International Handbook of Research and Development in Technology Education

Alister Jones and Marc de Vries (Eds.)
International Handbook of Research and Development in Technology Education
Scope
Technology Education has gone through a lot of changes in the past decades. It has developed from a craft oriented school subject to a learning area in which the meaning of technology as an important part of our contemporary culture is explored, both by the learning of theoretical concepts and through practical activities. This development has been accompanied by educational research. The output of research studies is published mostly as articles in scholarly Technology Education and Science Education journals. There is a need, however, for more than that. The field still lacks an international book series that is entirely dedicated to Technology Education. The International Technology Education Studies aim at providing the opportunity to publish more extensive texts than in journal articles, or to publish coherent collections of articles/chapters that focus on a certain theme. In this book series monographs and edited volumes will be published. The books will be peer reviewed in order to assure the quality of the texts.
International Handbook of Research and Development in Technology Education

Alister T. Jones
*University of Waikato, New Zealand*

and

Marc J. de Vries
*Delft University of Technology, The Netherlands*

*Associate Editor*
Cathy M. Buntting
*University of Waikato, New Zealand*

*Section Editors*
International Developments: Alister Jones
The Nature of Technology: Marc de Vries and John Dakers
Perceptions of Technology: John Dakers and Marc de Vries
Technology and STSE: Derek Hodson
Learning and Teaching: Robert McCormick
Assessment: Judy Moreland
Teacher Education: P. John Williams
Theoretical and Practical Approaches to Research: Alister Jones

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The *International Handbook of Research and Development in Technology Education* was borne out of discussions over a long period of time over a number of international conferences. In fact, it probably has its roots at the second Jerusalem International Science and Technology Education Conference (JISTEC) in 1996. This conference brought a number of us together to focus not just on research but also to consider implementation in a much wider historical, cultural and political context.

Ten to twelve years later the time appeared right for the writing of an international handbook. International handbooks represent significant markers in their respective fields and this handbook is no different. The field of technology education has reached a particular stage where it is possible to write such a book. In developing this book we have been able to reflect on the key characteristics of the field that is highlighted in the different named sections and also in the nature of the chapters themselves. We have been very fortunate with the enthusiasm of the section editors and the authors of the chapters themselves that they have not only identified the need for a handbook but they have whole heartedly committed themselves to it.

This book constitutes a significant collection of work from numerous countries and authors actively engaged in technology education research and development. This book is also unique in that it includes country overviews from developed and developing countries, philosophical discussions of the discipline of technology, as well as considerations of teaching, learning, assessment, teacher education and research. It is impossible to separate the development of a field from its historical, philosophical and social setting. Technology education is no different and this is reflected throughout the chapters.

We have considered it a privilege to work such people of influence in and commitment to the developing field of technology education. We trust that this handbook will contribute to the on-going development of the field and may be of benefit to those who read it.

*Alister Jones and Marc de Vries*  
*Editors*
1. THE DEVELOPING FIELD OF TECHNOLOGY EDUCATION: AN INTRODUCTION

INTRODUCTION

The fact that this *International Handbook of Research and Development in Technology Education* is now available indicates that technology education has grown out into a well-established field. Although it is still very much in development, there is a certain maturity that justifies presenting a survey of what has been accomplished in the past. That is why the editors and the publisher considered it to be timely to bring out this *Handbook*.

In this *Handbook*, all the main topics one would expect for an educational field are present: the underlying philosophy, curriculum development, relations with other subject areas, teacher education, assessment, and educational research. The (relative) maturity of technology education is illustrated by the fact that for each of these topics a sufficient number of high quality contributions could be commissioned. This introductory chapter offers an overall survey of the topics and the way they have developed in the (relatively short) history of technology education. Let us first consider what is meant by ‘technology education’ and related terms.

DEFINING THE FIELD

In this *Handbook*, we use the term ‘technology education’ to indicate the learning area that deals with the ways in which human beings change their environments to be better suited to their needs and wants, thereby using various types of knowledge. This description fits well with the current state of the philosophy of technology (see Section 2). Technologies surround us, and it makes sense to educate future citizens about this important aspect of our lives. It is another matter, though, to consider how this should be done. Does it mean a separate school subject is necessary? Or can one deal with technology entirely in the context of another school subject, be it science or something else? Does it require interdisciplinary projects at intervals in the normal curriculum? Different answers to these questions are provided in different countries, and for different school levels. For this reason, technology education is still a fairly fuzzy concept in spite of its current state of development. It is important to discuss a number of possible confusions.

The editor-in-chief of the *International Journal of Technology and Design Education* receives a substantial number of submitted articles that are rejected even before they are reviewed because they are not within the scope of the journal. These include articles that describe studies into the ways technology can be used to support the teaching and learning of various school subjects, such as science, mathematics, and languages. Apparently the term ‘technology education’ in the title of the journal has triggered scholars to submit articles in which technology is not the content of what is taught and learnt, but a means for teaching and learning about other issues. For that, however, the term ‘educational technology’ is more appropriate and more commonly used. This is a first confusion regarding the nature of technology education. Of course technology education and

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educational technology are not entirely unrelated. For instance, educational technologies can be applied in technology education no less than in other educational fields. Perhaps one can even consider technology education to be one of the most obvious learning areas where new technologies can enhance teaching and learning. Secondly, a good understanding of the possible and the appropriate role of technologies in the teaching of science, mathematics, languages, or any other subject area, assumes a good understanding of technology itself – and this is exactly what technology education aims at. Still, one can distinguish clearly between questions that are solely concerned with the effects of new technologies (new media in particular) on teaching and learning, whereby the technology itself is taken as a black box, and questions that concern the nature of the technology, whereby the black box is opened. The former is ‘educational technology’; the latter is ‘technology education’.

Another term related to technology education is ‘technological literacy’. This term is used to indicate an important aim of technology education, namely to provide students with a type of literacy that is important particularly for the technological society in which we live. Not only do people need to be able to read and write (the original meaning of the term ‘literacy’) and use numbers (numerical literacy), they also need to be able to use and control technological devices and systems. The term ‘technological literacy’ is not identical to ‘technology education’ because the aim of helping students to acquire technological literacy can partially be done in the teaching and learning of other domains in which technology is not the main focus. The term ‘technology education’ is applied to teaching and learning in which technology is the main focus.

A third related term is ‘engineering education’. This term, too, must be distinguished from the term ‘technology education’. Engineering is the domain of professions concerned with the development and maintenance of technological devices and systems. Although engineers use technology, like citizens also do, this is not their primary role. The work of engineers is to design new technological solutions to practical problems, or to improve existing systems. In order to do this, engineers use knowledge about the physical and chemical phenomena that underlie the functioning of artefacts and systems. They also use knowledge of mathematics for modelling and making calculations. Technology education is broader than engineering education because it also considers what users need to know and be able to do. Another difference that is sometimes articulated is that technology education covers the human and social aspects of technology, whereas engineering education only deals with the ‘hard’ aspects of technology. This, however, is in conflict with many developments in engineering education today; it has become clear that engineers cannot do a good job without taking into account the human and social aspects. Every technological problem is a socio-technological problem, and therefore needs to be approached as such. This has caused important changes in the education of engineers. It has certainly brought engineering education closer to technology education, as engineers are now often taught to imagine themselves in the position of users. Nevertheless, there is still a difference. In engineering education, students are still primarily prepared to become engineers; in technology education, students are prepared to become citizens, irrespective of their future career.

The term ‘engineering education’ is closely related to another term than can easily cause confusion about the nature of technology education, namely ‘vocational education’. Like engineering, vocational education prepares for a specific profession. Technology education, in contrast, offers an introduction to technology as a component of both our professional life and our life as a consumer and citizen. Consequently, vocational education – like engineering education – deals with technology in a much more detailed and in-depth way. This is only possible due to the limited scope of vocational education. Put another way, technology education is a form of generic education, whereas vocational education is a form of specialised education. Sometimes vocational education is seen as part of technology education. In this Handbook, however, the term
‘technology education’ is used to refer to the type of education that primarily contributes to the general education of all future citizens.

THE DEVELOPMENT OF TECHNOLOGY EDUCATION

Although now sufficiently mature to warrant having its own handbook, technology education is still a latecomer in education. It was only in the past two or three decades that it has been developed on a worldwide scale (see De Vries 2000; 2006). In this respect it is relatively new. But ‘new’ is not to be taken in an absolute sense. In many cases technology education emerged from an already existing subject. In most countries that subject was craft. The history of technology education can to a large extent be characterised as the effort to move away from this past, both in content and in reputation. However, technology education continues to struggle with inappropriate popular images of what it is. Policy makers, school boards, parents, and industry still tend to think of technology education as a school subject in which pupils learn to make simple devices by processing materials with a variety of hand tools and simple machines. These prejudices are extremely hard to correct.

The development of technology education is also hampered by competition with science education. In principle, science education and technology education need not be competitors, but in practice this is often the case. The simple explanation is again related to terminology: it is commonly said and heard that televisions, mobile phones, computers, and other such devices are the outcome of science, not of technology. In newspapers, one reads that “scientists have invented a new type of device for …”, while actually invention is not the work of scientists, but of technologists. This has to do with an old and deeply embedded preference for valuing the cognitive over the practical. We admire the new high-tech devices that we see around us, and because of their sophistication we think that they must be the work of scientists. Technology, in contrast, is associated with technicians and what are considered to be simple tasks, like repairing the toilet or screwing a plug onto a wire. It will take a long time for such prejudices to be outgrown, and in the meantime technology education will continue to struggle against the stronger position of science education in the school curriculum.

Over the course of time, technology educators have adopted different approaches to overcome this prejudicial barrier. One obvious way has been ‘if you can’t beat them, join them’. This, however, still assumes that science and technology are competitors – not a very fruitful way of thinking. There are good reasons related to the nature of both science and technology that these two learning areas can be related. For instance, science does play an important role in technology because it offers insights into the sort of variables designers can consider for optimising their designs. Vice versa, technology offers instruments to scientists for experimenting, measuring, and processing data. If one then also realises that this interaction between science and technology does not take place in a vacuum, but is embedded in a social context, one ends up with a type of education that is often called ‘Science, Technology and Society’, or STS. In theory, this could be an appropriate way to teach about both science and technology (see Section 4). In practice, however, the central T is crushed between the surrounding S’s and the practice has often been to use technology merely as a motivating context for teaching science. It is the social relevance of technology that features in such STS teaching, not the nature of technology itself. STS has thus tended to problematise the development of technology education, rather than acting as a stimulus.

