITEA, 2000),
this study demonstrates the need to place greater emphasis on the methodology and skills. Since methodology and skills were seen by both groups as very important, the characteristics may also be useful in the critically evaluation of current national and school policies and practice.

There appears to have been limited consideration given to the need to consider the uniqueness of technology education within the overall primary curriculum. The final results suggested that the technology education experts were more analytical in their survey responses than the primary teachers. This resulted in fewer items being described as "unique" by the experts (8) than for the primary teachers (35). One possible explanation is that the experts have had more opportunity to study the outcomes of technology education nationally and internationally, leading them to think more critically about the problems of an overcrowded curriculum. Alternatively, the primary teachers may see more of the characteristics of technology education as an opportunity to integrate some of the primary curriculum. This alternative possibility is borne out by some of the teachers' comments. In both cases, however, when considering the "uniqueness" of items, the emphasis was on methodology (experts 88.9%, teachers 31.4%) and skills (experts 25% teachers 57.1%), with knowledge and understanding items being designated "unique" in a proportionately few cases (experts 0%, teachers 11.4%).

Creating the Delphi survey on a web-based package made for an efficient system. It was efficient in the sense that the data for this survey was collected over two months. This was a shorter time than if a traditional mailing system had been used (Scarcella, 1997). During this time, five different surveys were designed and completed by the participants; one common survey and two different surveys were used for each of the groups. The majority of returns were made within a week of the survey being sent out, although reminders, which were easy to send because of the medium, were sent out for all three rounds. High percentage returns and comments from the participants provided evidence of the efficiency of the method. Comments from the participants also demonstrated that they were of the opinion that the medium was effective with one or two reservations.

The results form this study could provide a starting point for policy makers, local authorities, or individual schools in the USA to begin developing primary technology
education programs (Thomson, 2000). The "unique" characteristics could provide the core characteristics for any program or at least spark a debate about a way forward.

It is recognised that this survey was based in one country, the USA, and as such the results should not be generalised to include other countries. Consideration should now be given to a larger scale survey of the unique and essential characteristics of primary technology in a several countries. The results of such a survey would provide valuable information for policy makers and practitioners and perhaps lead to improved practice for teachers and more worthwhile experiences for pupils.

Primary technology education will only be successful if it is sustainable and focusing on fewer core characteristics for the technology education curriculum could have this desired effect. This study has begun a process which may lead to the identification and better understanding of the unique and essential characteristics for technology in the primary curriculum.
References


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Appendix 1  Comprehensive Composite List of Items