An alternative route for addressing the problem of competition with science education is to develop technology education into a separate subject in which the specific characteristics of technology are strongly emphasised and used to differentiate it from science. There are certainly many opportunities for doing this, and in fact a lot of recent insights in the philosophy of
technology deal with such specifics. One such distinguishing element is the normative dimension in technological knowledge, which is absent in scientific knowledge; another relates to the ‘designerly’ ways of thinking identified by design methodologists (‘means-ends’ reasoning as opposed to ‘cause-effect’ reasoning). In general, design as a distinguishing activity in technology has been put forward to promote technology education as a distinct area in the curriculum (as opposed to ‘investigating’ in science). The manipulation of tools and materials, inherited from past emphasis on crafts, also often features as a distinct characteristic of technology education.

The outcome is that in many countries technology education has become a separate school subject (see Section 1). In some, it has survived serious threats of being removed from the curriculum (e.g., in South Africa and Sweden). When this text was written (November 2008), technology education in Australia faced a similar threat. In many countries it still struggles to maintain its position in the curriculum. Even in the United Kingdom, where ‘Design and Technology’ (D&T) had a longstanding status as a compulsory subject for pupils of ages 6–18, it is elective for upper secondary education (ages 16–18) and its status is probably already under negotiations when this Handbook is published.

Other countries have integrated an existing subject ‘technology’ (or whatever the name may be) with science education. In these cases, there is potential to create a positive combination in which the nature of both is done justice, balanced with the risk that technology will simply be absorbed by science (this scenario threatens technology education in, for example, the Netherlands). In contrast, technology education is making significant progress in countries like New Zealand; in others it maintains its craft emphasis (e.g., Switzerland, Denmark). In a large country such as the United States of America, we find different practices in different states, and the main activity of the International Technology Education Association (ITEA) in that country has been to create some unification in this palette to strengthen the overall position of technology education in the curriculum across the country. The Standards for Technological Literacy (ITEA, 2000/2002/2007) has been a major accomplishment in this context.

MOTIVES AND STAKEHOLDERS IN TECHNOLOGY EDUCATION

The development of technology education in the school curriculum has been driven by several motives. The most obvious, of course, is the fact that technology plays such an important role in society, and that citizens must be technologically literate in order to be able to live in and contribute meaningfully to such a society. A similar, but probably more vulnerable, motive is that technology education is the subject ‘par excellence’ to stimulate general abilities such as creativity, problem solving, and communication skills. This ambition, however, is not unproblematic. Research studies have shown that these skills are much more context-dependent than was assumed in the past. One can therefore question if learning how to solve a technological problem will ‘automatically’ also improve pupils’ abilities in solving other problems. It seems that one can indeed transfer from one context to another, but still not have achieved a ‘general’ level of skill.

A third motive for technology education is that pupils need to learn about the nature of technology as a possible field of studies and future career pathway. In many countries, shortage in the number of engineers is a continuous concern and technology education is seen as a means for promoting post-school technological studies and professions. The risk of drawing too heavily on this motive is that it will move technology education in the direction of vocational education, with negative effects on its status and maybe also negative (narrowing) effects on its scope and content.

Ultimately, the primary motivation depends, of course, on the stakeholder that promotes it. Although no data are available on which stakeholders prefer which motive, the following analysis seems plausible: Technology educators themselves tend to put most emphasis on the cultural and
social importance of learning about technology. Governments and industries often have primary interest in assuring a sufficient future workforce. Parents and school boards tend to focus on the general educative merits of technology education, such as its contribution to stimulating creativity and problem-solving skills. For pupils, a new motive appears in cases where they have encountered effective technology education: It is fun! In such cases, pupils may experience technology education as a welcome change in a curriculum that is otherwise filled with more abstract subjects.

We have already seen that developments in technology education have been hampered from negative images of the subject. A further problem arises from ways in which stakeholders assess technology education against the purposes to which they subscribe. All stakeholders tend to be impatient when it comes to the realisation of the motives for technology education. Although no school subject has ever been removed from the curriculum because it did not result in measurable social effects within a time span as short as one or two decades, or even only one government period, technology education has been expected to meet and fulfil such unrealistic expectations. When, for example, enrolment numbers for engineering studies do not increase within a couple of years, it is assumed that technology education has failed to achieve its goals.

THE LONG-TERM AIM OF TECHNOLOGY EDUCATION
AND WHAT IT REQUIRES

The naïve thinking sketched above does not do justice to the fact that the most important aims of technology can only be realised in the long run. For the realisation of all the motives mentioned in the previous section, it is necessary for technology education to result in helping students to develop an appropriate concept of technology, an understanding of the basic concepts in technology, and a positive-critical attitude towards technology (see Section 4). Many technology educators are of the opinion that in order to reach these goals, it is best to give students experiences in undertaking the process of technology. Going through a process of designing is probably the best way to learn that technology is a human endeavour in which decision making, based on normative judgments, and the use of a variety of knowledge domains plays a vital role. This approach has the additional advantage that it connects the various types of literacies that are aimed at in general education; designing entails the use of language, symbols, and numbers. In this way, doing design connects technological literacy with linguistic and numerical literacy. Sometimes this multi-literacy is used as an additional motive for having technology education in the school curriculum. A factor that can further enhance this multi-literacy is the increased role of new media and other technologies in technology education.

This multi-literacy learning can only take place when a number of conditions are fulfilled. In the first place, teachers are needed that have an appropriate attitude and the necessary knowledge and skills to be able to design and implement teaching and learning situations and environments conducive to such learning (see Section 5). Teacher education programmes thus need to be targeted towards educating such teachers (see Section 7). Secondly, teachers, teacher educators, and curriculum developers need to develop curricula and teaching materials that such teachers can use. Thirdly, the assessment of technology education, both formative and summative, must be rich and multifaceted in order to assure that multi-literacy teaching and learning takes place (see Section 6).

Fourthly, industry support is needed to ensure the ‘empirical validity’ of technology education. Sometimes it is feared that industry involvement in technology education will narrow its scope, but this overlooks the fact that industries in the past decades have learnt a great deal about the importance of human and social aspects of technology. In some countries, like Germany, it is even
industry in particular that challenges technology education to emphasise this multi-literacy (for which the term *schlüsselqualifikationen* or ‘key competencies’ is used).

A fifth crucial factor in the development of such learning is that the development of technology is supported by sound educational research. A true ‘R&D culture’ is thus needed for technology education to continue to grow and develop. It is an area in particular that still leaves much to be desired, and this Handbook includes a special focus on research for technology education (Section 8). It is here that it becomes perhaps most clear that the Handbook should be seen as a torch rather than as a milestone. Much of what is written needs further development in order to reach its full value, and the Handbook is thus forward-looking rather than backward-looking. Alister Jones resumes this point in his concluding section.

A final condition for reaching the long-term aims of technology education is the development of a continuous path of learning through the various levels of education. Many countries are still far removed from this situation. Ideally, pupils would get a first orientation and awareness in preschool and primary education, a learning of basic concepts and processes in lower secondary, a more precise and differentiated image of (the various types of) technology in upper secondary, and specialisation in tertiary education (higher vocational or academic). This condition appears more and more to also affect for the survival of technology education in the school curriculum. For example, in the countries where technology education is or has been under threat, the fact that technology education was only present in some levels of education contributed significantly to its vulnerability. Subjects that are only taught in lower secondary education and are not part of the exam syllabus are almost inevitably doomed to get a low status. This unfortunately holds for technology education in many situations. In addition, having technology education as part of lower secondary education but not in primary education (which is the case in many countries) means that the position of technology education is open to attack. Apart from the educational value, a continuous learning pathway is therefore a prerequisite for the success of technology education.

**INTERNATIONAL DEVELOPMENTS**

One of the driving forces behind the development of technology education, apart from the ones that have already been mentioned, is the increasing level of international cooperation. One of the most obvious effects of this is the blending of elements from different national traditions in technology education curricula. As Section 1 shows, technology education emerged from a form of craft education in the majority of countries, although the direction in which it emerged differed. In some countries, design was brought in as a new element (as was the case in the United Kingdom). In other countries, such as the countries that were part of the former East Block in Europe, industrial production became the new focus. In yet others, learning concepts (that is, an enhancement of the cognitive element) became the new trend whilst others brought in ‘high tech’ elements, such as robotics. Finally, some countries emphasised the social aspect as a new ingredient. Thus, a spectrum of approaches in technology education has developed worldwide. Due to international conferences where people representing different approaches have met and exchanged ideas, elements from these approaches were transferred and curricula with richer combinations of elements developed.

One of the first organisations that initiated international exchange of information was the American Industrial Arts Association that changed its name into International Technology Education Association (ITEA) to indicate firstly a shift away from craft-based education and secondly an interest in internationalisation. At around the same period, the series of international PATT conferences started. PATT is the acronym for Pupils’ Attitudes Towards Technology. This name referred to attitude research among pupils, which was the original interest of the PATT
conferences. Later, the scope of the conferences widened and specific themes were defined for each conference. Cooperation with ITEA was established and since then international sessions are a recurring phenomenon at the ITEA conferences, held annually in the USA. Another organisation that initiated international cooperation and meetings was the World Council of Associations for Technology Education (WOCATE). The early death of its founder, Dietrich Blandow, however, meant a substantial reduction in activities and today its existence is not much beyond a formality only. In the UK, the International Design And Technology Education Research (IDATER) conferences for some years functioned as a platform for exchange of research output, but they no longer exist. To some extent the conferences organised by the UK’s teachers association DATA (Design And Technology Association) have taken over this role.

Apart from these conferences and their organising bodies, the international journals act as a vehicle for the internationalisation of technology education. Of these, the International Journal for Technology and Design Education is the only one published by an academic (commercial) publisher, namely Springer (formerly Kluwer Academic Publishers). The Journal of Technology Education is published under the auspices of ITEA. Then there is the Journal of Technology Studies, published by Epsilon Pi Taw, a USA-based fraternity for technology education. The Journal for Design and Technology Education, published by DATA, increasingly has an international character, visible in both its editorial board and its contributing authors. Apart from the academic journals, several book series exist for technology education. Sense Publishers, an academic publisher founded fairly recently, publishes the International Technology Education Series, of which this Handbook is one volume. Springer publishes the International Science and Technology Library, which includes some titles with a strong technology focus.

The result of these efforts to bring together knowledge and experience from different countries has not only been the merging of elements from different approaches to technology education internationally, but also the emergence of international research projects. The DEPTH project, for instance, was initiated at a PATT conference and the results were later published in the International Journal of Technology and Design Education. Effort has also been placed on producing an international agenda for technology education research, but this has to date not led to a substantial effort to coordinate international research for technology education. The idea of an international technology education curriculum has also been raised at several conferences, but that has not resulted in any practical outcomes. The differences in (national) contexts appear to be a very real barrier for more drastic internationalisation of technology education. The more modest efforts, though, clearly have had an impact on technology education practice. International contacts have also been instrumental in supporting technology educators in, for example South-Africa and Sweden, in their efforts to save the position of technology education in their national curricula.

TECHNOLOGY EDUCATION AND GENDER

Glancing through the Table of Contents, a reader may wonder why there is no separate section, or even chapter, about the technology education and gender. Most introductory technology education books have such a section, with good reason. This issue has been an important topic for research and development work, attitude studies showing time and again that females hold different concepts of technology – and different attitudes towards it – when compared with males. Usually this impacts negatively on technological study and career choices. However, despite all the efforts made to date, the problem has not been adequately resolved. Gender differences continue to be deeply embedded in our society, and no doubt embedded in our being human. But this does not have to mean that one gender is more suited to technology than the other; some comparative
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studies of male and female performance in technology education suggest that girls outperform boys in terms of design creativity and sensitivity to usability issues. However, this does not – in general – help when it comes to the social acceptance of women in engineering. The issue is particularly difficult to tackle because on the surface it seems that nothing is wrong; there are no formal restrictions that keep women from being involved in technology. However, references to a ‘glass ceiling’ in career pathways are common and although this ceiling cannot be seen, women can hit their heads hard against it.

We chose not to dedicate a specific chapter or section to this issue in the Handbook in order to acknowledge that it is not – and cannot be seen as – an isolated issue. Neither can it be solved by treating it as an isolated problem; introducing specific ‘female friendly’ topics in technology education often has no measurable effect. A more fruitful approach could be to develop good technology education that does justice to what technology really is, and then to expect that technology as a human activity – in which both men and women have been involved from the beginning – will enable pupils of both genders to live out their capacities and interests. Good design projects will necessarily draw from creativity and involve an interest for humans, and if this appeals to girls more than boys, so be it. Equally, when this is not true and creativity is evenly distributed between girls and boys, the project will still appeal to girls.

The Handbook includes several chapters in which the gender issue is raised, but always in relation to the topic of the particular chapter. Thus we avoid the impression that the gender issue is something that can be dealt with in isolation from other issues.

READERS AND AUTHORS

The purpose of publishing this Handbook is to provide a general introduction to the field of technology education those on the relative outskirts of technology education, and as a source of information for those involved in it. We believe it can also serve as a reference text for teacher education programs to introduce future technology teachers to issues relevant to their (future) field of teaching.

In the course of this introduction chapter, the eight sections have been introduced. The editor of each section has written an introduction that provides more detailed information about the chapters in the section, as well as a more in-depth introduction to the topic with which the section is concerned. Finally, Alister Jones bring together the various topics in his closing chapter, presenting a final consideration of the future of technology education that focuses particularly on the quest for the sustainability of technology education as an often threatened learning area.

Readers will notice that the various chapters in this Handbook differ in nature. These differences are often related to the various backgrounds from which the authors have contributed their texts. Several of the authors in Section 2 (in particular the philosophers of technology) are not directly involved in technology education but have developed insights that can serve as a resource for those that are. Other authors are involved in technology education, but only as researchers and not in technology education practice. This may sometimes give a certain colour of distance to their texts, although mostly it is not difficult to imagine consequences for technology education classroom practice. Other authors, mainly those in Section 4) write from a science or STS education background. This is at times reflected in their use of the word ‘science’ to indicate both science and technology. Finally, there are authors that are directly involved in technology education practice, either as teacher educators or as technology teachers. Their chapters, of course, reveal a great degree of practical experience. Many of the teacher educators combine educational research and teacher training. In this context, a direct translation of research output into educational practice is not only possible, but often realised. Perhaps the gap between research outputs and the use of those
outputs for improving and enhancing practice is one of the most difficult to bridge. Hopefully this Handbook, which brings together issues in technology education research and in technology education practice, can help.

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Marc de Vries
Faculty of Applied Sciences
Delft University of Technology
Delft, The Netherlands
SECTION 1

INTERNATIONAL DEVELOPMENTS
2. THE DEVELOPMENT OF TECHNOLOGY EDUCATION INTERNATIONALLY

The last 15–20 years have seen the emergence of technology as an area of study in its own right and the development of school curricula in Australia, the United Kingdom, USA, Canada, Europe, South Africa, and New Zealand that emphasise the importance of students developing technological literacy.

The development of technology education within countries and regions is set within the historical, cultural, and political environment. Curriculum, teacher education, and in fact educational research do not sit in isolation from these. Each of the chapters in this section sets out the context for technology education in its respective country and provides a historical and political analysis of the development of technology education as a field of development. The history of technology education is a long one if we consider its development back to the days of craft, and in this section many of the chapters trace the journey from craft through to much broader notions of technology and technological literacy.

In Chapter 3, Clare Benson explores the development of design and technology in the curriculum of England. She traces the development of over 50 years, through the different political and educational agendas from the 1950s until the mid 2000s. The subject of craft, design and technology (CDT) was developed in the 1980s to expand the notion of craft, with its gendered and set pieces to include planning and thinking. However, national assessment and/or monitoring can have a large impact on the possible development and implementation of a new subject and Clare highlights the influence of the Assessment Performance Unit on the development of design and technology curricula. In addition, external professional bodies such as Design Councils and engineering groups can act as advocates for a curriculum, but also limit its development.

Literacy and numeracy initiatives as well as over-crowded curriculum can lead to a reduction in curriculum time in ‘new’ subject areas such as technology, particularly in primary schools. Different subject subcultures also influence the interpretation of a curriculum area like technology, which can be perceived as an applied science or craft depending on the background of the teacher (Jones, 1997). Clare highlights the different influences on the 1990s curriculum revisions in England and the fact that there was little professional development available for teachers. She concludes that whilst good practice in design and technology is developing in England, teacher knowledge remains a significant barrier to effective national practice.

Jacques Ginestié in Chapter 4 presents the ways in which technology education is represented in France, particularly with respect to technology education research. Jacques also highlights the way that more dominant subject subcultures can influence how technology education is perceived and operationalised in curricula and research. The identification and articulation of knowledge suitable for technology education is an open-ended problem and highlights the fragility of technology education. However, although Jacques indicates that the emerging area of technology may be somewhat fragile in nature, there is a world wide movement to develop a more robust framework.
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Tapani Kananoja introduces an historical perspective to technology education in Finland in Chapter 5 and notes that the teaching of practical skills and technology in general education was evident in Europe as early as the seventeenth century as ‘education for work’. Handicrafts were included in the Finnish curriculum in 1866, reflecting the main aim of the curriculum as training the future workforce. Industrial arts were included in the 1920s as the technical skills required for work changed.

Building on the notion of industrial arts, William (Bill) Dugger analyses the development of technology education in the United States of America in Chapter 6, noting that in industrial arts evolved from manual arts in the late 1800s and early 1900s. ‘Technology’ was used in the 1970s and 1980s by particular curriculum development projects. Although curriculum can be agreed at the national level in the USA, the way it is implemented – or even included – is defined at the State and even the school district level. The development of the national curriculum – *Standards for Technological Literacy: Content for the Study of Technology* [STS] (International Technology Education Association [ITEA], 2000/2002/2007) – is discussed in detail. Very rarely do we get such an insight into the development of a national curriculum from an insider’s perspective, including the ways in which curriculum and stakeholders interact.

The STS makes a strong call to educators, engineers, scientists, mathematicians, and parents for the notion of ‘technological literacy for all’. However, this is not federally mandated in the US, nor is it an actual curriculum for direct implementation in schools but rather a framework for developing a curriculum. The ITEA released *Advancing Excellence in Technological Literacy* in 2003. This document outlines the standards and principles in relation to assessment, professional development, and programme implementation. The integration of these is one of the strengths of this approach to curriculum. Too often in national curriculum development, their isolation becomes a barrier to successful implementation. Bill concludes his chapter with the sobering note that technology education and technological literacy will become a reality for our students of tomorrow only when the different sectors in the country work together to this end.

The implementation of the technology as a curriculum area is always diverse when a country’s education system is run at the national and state/provincial/local level. This is true for Canada as well as the US, and in Chapter 7 Anne Marie Hill provides a thorough analysis of the recent research and development in the study of technology in Canada, with its 10 provinces and 3 territories. One of the interesting pieces of analysis to come through in commentaries and research evidence is that students enjoy technology as a subject in schools. Anne Marie provides an historical account of Canada to set the context for curriculum and curriculum development, illustrating the multifaceted nature of education in Canada and the political nature of curriculum development. Although most places internationally have had a history of technical education in secondary schooling and this has moved to broaden into technology education, Anne Marie highlights that if we are to have effective technology education in secondary schools we must start with effective technology education programmes at the elementary/primary end of the school system.

Australia is in some ways similar to Canada in that there is some federal influence on curriculum, although it is mainly a state responsibility. Howard Middleton in Chapter 8 outlines the development of technology as a key learning area at the national level, highlighting the importance of co-operation between researchers, administrators, schools, and teachers. He goes on to report on ways in which researchers are exploring issues in the teaching and learning of technology. The disconnection between having a curriculum but being slow to implement professional development opportunities for teachers is raised. As has been found in other countries, primary teachers are enthusiastic about technology whereas at the secondary school level there has been a much more mixed response. For effective implementation of technology, then, there not only needs to be effective teacher professional development, but effective
pre-service teacher education programmes also need to be developed, including the appropriation of government scholarships to encourage people into technology teaching. Although pre-service and in-service training are important aspects of curriculum implementation, Howard also highlights the productiveness of working collaboratively at the national, state, and local level to implement technology education. In the development and implementation of a new curriculum area there are always tensions and contradictions, particularly around general technology education and vocational education, shortening teacher education programmes, and more instrumental approaches to research.