Technology Instrument

1. Technology education should provide a concrete context for learning science concepts.
2. Technology education should be taught to encourage/because of its positive effect on children's attitudes and self esteem.
3. Technology education should be used to develop learning goals rather than to achieve performance.
4. Technology tasks should be organised so that children achieve success (make them believe they are intelligent).
5. Technology should be taught to develop practical skills, which will be useful for the workplace.
6. Technology in the form of handling objects should be taught for the use of "motor expression" in general education.
7. Boys and girls should be taught technology through different contexts.
8. Technology education should be taught in order to develop intellectual capabilities.
9. Technology education should be taught so that the economic means of the community are met.
10. Technology should be about the manipulation of objects.
11. Technology education should be used to enable children to externalise their ideas by constructing a model.
12. Technology education should be used to encourage children to be creative/expressive.
13. Technology education should be used to develop critical appraisal.
14. Technology should be used to integrate the curriculum. Children learn better multiple uses to which knowledge will be put.
15. Technology tasks should be authentic, reflecting the environment in which children live.
16. Technology should be used to enable children to develop their modelling skills.
17. Technology should be used to enable children to gain access to their own problem solving strategies.
18. Technology should be used to bring authenticity, knowledge of a concept in the real world, to the classroom.
19. Technology should provide the real world objects and events necessary for the concrete operational stage of development.
20. Technology should be used to help children to develop mental models through the deconstruction and reconstruction of artefacts.
21. Technology should be used to develop children's 'tools for thought' through the construction of working models.
22. Technology should be about handling objects so that children learn about what they are made and how they are composed.
23. Technology should be used to develop children's kinaesthetic abilities.
24. In technology children need to manipulate objects to enable them to think about what they are doing and reflect on their actions.
25. Technology should enable children to learn about the properties of objects.
26. Technology should enable children to develop mental images which lead to mental models allowing them to make better sense of their world.
27. Technology should be used to provide a wide range of contexts to enable children to build schemes which are generalisable across contexts.
28. Technology should provide evidence of constraints about real entities through the manipulation of objects within a given context.
29. Children's understanding of the process of technology should be assessed.
30. Technology should involve children learning technological concepts.
31. Technology education for elementary children should concentrate on the design/technology process.
32. Technology education for elementary children should concentrate on developing children's learning without the need for recourse to work.
33. Technology education is essential for children's learning at the elementary grades.
34. Technology education should enable children to understand trade-offs, constraints, redundancy, over design and failure.
35. Technology education for elementary children should include knowledge about control systems.
36. Technology education for elementary children should include the properties of materials which affect their use in products.
37. Technology education should include the knowledge of the properties of objects.
38. Technology education should include the knowledge of structures and their appropriate uses in products.
39. Teachers must draw out and work with the pre-existing understandings their children bring with them.
40. Technology should be formatively assessed to aid with monitoring and refinement in thinking (linked with metacognition).
41. Technology should be taught in some depth, providing many examples in which the same concept is at work.
42. Technology should be taught on a broad front, providing general concepts within a variety of contexts.
43. Technology should involve hands-on tasks that encourage 'doing with understanding'.
44. Technology should involve hands-on tasks for children's enjoyment.
45. Technology should be used to build a sense of community in the classroom.
46. Technology should be used to make links between home & school.
47. Technology in elementary education should focus on a prescribed set of activities in limited number of contexts.
48. Technology education should enable children to meet a variety of activities set in a wide variety of contexts.
49. Technology activities should reflect the culture within which children are familiar.
49. Technology activities should begin in familiar cultural contexts and expand to allow children to meet technological activities in unfamiliar cultural contexts.
50. Children should know how technology affects their environment.
51. Technology education should involve children in brainstorming.
52. Technology needs to be taught in a non-threatening environment when children reassured in a supporting atmosphere.
53. Technology education should encourage children in process skills.
54. Elementary education children should engage in technological problem solving.
55. Formative assessment should be used to collect evidence which is then used to adapt teaching to individual needs.
56. Elementary children should be engaged in self assessment in technological education.
57. Technology education activities should be used to provide motivation.
58. Technology problems should be open and person centred and should require reasoning prediction, interpretation and argument.
59. Technology education should teach children to use tools and implements safely.
60. Technology should be used to enable children to generate designs.
61. Technology education should be used to enable children to sketch ideas.
62. Technology education should be used to enable children to model ideas.
63. Technology education should be used to enable children to think creatively.
64. Technology education should be used to enable children to think critically.
65. Technology education should be used to enable children to cut and shape materials accurately.
66. Technology education should be used to enable children to join materials successfully.
67. Technology education should be used to enable children to evaluate work throughout the technology process.
68. Technology education should be used to enable children to show careful attention to structural details.
69. Technology education should enable children to understand that products are made to meet needs and wants.
70. Technology education should be used to enable children to distinguish between products which are made to meet needs or wants.
71. Technology education should enable children to understand that people developed technology to meet their basic needs for food, clothing and shelter.
72. Technology education should engage children in the improvement of their own made products.
73. Through technology education children should discover how things work by assembling products/by-disassembling products.
74. Enable children to understand the characteristics and scope of technology.
75. Enable children to understand core concepts of technology.
76. Enable children to understand relationships among technologies, relationships between technology and other fields of study.
77. Enable children to understand cultural, social, economic & political effects of technology.
78. Enable children to understand the effects of technology on the environment.
79. Understand that technology produces a need for further technology.
81. For elementary contexts should be limited to the home, school and community in which the children live.
82. Enable children to identify human made products and the needs or wants which they have been designed to meet.
83. Enable children to see technology appropriate to their needs and wants.
84. Identify problems which technological products create in their own lives.
85. Investigate products to find out how appropriate the materials, structures and mechanisms are for its intended use.
86. Encourage children to consider costs of products.
87. Encourage children to cost the materials used and their time in the making of a product.
88. Technology should be used to teach mathematical concepts.
89. Understanding of systems requirements/ trade-offs
90. Understanding of resources optimisation/processes/controls
91. Technology has changed children's lives. Investigate how their parent's and
grandparent's lives in particular ways.
92. Technology has changed people's lives throughout history.
93. Investigate how tools have changed within the home and school to meet specific
needs.
94. Investigate how tools have changed over time to meet the needs and wants of
people.
95. Expected/encouraged to design products to meet given criteria.
96. Evaluate manufactured products against criteria.
97. Evaluate their own products against criteria.
98. Understand the need for criteria in the design process.
99. Constraints in the designing and making of a product.
100. Procedural knowledge of the steps in the design process.
101. Recording throughout the process
102. Presenting - written and oral, use of variety of media/displaying.
103. Make suggestions/investigate how things can be improved.
104. Make modifications to improve their own products.
105. Identify everyday problems within the home, school and local environment
problems which can be solved by inventing a product to meet a need or want.