Although New Zealand and Australia collaborate in areas of education, the national systems are different. Whereas Australia has a federal and state approach to education, New Zealand has a national approach due mainly to its small size. Like other countries, New Zealand has had a history of technical education and in fact has had a national curriculum since the late 1870s. Chapter 9 provides background on the education system both from a historical and more recent perspective. As in other countries, technology emerged as an area in its own right in the 1990s with the development of the national curriculum (which was reviewed from 2001), national research projects, and national assessment and monitoring. In 2006-2008 changes were made to the curriculum to reinforce the notion of technological knowledge and practice, as well as students developing an understanding of the nature of technology.

Associated with the development of the technology curriculum in NZ has been a significant increase in the technology education research over the last 20 years. From 1990 onwards there has been a developing postgraduate research culture in technology education, including a focus on classroom studies. In the early days of the implementation of the curriculum there was a strong national focus on professional development. However, this was only for a limited time. The area of senior secondary technology became a concern and significant resources were obtained to enhance this area. These resources have expanded beyond senior secondary school and have the potential to significantly enhance technology education in the lower secondary level. However, concern must be expressed about the pressures of major curriculum revision by primary teachers, particularly with emphases on literacy and numeracy. Like Australia, the government is responding to the technology teacher shortage by introducing scholarships for pre-service teacher qualifications. Specific attempts have been made to link research, teacher education, professional development, and the curriculum framework together. Only time will tell if this has been an effective way forward.

In Chapter 10, Chitra Natarajan and Sugra Chunawala outline the development of technology and vocational education in India, showing strong links between the two. Similar to other chapters, they provide an historical perspective of the education system through to its current structure. The link between the structure of schooling and the structure of work is an important context in this chapter. In terms of curriculum change, Chitra and Sugra highlight that the current education system does not necessarily encourage collaboration and that there is a tendency to shy away from radical changes. The possible breadth of technology education also causes some difficulties in implementation, as do the inclusion of creativity and choice. This chapter clearly articulates how historical, political, social, and environmental perspective can both facilitate and constrain curriculum change.

Similarly, in Chapter 11 Bangping Ding provides an historical and social analysis of technology education in China, where labour-technical education has been officially recognised as a school subject in primary and secondary schools since the 1980s. However, Bangping highlights that China is no different from other countries in experiencing difficulties implementing a new curriculum. In particular, the influence of exit examinations, the shortage of qualified teachers, lack of resources, the influence of parents, and assessment methods constrain implementation. Given the size of China, Bangping uses the examples of Shanghai and Beijing to describe the
emergence of technology education in secondary schools and the growing influence to move away from technical skills to general technological literacy and replacing labour-technical education with technology education.

In Chapter 12 Andrew Stevens again highlights the ways historical and social issues influence curriculum development. South Africa has undergone radical political and social reform in the last two decades, with educational reform being part of this. Teacher education has also been restructured, impacting on the implementation of technology education. The country, as Andrew notes, is still in a period of transition.

Research has mainly focused on the development and implementation of the curriculum and this needs to expand to highlight a way forward for technology education in South Africa.

All curriculum development is set within the social and political fabric of a nation and or state, in fact all curricula are essentially political. The opportunities for research and development are also influenced by the political frame. This section provides a sound basis from which to interpret the development of technology education research, development, teacher education, and curriculum.

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Alister Jones
School of Education
University of Waikato
Hamilton, New Zealand
3. DESIGN AND TECHNOLOGY: A ‘NEW’ SUBJECT FOR THE ENGLISH NATIONAL CURRICULUM

INTRODUCTION

This chapter will outline the introduction and development of a ‘new’ curriculum area into the English National Curriculum in 1990. The background to this major educational change will be given; a rationale for the introduction of a National Curriculum in design and technology will be suggested; the developments from 1989 until 2008 will be discussed; and future pathways will be explored.

BACKGROUND TO THE INTRODUCTION OF A NEW SUBJECT

Not since the 1944 Education Act had such a major reform of educational policy taken place in England, together with Wales, as that which took place following the Education Reform Act 1988. Whilst there may always be a tension between two major aims of education – to provide education as a right to the individual, and to promote education as a means of providing economic success – the 1944 Education Act attempted to cover both purposes (Encarta, n.d.). In theory, schools had freedom to create their own syllabi and identify their own priorities, linked to the needs of individuals, until pupils reached 14 years and national examinations placed certain restrictions on the curricula that were offered. Pupils in primary schools (aged 5-11 years) had opportunities to do craft, woodwork, sewing and cooking. In science they mainly studied the natural world relating to flora and fauna, and areas such as mechanisms, forces, structures, and energy were largely ignored. In secondary schools (pupils aged 11-14 years) studies included woodwork, needlework, cooking, building work, and metal work. Whilst there were no regulations prohibiting girls and boys from taking particular specialisms, often girls were not given the opportunity to take, for example, wood work and metal work and had to opt for needlework and cooking, and vice versa. These handicraft and domestic science subjects were accorded a higher status with the creation of national exams (General Certificate in Education, GCE) but it also led to an almost total lack of creativity as pupils had to produce set pieces and learn different procedures by rote.

During the 1950s and particularly the 1960s there was a continuing movement towards focusing on the provision of education for individuals even if it produced little, if any, return (Central Advisory Council for Education [CACE], 1959). The establishment of the Schools Council in 1964 focused on the needs of pupils who were not following traditional academic courses and the Plowden Committee (CACE, 1967) discussed providing primary children with more informal experiences in the classroom. Teachers were encouraged to follow their pupils’ individual interests through topic work to help engage all children in their learning.

With knowledge and understanding constantly evolving to take account of the rapid changes in the designed and made world, recognition was given to the need for the curriculum to prepare pupils to be adaptable, to participate actively in acquiring new knowledge and skills, to be able to solve problems, and to make decisions (Eggleston, 1996). Even in 1955, Friedman wrote of the need to prepare pupils for job changes throughout their careers as a single occupation for life could not be thought of as the norm. Design and technology was well placed even then to provide pupils with the kinds of experiences that would help them throughout their lives.

At the start of the 1970s, economic recession affected the amount of money available for the education budget and tighter controls on spending were introduced. This was coupled with a backlash by some (Cox & Boyson, 1977; Cox & Dyson, 1969) against what they saw as a decline in standards through the laissez-faire attitudes towards educational structures. In 1976, James Callaghan gave his now famous speech at Ruskin College in which he declared that too many pupils, from 16-18 years, were studying arts and humanities and not science and technology, which he felt would not lead directly to increasing economic and commercial wellbeing. However, it was during the 1980s, particularly in secondary education, that a number of initiatives developed curriculum ideas that fundamentally influenced the development of design and technology to what it is today.

One initiative that attempted to redress the balance in favour of science and technology for those pupils who wanted to follow a more vocational path was established following the Manpower Services Commission’s brief in 1982. Called the Technical and Vocational Education Initiative (TVEI), it had a clear aim and purpose and was a step towards a more government-controlled education policy where economic purposes were given a higher priority than those of education for the individual. Courses included those in computer studies and information technology. Initially schools were given generous funding, and were then well placed to teach the new subject ‘design and technology’ as it came on stream.

Other, more powerful initiatives included two projects – Project Technology and the Design and Craft Education Project – that led to a reforming movement in the secondary school curriculum to introduce two new subjects: Technology and Design (Eggleston, 1996). Practical support for teachers came from both projects in the form of published resources, providing much needed ideas and strategies for implementation. By the early 1980s the reforming movement led to the creation of the subject Craft, Design and Technology (CDT). Its acceptance as a subject is outlined in an article published in The Sunday Times newspaper (5 March 1989), highlighted the fact that CDT was more than just a practical subject and that it involves a great deal of thought and planning. The subject brought together manual, intellectual, and organisational skills – all of which are vital in preparing pupils for living and working in a technological world (Eggleston, 1996). This notion has continued, and is embedded in the ‘Importance’ statement in the National Curriculum revision (Department for Education and Science [DES]/Qualifications and Curriculum Authority [QCA], 1999). The insightful article is unusual as even in 2008 many educational press reports and articles fail to draw out the nature of CDT as a subject, focusing instead on the practical, making element of design and technology.

Perhaps the most powerful initiative in the development of secondary design and technology in the late 1970s and 1980s came through the Assessment of Performance Unit project (APU). Whilst this project started to look at assessment in English, mathematics, and science, both in primary and secondary schools, a strong lobby resulted finally in a project that focused on the teaching and assessing of the subject design and technology at the secondary school level. A pilot study was conducted by Nottingham Trent University before a major project was established at Goldsmiths College, London University in 1986. This project was ongoing throughout the development of the...
National Curriculum, with findings starting to be published in the early 1990s (Schools Examination and Assessment Council, 1991).

Throughout this period, design and technology did not grow significantly in primary schools, where handicrafts were still an important and enjoyable element of the curriculum for most. The Design Council had promoted the teaching of Design, and where there were individual enthusiasts pupils were given exciting experiences in this area. It was not until the National Curriculum (1990) that most primary schools realised that they had to plan for this curriculum area, despite a majority of teachers having little understanding of the nature and value of the subject.

THE NEW NATIONAL CURRICULUM FOR DESIGN AND TECHNOLOGY

Interestingly, even in the late 1970s, Her Majesty’s Inspectorate was still promoting experiences for the individual, and suggested organising the curriculum in areas of experience, including technological experience, rather than traditional subjects (DES, 1977). This was not taken up, and against a climate of change towards more control of the curriculum, the creation of a Consultation group and publication of its findings in a paper (DES/Welsh Office [WO], 1987) marked the end of an era that had highlighted the importance of meeting the needs of all pupils. In 1988, the Education Reform Act led the way for a National Curriculum to be written and published initially for English, mathematics, and science in 1989, followed in March 1990 by Design and Technology and other foundation subjects. Implementation of Design and Technology was to be started from September 1990 in all state schools in England and Wales for children aged 5-16 years. Pupils aged 16-18 years would follow vocational courses or exam syllabi set by the exam boards. Wales continued to be joined to England, but separated after the 1995 National Curriculum. Scotland and Northern Ireland had different curricula and have continued their own development of the subject. Scotland has National Guidance rather than a National Curriculum, and both countries incorporate Technology within broader areas of experience.

The content of each subject area was developed by working parties, mainly working in isolation from each other. This resulted in an overloaded curriculum and lack of coherence, continuity, and progression, especially at primary level. The chairperson of the Design and Technology Working Group, Lady Parkes, was lobbied by different pressure groups as the work progressed – the design lobby led to the inclusion of the word ‘design’ in the title; the science lobby pushed for a focus that would lead the subject down the ‘appliance of science path’; the home economists were afraid of losing food and textiles to design and technology and wanted them to be separate; and the business and vocational lobbies wanted to keep their places in the curriculum, rather than have them integrated into Design and Technology. The working group was composed mainly from business and industry and those with secondary or higher education backgrounds. Primary views were certainly not strongly represented. Indeed, the science working party had much to do with the initial development of primary Design and Technology, creating a different philosophy to that of secondary Design and Technology. However, the group soon handed the subject over to the newly created Design and Technology Working Group and a more coherent approach to both phases of schooling was developed. Damage was done, however, as open discussions from the group resulted in early misconceptions of the nature of the subject in primary schools. The ‘appliance of science’ view was really only dispelled during the late 1990s.

Finally, on publication the subject was joined with Information Technology into one document entitled Technology in the National Curriculum (DES/WO, 1990); it was in two parts: design and technology capability, and information technology capability. If there had been confusion and misconceptions before, this only served to add to the problem. Primary teachers in particular, who mostly had little knowledge and expertise in the area, immediately thought that the subject focused
on computers. Unpublished surveys undertaken by the author for the five years after 1990 found that this was a common perception held even by those leading the subject in their primary schools. This was less of a problem for secondary teachers as they only had one subject to focus on – Design and Technology – and they had more time to disentangle the mixed messages contained in the documentation.

The content of the document was organised under four Attainment Targets (DES, 1998b), reduced from five in the interim report (DES, 1998a):
- AT1. Identifying needs and opportunities;
- AT2. Generating a design;
- AT3. Planning and Making; and

Each Attainment Target had a different weighting when assessing pupil progress and the whole process was unwieldy, unworkable, and complex. The layout of the Programmes of Study was confusing and the examples given were all taken from different contexts so that it was impossible to follow through one context and see how an holistic experience could be achieved. Pupils were to be given experiences related to artefacts, systems, and environments – words that meant little to many primary teachers.

As implementation got underway, perhaps the most disappointing development was the way in which the subject was delivered. Teachers both in primary and secondary schools saw the four Attainment Targets as a linear process to be worked through, rather than areas that could be covered in innovative and flexible ways. This was hardly surprising. With little previous knowledge, and little continuing professional development (CPD), teachers looked for strategies that would help them; working through four Attainment Targets gave them a structure, albeit a rigid one.

When the ‘new’ subject Design and technology was finally acknowledged and created for primary and secondary pupils, the challenge that this laid down for both primary and secondary schools was almost overwhelming in different ways. Against a background of primary teacher subject knowledge and skills primarily in art and craft, nature studies, cooking and needlework, and many secondary teachers’ expertise in, for example, domestic science, woodwork, and metalwork, teachers were expected to understand, plan, and deliver a ‘new’ subject that was different in nature to any existing curricula. In addition, primary teachers had to implement the National Curriculum in eight other subjects, including the core subjects of English, mathematics, and science. Little, if any, support for implementation was organised except for the core subjects; few resources were available, partly due to the short time scale between publication of the National Curriculum and its implementation; CPD was almost non-existent in design and technology, partly due to the very small number of people who could provide relevant courses; and, perhaps most importantly, there was confusion as to the nature of the subject. It would be fair to say that many primary teachers concentrated on implementing the core subjects as the pressure of testing and target-setting grew, and despite more work in the 1980s on the development of the subject design and technology, many secondary teachers hoped that by slightly adjusting their approach they could continue with their ‘own’ subjects and ignore design and technology.

‘GROWING’ THE SUBJECT 1990 – 2007

1990–1995

It might be imagined that after such a confusing and pressured start, teachers would be given time to gain an understanding of the new Order, to plan appropriate schemes of work, find suitable
resources, trial activities, and evaluate and change practice as they grew in confidence. This was not to be. Almost immediately, concerns were raised about the way in which the subject was developing and the document *Technology in the National Curriculum – Getting it Right* (Smithers & Robinson, 1992), prepared for the Engineering Council, was released into the public domain. They talked about ‘Mickey Mouse’ activities with egg boxes and suggested that the subject had become generalised problem solving without a specific knowledge base. There was much debate as to the specific knowledge base that was part of the subject, some arguing that it needed to be very limited, whilst others promoted the notion that it should draw on a range of subjects, including science, art, mathematics, IT, home economics, and business studies.

Primary teachers started to create some exciting projects, but as more subjects came on stream in 1991, pressures of time and lack of understanding hindered these developments. An inquiry group was set up under the new Inspection service – Office for Standards in Education [OFSTED] – and their findings became the basis for the new draft Order for Technology (National Curriculum Council [NCC], 1992). Again, progress was slow as a new Secretary for State, John Patten, announced a review of the entire National Curriculum. During 1994 a new draft Order was published for design and technology – not technology – (School Curriculum and Assessment Authority [SCAA], 1994) before the final Order was published (Department for Education [DFE]/WO, 1995). Thus, it seems hardly surprising that progress was slow during 1990-1995, and that teachers began to lose sight of the nature and importance of the subject. However, the Schools’ Inspectors report ‘Subject and Standards 1994-5’ indicated that pupils were almost always enthusiastic about the subject and found the work enjoyable and interesting. Primary standards and standards in teaching (satisfactory and above) in English, mathematics, science, and design and technology were all graded at 80% with the exception of Key Stage 2 (7-11 years) teaching; this was graded at 75%. The format of reports changed after this, thus making comparisons in future years impossible.

**1995–2000**

The new National Curriculum in 1995 clarified the nature of the subject through the statement “pupils should be taught to develop their design and technology capability through combining designing and making with knowledge and understanding in order to design and make products” (p. 2). This was similar to the statement in the 1992 new draft Order (NCC, 1992) but lacked its important emphasis on “good quality products fit for their intended purpose” (p. 5). The content of the 1995 document was slimmed down; the language of the document was simpler and much more easily accessed, especially for primary teachers; the attainment targets were reduced to two: designing and making; and the holistic nature of design and technology was emphasised through the level descriptions.

One of the major positive changes, particularly for primary teachers, was the introduction of the section relating to opportunities through which pupils could develop their capability. Three opportunities were identified: assignments in which pupils design make products (DMA); focused practical tasks in which they develop and practise particular skills and knowledge (FPT); and activities in which they investigate, disassemble, and evaluate simple products (IDEA). This offered a clear structure for teaching, and whilst it did lead to linear teaching programmes, it promoted the idea that teaching pupils skills and knowledge was essential for good quality design and technology. Ive (1997) HMI identified that this structure had been responsible for rising standards, certainly in primary design and technology.

Whilst secondary schools were now left to develop appropriate schemes of work, primary teachers were faced with major changes in 1998. The government, faced with poor standards in
literacy and numeracy, introduced two new initiatives – one for literacy (Department for Education and Employment [DfEE], 1998) and one for numeracy (DfEE, 1999) – and whilst they were not mandatory, head teachers felt pressured into implementing them. If schools did not have these in place and standards were shown to be less than satisfactory, then school leaders felt they would be heavily criticised by inspection teams. There were time implications now as schools tried to cover the new, suggested content, and foundation subjects such as design and technology were once again under threat of being marginalised. The government, through the document “Maintaining breadth and balance” (QCA 1998a), did suggest that schools should keep a balance in their curricula, but the threat of poor inspection results did much to negate the content of this document.

The publication of the national ‘Schemes of Work’ (QCA, 1998b) for Key Stage 1 (5-7 years), Key Stage 2 (7-11 years), and Key Stage 3 (11-14 years) did go some way, particularly at primary level, to offset the damage to the development of design and technology. The schemes of work were created to give schools possible ways of delivering the curriculum; they were only guidance; and they were for schools to use as a tool against which they could evaluate, monitor, and plan new units of work. QCA surveys found that at primary level the scheme for design and technology was the most used scheme, but not at secondary level. It can be argued that for the first time since the National Curriculum was introduced, schools had an overview of a possible design and technology scheme of work for 5-11 years that incorporated flexibility, and alternatives, whilst covering the content of the National Curriculum. As the majority of primary teachers had little knowledge and understanding of the subject (OFSTED, 1998), this resource proved invaluable. However, problems arose when teachers kept rigidly to the suggested activities and did not develop the units to meet the needs of their own pupils. Initially the Schemes therefore did much to help raise standards and, if used appropriately, continue to do so even in 2008.

2000–2008

The five year moratorium on National Curriculum change drew to an end and during 1998-9 fresh debates took place with regard to proposals for the new 2000 Curriculum (DfEE/QCA, 1999b). Perhaps the most significant change in design and technology was the inclusion of an ‘importance’ statement at the beginning of the programmes of study. There was still some confusion as to the nature and importance of the subject and it was felt to be crucial to have a clear statement that set out the rationale for the subject, together with key elements relating to the nature of the subject. This was not an easy task and as soon as it was published, discussions were underway as to how it could be improved. However, the user, purpose, and function of a product is emphasised and this is something that needs to be focused on throughout all phases of education, but particularly in the primary school. The content of the new document was slimmed down again but there were few fundamental changes. The heading ‘Structures’ was taken out as it was felt that structures could be included in all projects; there was more emphasis on the use of ICT, including Computer Aided Design and Computer Aided Manufacture (CAD/CAM) as a tool; and the two Attainment Targets became one to emphasise the holistic nature of design and technology and the importance of assessing design and technology as a whole, not as a series of ‘can do’ statements.

At the same time, a new National Curriculum for children in the Foundation Stage (3-5 years) was published (DfEE/QCA, 1999a). This curriculum was divided up into six areas of experience, and whilst design and technology capability can be developed through all the areas, the main focus for the capability is within Knowledge and Understanding of the World. Through a Department for Education and Skills (DfES) funded project, Developing Designerly Thinking in the Foundation Stage, Benson (2003) identified the lack of opportunities that 3-5 year olds are offered in developing their design and technology capability through the activities they experience. There is
till much emphasis on the natural world, and little on the designed and made world. Children are
given many activities in relation to making, but few that will develop design skills. If pupils are to
develop their capability, then it is vital that they have appropriate experiences from the start of
their education.

Since 2000, primary OFSTED inspection reports (e.g., OFSTED, 2001, 2002) indicate that
whilst there is much good practice in design and technology, much remains to be done at all levels,
particularly in the areas of designing and developing teacher knowledge and understanding.
However, schools were not given much time to implement the new curriculum: Primary schools
had yet another initiative to contend with in 2003 when the government started a review of the
whole curriculum, starting with the publication of ‘Excellence and enjoyment – a primary strategy’
(DfES, 2003a). Through this strategy, it was hoped that schools might place less emphasis on
numeracy and literacy and give children a broader, more balanced curriculum. However, with the
subsequent creation of the Primary Strategy (DfES, 2003b), many hopes were dashed. Literacy
and numeracy were still emphasised, but the inclusion of the importance of the development of
thinking skills, questioning, and problem solving did link with design and technology and are
integral to good practice. In addition, misconceptions about the content of the document arose.
Schools started to plan using a topic, or thematic, approach based on the perception that the
Strategy promoted cross curricular links. This led to a growth in making, or craft, activities rather
than design and technology. Topics linked to history often provide the worst examples, with
children making Viking boats from card templates and Tudor houses using straw and card boxes.
The user, purpose, and functionality of the product are ignored as design is not included in the
activities that are undertaken. The latest OFSTED report (OFSTED, 2007) covers the three years
2003-6, provides a clear overview of the state of design and technology, and suggests key areas
that need to be addressed. These do not surprise those working to develop primary design and
technology and include teachers’ limited expertise and confidence; schools’ reluctance to allow
teachers to attend staff development courses due mainly to funding; and the need to improve
assessment, recording, and reporting of pupils’ progress.

Secondary schools faced another upheaval in 2006 with the development of a new Key Stage 3
(11–14 years) programme of study (QCA, 2007). The ‘importance’ statement has been updated to
include references to creativity and innovation. The programmes of study have been reorganised
into four areas – key concepts, key processes, range and content, and curriculum opportunities –
with the intention to promote creativity and innovation. The assessment levels from 4-8 have been
rewritten to reflect the changes to the programmes of study.

FUTURE PATHWAYS

It is almost impossible to identify long term developments in the subject, if the past is to be
repeated with its constant push for change. In July 2004, the DfES published its ‘Five Year
Strategy for Children and Learners’; in December 2007, the Department for Children, Schools and
Whilst there are some similar messages, reference to the Five Year Plan was not built into the new
Ten Year Plan. Whilst these are not specific curriculum plans, this exemplifies the way in which
educational change does not necessarily build on what has gone before.

It can be argued that it is a great tribute to teachers that design and technology has become an
established and well-liked subject within primary and secondary school curricula. Without their
resilience, hard work, and commitment to the subject, and their belief in its value to the children
they teach, the subject could have disappeared after one of the numerous, major changes over the
years. However, there are already some indications of changes that will affect the subject. There is
a primary review being undertaken of the whole curriculum, led by Sir Jim Rose. A draft of the proposals will be available in November 2008, the final document will be available in the Spring of 2009, and implementation will be in September 2011. One of the main areas for debate is how to organise the curriculum; ‘subjects’ may disappear and ‘areas of experience’ may take their place. This links back to the HMI suggestion in the late 1970s and to the way in which the Foundation Stage curriculum is organised. It could be that there is an area – Technological Experience – or that design and technology becomes art, design and technology; or even back to science and technology.

The Science, Technology, Engineering, and Mathematics (STEM) agenda is one that is being promoted strongly by the DCSF. Whilst this could result in closer links being made across the subjects, exciting, relevant projects being created for pupils, and curricula that will prepare young people for the rapidly changing world and technologies that they will experience, it could also lead to a struggle between subjects to maintain their integrity and identity in the curriculum. STEM in primary schools at the present time is not an issue that many working in schools would identify as important. However, increasingly engineering challenges are being presented to primary schools that can lead to confusion as to what is design and technology, and what is engineering? How do they fit together, and where do they fit in the current National Curriculum?

Two other issues will undoubtedly have high priority in the foreseeable future. First, with the high profile given to global warming and issues relating to sustainability, design and technology should offer opportunities for pupils to work through projects that offer possible solutions to enable us to make appropriate changes in our lifestyles. Second, whilst food technology has always been included in the primary curriculum, there have been periods of time when it has been optional in secondary schools, including the present new Orders (2007). However, within six months of their publication the government decided to change this and make food a compulsory element for Key Stage 3 (11–14 year olds) within design and technology from September 2011. The issue of growing obesity levels, an emphasis on healthy eating and lifestyles, and other food initiatives for schools appear to have been the government’s motive for this.

From lessons that have been learnt, whatever changes take place, it is vital that the nature of the subject is always clear for those who have to implement the curriculum. Changes should be well supported through the provision of quality CPD and relevant resources. One thing is certain: It will be crucial for design and technology to keep abreast of technologies in the rapidly changing world, enabling the pupils who experience the subject to become “responsible citizens who make a positive contribution to society” (QCA, 2007, p. 51).

INITIAL TEACHER TRAINING

Not surprisingly, there have been many changes in Initial Teacher Training (ITT) since the subject design and technology became part of the English National Curriculum; even the title ‘Initial Teacher Training’ has been contentious, despite being chosen to reflect the notion that students were involved in a reflective, evaluative course rather than one that trained them to perform in the classroom. It is now ITT but hopefully students are not ‘trained’, but engage in debate and reflective practice throughout their courses. Updates are constant, so it is important to use the Teacher Development Agency (TDA) website (http://www.tda.gov.uk/) to keep abreast with the constant revisions.

Secondary courses used to focus on Craft, Design and Technology (CDT) as well as individual subjects such as wood work, metal work, and home economics, whilst primary courses included art and craft. With the introduction of the National Curriculum in 1990, ITT had to change the nature of its courses to reflect the required practice in schools. Courses have to be validated before
they can be taught, and whilst small changes could be made without the usual lengthy process of revalidation, it took time for ITT to be able to offer courses that reflected these significant changes. Staff also needed to quickly understand the fundamental changes in approach to this new subject. There was little professional development available to them to support the change, and whilst some staff embraced the changes, understanding the value that the new subject had to offer young people, others felt threatened by the perceived loss of their own specialism.

In primary ITT, it was a case of starting a new subject area, not adapting established ones. Again, this caused problems as there were few existing staff who could lead the subject, and no resources were provided to train new staff. Initially, many of the science lecturers were asked to take on the subject, which led to some confusion. Design and technology is a subject in its own right and not to be viewed as the ‘appliance of science’. Thus, some students were making lighthouses with electric circuits, buggies with motors, and rubber band powered vehicles that were not designed – the students just followed instructions – without giving consideration to the purpose or user. The situation did change as new staff, often recruited from Education Support Grant (ESG) teams and Local Education Authorities (LEA) and who had devised development programmes for existing teachers, began to create new programmes of work for ITT. During the period 1995-2000, ITT was able to produce some very well qualified teachers of design and technology who had enthusiasm, knowledge and understanding and skills, and who understood the value of the subject for young people. However, research by Davies (2000) highlighted the lack of opportunities for teaching design and technology by trainee teachers during their school experience.

More recently, there have been problems in retaining courses, staff, and specialisms for a variety of reasons. Design and technology requires specialist training resources that are expensive and need updating regularly, and this has been one of stumbling blocks in keeping departments. Falling numbers of applicants, fewer staff with the right qualifications, and the cutting of specialisms in primary ITT have all contributed to a downturn in numbers. Numbers seem more stable now in secondary training; indeed there has been a substantial increase in those wanting to do a food specialism in the last three years. In primary, although there are only a very few courses that have retained specialisms, these are well subscribed and students are in demand on leaving ITT.

At present there are a number of different routes through which ITT in secondary design and technology can be accessed. These routes all lead to qualified teacher status (QTS). They combine theoretical learning with at least eighteen weeks of school placement training. The routes include:

- School-based training schemes, such as School Centered Initial Teacher Training (SCITT), the Graduate Teacher Programme (GTP), Overseas Trained Teacher Programme (OTTP), or the Registered Teacher Training Programme (RTP). These courses are taught in schools with the support of experienced mentors. Lectures or discussions cover the theory related to teaching. Trainees on these routes receive a salary from their school. This is at least equal to the minimum point on the unqualified teacher pay scale.
- Universities and colleges offer both undergraduate and postgraduate courses. They combine theoretical learning with school placements. All undergraduate and postgraduate students are eligible for a means-tested grant from their local authority (LA). Eligible design and technology postgraduate trainee teachers are also entitled to a tax-free bursary. In August 2008 this was £9,000 (£225 per week).
- Online options allow for distance learning courses. All trainees teach and train in at least two schools. When in school, they are supported by trained teachers who provide training and feedback.
Typical ITT courses include taught modules using a combination of workshops, lectures, seminar groups and individual study to support work in school. Education, pedagogy, and professional studies during the training allow trainees to explore a range of educational issues based on school experience. During training it is important to develop professional practice in subject teaching to enable trainees to apply knowledge and understanding gained to teaching design and technology.

Subject pedagogy looks more specifically at design and technology as a specialist subject, addressing the “hows and whys” of teaching the subject including issues such as health and safety, managing workshops, promoting creativity, and developing computer aided manufacture and design skills. Guidance from the ‘Minimum Competencies for Training to Teach Design and Technology in Secondary Schools’ (Design and Technology Teachers Association [DATA], 2003) divides subject-specific knowledge and skills into core and specialist “materials”. All trainees, regardless of the specialist materials that they decide to study, cover the core competencies integrated into their subject specific specialist studies. The core competencies are based on the process and procedure of “designing”. The specialist materials are food technology, materials technology, textiles technology, electronics, and communication technology. Different ITT courses offer trainees the opportunity to specialise in one, two, or all of the specialist materials.

Assessment of design and technology ITT is made on the strength of a trainee’s ability to meet the requirements of the TDA standards for the award of QTS. This can include written work, school experience, online skills tests, and evidence portfolios. Employment prospects are excellent, as design and technology has been identified as a “shortage subject”. Secondary design and technology trainees who successfully complete an ITT course and accept a newly qualified teacher (NQT) position are also eligible for a one-off taxable ‘golden hello payment’ of £2,500.

For primary teachers, the training and financial support is different. Undergraduate students are awarded the same qualification whether their course is three or four years in length. Most ITT courses now are three years and students study English, mathematics, science, ICT, religious education, and education studies. They can be given a choice between art or design and technology, and history or geography. Few institutions maintain specialist routes, including design and technology, although those that do recruit well. The courses all feature a balance between theory and practice to help develop appropriate personal knowledge, understanding, and skills. Thus, the majority of primary NQTs do not feel confident in teaching design and technology as a subject and cannot help colleagues in schools who look for support. There is also no additional financial support for those students opting for design and technology as a specialism.

For postgraduate students who undertake a one year Post Graduate Certificate in Education (PGCE) to enable them to teach, there are almost no opportunities to specialise in their own subject during ITT. They are expected to make the connections themselves, although a degree, for example in engineering, may not have equipped them with appropriate skills and knowledge for teaching primary children. Some will undertake between 2-10 hours of lectures relating to a subject; others will have none. As the number of lecturers in primary design and technology fall, ITTs are employing teachers from the classroom for a few hours to deliver the subject. Whilst many of these will have excellent classroom practice, it is very difficult for a primary teacher, teaching nine subjects, to keep abreast of new developments and resources in their subject area. In 2011, the new primary National Curriculum will be a legal requirement for all primary schools in England. Consideration needs to be given now as to how staff in ITT will be updated and receive professional development to ensure that students have appropriate courses during their training.
Disciplines that have a long history, such as science, have an established background of research, supported by funding from a range of sources. It is therefore impossible for a relatively new subject to compete in research terms with those subjects that have been within the curriculum for decades, and even centuries. Nevertheless, research frameworks for design and technology have been quickly established; an annual International Design and Technology Educational Research conference was held at Loughborough University 1998-2001, and journals were published including *Studies in Design, Education Craft and Technology, Design in Technology Teaching,* and the *Journal of Design and Technology Education.* This provided subject-specific outlets for burgeoning research, in addition to general research conferences and publications. In 2000, DATA (now the Design and Technology Association) celebrated the millennium with its first research conference and it has continued to hold an annual conference. In 2001, Loughborough University’s annual face-to-face conference came to an end but various other options exist on their website. In 1997, as primary design and technology became more established, the Centre for Research in Primary Technology (CRiPT) was created at University of Central England (now Birmingham City University). Its first international biennial conference was held in the same year, and still continues. Conference proceedings produced ahead of all the conferences have provided an excellent resource for research, covering current key issues.

Large-scale funding for research projects has been difficult to acquire for a variety of reasons: the subject is in its infancy; some funders have been unsure as to the nature and value of the subject; other subjects such as science have overshadowed design and technology and its importance; and there appears to be less money available for such research projects. It could be argued that the first major project to be funded was based at Goldsmiths College, London (DES, 1987; 1988). The Assessment of Performance Unit (APU), the then major research arm of the DES awarded Goldsmiths the project to identify national design and technological capability (Kimbell, Stables, Wheeler, Wosniak, & Kelly, 1991). The research findings have, and still do, make a significant contribution to the teaching and learning of design and technology, not only in England but worldwide. Other projects undertaken by the team at the Technology Education Research Unit (TERU) can be viewed on their website (www.goldsmiths.ac.uk/teru) but the latest project reflects very recent changes in teaching and learning – the use of ICT. ‘Project e-scape’ came out of a project assessing design innovation for QCA. The principal outcome of the project was a developed portfolio assessment system, and the data and findings are in the project report.

Other research projects in technology education include ‘Young Foresight’ and ‘Understanding Creativity’. Young Foresight (2004) was funded by DfES and the Department for Trade and Industry. This involved young people in Year 9 (13–14 years) and focused on designing products and services for the future but not making them. More recently, a large scale project started in January 2005 involved pupils 11–16 years and was entitled ‘Understanding Creativity for Creative Understanding’. Funded by Gatsby and based at the University of Cambridge, the research aims were twofold: to develop a model of learning and teaching in design and technology that explicitly develops creativity; and to support heads of departments to become more effective in their role as leaders of learning in the subject, creating and managing the learning environment. The findings and implications have been published in numerous papers (Nicholl & McLellan, 2007; 2008).

The only large scale project for primary work has been funded by the DfES and was undertaken by Centre for Research in Primary Technology (CRiPT) from 2003-2006 (Benson 2003; 2005; 2008). The project – Designerly thinking in the Foundation Stage – supported the development of designerly thinking through the engagement of young children with the designed and made world around them, including designed and made products. Findings included the lack of such practice in
the Foundation stage, the active participation of children who had shown little interest in other types of activity, and the development of both speaking and listening skills, together with an increase in and use of technical vocabulary.

With regard to setting a research agenda, Baynes and Johnsey (1997) set out a platform on which to build research in primary education. This was followed in 2003 by a report from Harris and Wilson (2003), funded by the DfES to review, comment on, and offer recommendations for areas that should be funded and systematically researched. Their report provides an excellent, if not complete, picture of research relating to design and technology. They concluded, as many suspected, that there were few large scale projects; most were small scale and case studies that often made generalisation difficult, if not impossible. Whilst the report was favourably received in the main, it has not resulted in more funded projects.

The future of research into design and technology education has difficulties to overcome. It can be argued that the Research Assessment Exercise (RAE), that has been taking place since 1992 and is due to report again in December 2008, has done little to help. Many researchers are based in Faculties of Education within Universities, some of which do not see research as a major activity. A survey of the results of the RAE since it began shows that Faculties of Education do not fare well and are often towards the lower end of the ratings within a University. There are also fewer staff in many Universities who are research active or have research as a major component of their work. Funding is not forthcoming and the research that is often undertaken is small scale and based around a researcher’s everyday activity, rather than on areas that have been identified in the Harris and Wilson (2003) report. However, a positive development in recent years has been the growth of action research undertaken by secondary and primary teachers involved in MA courses (e.g., Benson, Lawson, & Till, 2005; Benson, Lawson, Lunt, & Till, 2007) and funded through the TDA. Whilst the research is small scale, it is classroom-based and offers other educators the opportunity to review findings and undertake similar activity in their own schools. This could be a very productive way forward in promoting research and providing findings that can be used to improve practice in schools in the next few years.

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BENSON


Clare Benson
Faculty of Education
*Birmingham City University*
*Birmingham, England*
JACQUES GINESTIÉ

4. THINKING ABOUT TECHNOLOGY EDUCATION IN FRANCE

A Brief Overview and some Aspects of Investigations

INTRODUCTION

Like all educational research, that concerned with technological education belongs to a category of research that is socially oriented, that is to say, research findings impact on school organisation. In addition, academic evolution alters and adds depth to the elements studied. Such research can be organised into three categories: research dealing with curriculum developments and the nature of the subject research concerned with the process of rendering these knowledge and research investigating teaching and learning in the classroom. Each of these will be examined in this chapter, in the context the way they have impacted on technology education in Western Europe, particularly France.

The nature of the knowledge used in technology education has been the subject of ongoing debate since the 1960s (see Section 2 of the Handbook). The goal is to examine what it is that a technologically literate citizen living in the 21st needs to know in order to understand the environment in which he finds himself. This task is based on the philosophy and history of techniques whilst also attempting to create a specific epistemology of technological knowledge. By constructing a scholarly epistemology in accordance with set objectives in a specific context, the reference knowledge can be transformed into an educational context. An important aspect within this is the organisation of conceptual progression based on the transmission and acquisition of the relevant knowledge, and impacted by the level of difficulty, depth, complexity, and portability. The definition of a subject area and the teaching curricula associated with it comes from this process of transposing reference knowledge into a scholarly epistemological framework that is socially, culturally, ideologically, and philosophically influenced.

Contrary to widespread belief, deciding what has to be taught, why, and to whom has nothing to do with how it is taught or how effectively it is learned. Rather, the teaching and learning process places the epistemological framework in the context of a classroom, where a teacher gives tasks to pupils who then organise how they will act in order to complete each task. Studying this process thus allows us to consider multiple dimensions: curriculum organisation, teaching methods used, and their effectiveness in enabling and enhancing student learning.

This article presents a few of the elements currently influencing research in technology education in Europe, with a particular focus on France. As such, the chapter focuses more on reviewing the types of questions dominating current research than on presenting the findings. This review of questions is underpinned by a reference list selected to reflect the richness and diversity of recent and current work. The list is, however, far from exhaustive. Rather, it provides a starting point from which the reader can widen his or her field of references.
THE NATURE OF TECHNOLOGICAL KNOWLEDGE FOR TECHNOLOGY EDUCATION
AT SCHOOL

The question of what to include in technology education gave rise, and continues to underpin, a
number of works – sometimes linked, sometimes specific – which all attempt to organise
knowledge to be taught in schools in such a way that all children are enabled to participate
effectively as part of a technological culture and understand and interact with their environment.

A longstanding Anglo-Saxon tradition of technological philosophy includes studies based on an
epistemology of technological knowledge as specific and separate from other domains, most
notably science. In this respect, technology education is required for all children because
understanding the technological environment depends on the establishment of a specific area of
knowledge – technological knowledge – which is separate from specific fields traditionally
defined in the sciences, but which relies instead on both the material and the human sciences
(Dakers, 2006). De Vries notes that this knowledge has a specificity to it that springs from its use
for producing identifiable knowledge artefacts in traditional academic subject areas (de Vries,
2005a, 2005b, 2006a); that said, the study of these academic disciplines, in translating them into
academic curricula, is of no help in facilitating comprehension (de Vries, 2006b). Hence, studying
the principle laws of electricity in science does not particularly aid understanding of how electrical
equipment operates any more than it assists the person to understand why the equipment in
question has the characteristics it does.

Somewhat surprisingly, this Anglo-Saxon line of research into the philosophy of technology
does not seem to draw upon (and vice versa) equally vast investigations in the same field in
Europe. Marc de Vries is one of the few authors to establish relationships and to show closely
linked points, as well as differences in approach. In France, works on the mode of existence for
technical objects (Simondon, 1989) serve as a reference for thinking about the place and role of
technology education in schools. Through a series of works, Deforge goes on to develop this
multi-reference approach for technological knowledge. Firstly, with regard to the viewpoint we
can have on technical objects (Deforge, 1970, 1985, 1988; Deforge & Chancerel, 1985), then in an
attempt to form a basis for introducing specific concepts for work and products (Deforge, 1990,
1993, 1995, 1997). For this author, out of all the points of view we can adopt in order to use
technological aids, there are four which are particularly interesting and that are given priority:
objects as products of a production system, objects in a system of consumption, machines in a
system of usage, and objects as entities in themselves within a system of objects.

If we develop this line of thought, we note that the existence of objects does not take into
account how they exist (Simondon, 1989). The mere use or manipulation of an object says nothing
about how or why it exists. Hence, there are limits to forming an approach based upon a history of
technology stemming from a history of objects (Perrin, 1991a). Again, we see that the result says
nothing (or little) about the production process or the way of organising and doing things (Perrin,
1988). In contrast, Deforge (1995) demonstrates the importance of the processes for the production
of objects. Others also underline this importance, be it to discuss the history of techniques
(Daumas, 1991; Daumas, Guérin, Hériea, & Moïse, 1978; Daumas, Perrot, Ache, & Audin, 1979;
Gille, 1992; Jacomy, 1997), technological evolution (Lattès, 1990; Perrin, 1991b), relationships
between product and producer from an ethnological point of view (Leroi-Gourhan, 1973; Sigaut,

Using artefact production processes as a starting point in this way hints at a given series of facts
or phenomena, in accordance with a certain setup and leading to a clear result. References for
technology education become clear with regard to the action based on three factors: conscience of
minimal satisfaction, awareness of the possibility for greater satisfaction, and hopes for
improvement based on the possible effectiveness of a particular action. Bringing together the means to achieve such an end hinges on this description of a process, in which the actors’ practices are set and where these practices are always social.

In this broadening of a social definition for technology education references, one should take note of works published on curricula, including those developed by the mixed research unit affiliated to l’École Normale Supérieure de Cachan (Lebeaume, 2000; Martinand, 1995), which have clearly influenced the definition of technology for the French national curriculum. Their main area of interest concerns the content of teaching syllabuses, and hence technological references. The terms ‘social reference practices’ (Martinand, 1986) and ‘socio-technical reference practices’ (Lebeaume, 2000) were introduced by this team to link technology education to human activities and hence to the social setups which organise such activities. This referential approach is based on working objectives, material and intellectual instruments, problems, knowledge, attitudes, and social roles. For example, “small scale building of something in class will allow one to relate to a similar situation in a business context and thus to consider the cultural vocation of such school activities” (Martinand, 1986, p. 138).

More recently, these authors defined some of the attributes of the concept of socio-technical reference practices (Lebeaume & Martinand, 1998), allowing one to question academic practices and pick out the different social practices that give meaning to these scholarly activities. Specifically, they define a relationship of authenticity (separate from identity) and coherence. This provides a way of taking stock of problem areas in technological disciplines. In spite of all this, such a proposal causes problems. Reference to practices evokes the question of how they are modelled in order to implement them in schooling; these are not methods which serve as a reference point for teaching in themselves, but constructions based on such practices. In her thesis from the ENS in Cachan, Paindorge (2005) uses as a starting point the link between task and target, an activity suggested by Lebeaume (2000) to help the model to evolve. This reorientation of referring to practices shows that these are not methods which serve as teaching references, but as knowledge of such practices: “the schooling setup is linked to a specific way of teaching, and hence to a transposition of knowledge, knowledge relating to practical methods” (Johsua, 1996, p. 67). Along with innate knowledge (Chevallard & Johsua, 1991), there is also said to be expertise. This distinction allows one to more clearly define the places where knowledge is institutionalised. Indeed, innate or academic knowledge is produced by identified (or identifiable) scientific communities, whereas expert knowledge aims to take into account other sources of knowledge production that do not collate with these institutional production criteria. From this perspective, knowledge (of an academic or expert nature) is put into textual format using knowledge production sources (Ginestié, 2005c).

The identification of knowledge suitable for forming the basis of technological education remains an open-ended problem. Can we find an epistemology of scholarly knowledge for technology education that is not based on clearly identified epistemologies? The ongoing debates about relationships with sciences – which tend to lead technology back to applied sciences, or even the application of sciences – or its position as a form of initiation and job-finding – which is often insisted on for pupils encountering difficulties at school – or as a group of activities to heighten awareness – which must allow one to associate thought and action – demonstrate the complexity and fragility of the position of such an academic subject area.

ACADEMIC KNOWLEDGE TAUGHT IN TECHNOLOGY EDUCATION

Technology education curricula are the result of consensual constructions that, in the absence of clearly defined epistemological references, reflect the uncertainty linked to their creation. As a
As a result, the teaching of technology differs vastly from one country to the next. This diversity can be defined according to four different approaches: the production of artefacts, the study of existing technological artefacts, the study of the job market and world of work, and the study of how and why technological artefacts are developed and used.

When discussing the production of artefacts, a distinction can be made between objects used domestically or decoratively as part of a tradition of working at home or manually on the one hand, and more industrialised work based on the planning and putting into practice of industrial processes on the other (Crindal, 2001; Manneux, 2004). Pupils’ activities are mainly centred on building things, with the views of the end-user often not considered; obtaining an acceptable product in accordance with aesthetic or even artistic criteria constitutes the main aim of this teaching.

The study of existing technological artefacts includes the use of familiar tools right through to using ‘high-tech’ objects, for example, micro-technologies or information technologies. Here, the aim is to familiarise students with their everyday environment and enhance their understandings of the world of technical appliances (Leroux, 1995; Levin & Mioduser, 1996). Such a setup often hinges on an ambiguity between science and technology activities, with technology often viewed as an applied science, or even the application of sciences (Fourez, 1994; Talis & Ginestié, 2003).

Studying the world of work forms part of a process designed to allow pupils to get to grips with the working world and their own possible career paths. The study of the evolution of the job market is generally based on the development of general skills such as cooperation, teamwork, flexibility, adaptability, and innovative thinking. Activities offered in the classroom thus tend to emphasise the development of behaviour linked to these general skills and often simulate socio-professional organisations (Crindal & Larcher, 2007; Gonin-Bolo, 2006; Vérillon & Ouvrier-Bonnaz, 2007).

Studying how and why technological artefacts are developed and used includes an analysis of social interactions and is based on processes related to engineering, the life of products, as well as social sciences. Classroom activities such as analysing processes for the design and development of an object and using semantic tools (taken from the systemic approach, functional analysis, for example might be the economic organisation of businesses) aim to place technological artefacts within a social context that needs to be studied (Andreucci, 2006; Brandt-Pomares, 2008; Chatoney, 2008; Cheneval-Armand & Ginestié, 2008).

The diversity of aims within each of the four approaches reflects the difficulty of designing and organising a stable and socially acceptable technology education framework. It also impacts on the social position of a school subject area and the amount of legitimacy it is accorded. In some ways, each approach (and all those concerned with the subject but which are not cited here) attempts to confirm the social necessity of technology education for all, even when schools do not have the means to implement it in ways that are intended (Ginestié, 2006a). Judging from the facts, education technology is not clearly defined, its references are fluctuating, its aims are not stable and, at the end, its social status is problematic.

The development over the last twenty years of technology education for all reveals another dimension, that is, the link between knowledge as defined by the curriculum, and ways in which such knowledge is transmitted. Again, little research has been done in this area. For example, if one adopts a view that technology teaching has something to do with an understanding of industrial production processes (the subject to be taught), one needs to consider this teaching as something which incorporates industrial production in the way the subject is organised and taught. In the absence of a well-established body of knowledge, the difficulty in defining clear areas of reference and the instability of curricula in which the academic knowledge is organised, technology education research is given particular depth. All that seems to be self-evident in any...
other academic discipline needs to be questioned and there is still much to be studied. There are also multiple, even different, ways of carrying out the research (Graube, Dyerenfurth, & Theuerkauf, 2003).

Because of these broader issues, technology education has developed and will continue to develop based on a different model than that of a traditional dogmatic pedagogy – the teacher teaches and the students memorise – or a pedagogy used in science teaching – the observation of a phenomenon, offering a hypothesis, and the putting in place an experimental protocol and treatment of data to either confirm or question the hypothesis. Rather, foundations will hinge instead on the link between mastering a particular technological skill and constructing meanings for the said skill: action for contemplation and contemplation for action. Technology teaching will find its niche in teaching skills, emphasised in the production of artefacts (Tauke, Story, & Ostroff, 2004). From this point of view, the link between what the pupil conceptualises and what he/she builds plays an important role. This, for example, is what we notice in France with the structuring role played by the industrial projects method (Ginestié, 2002) in which all the process of putting on the market a new product is formalised and decomposed in successive and definite procedures. Similar examples exist in Germany, Holland, Belgium, Italy, and Spain.

Discussions about technology education thus need to involve the link between an approach taken from scientific education centred around the structuring of observable facts on the one hand, and an approach focused on practical education involving mastery of professional skills and the construction of meaning for these skills on the other. Is it a kind of teaching based on lessons about things, where one studies a technological artefact in order to extract the main scientific principles? Is it a matter of looking at how an object exists and the process which allows this object to exist? Is it about studying the social context in which the artefact exists and came into existence? Numerous pieces of research exist that defend one position or another, often with more ideological than scientific reasoning.

**TASKS AND ACTIVITIES FOR TECHNOLOGY EDUCATION**

Of course, if we consider that schools serve to help students construct and learn knowledge and values, the matter of the pupils acquiring this knowledge becomes vital: It is not enough to simply put social structures in place for the transmission of knowledge; it must also be assured that pupils learn them properly. Such a process brings with it pressure that is greater than the social demands of sharing knowledge: of education for all, and equal opportunities (extending fields of knowledge, academic broadening, availability to other social groups and cultures) (Bautier & Derycke, 2005; Felouzis, 1990; Ginestié, 2006b; Schwartz, Labbé, & Association nationale des directeurs de missions locales, 2007). Putting teaching structures into place is a necessary but insufficient condition: “They [the teachers] teach but what do they [the pupils] learn?” (Altet, 1997, p. 11). The process which links teaching and learning is a specific one, academically oriented, and drawing on the wider process of knowledge transmission/acquisition. Research into the study of this process is out of the ordinary and little is known about it (Ginestié, 2006c).

The knowledge acquired by an individual is mediated by the objects the person creates in order to establish social relationships, and hence to be able to act in and with the material world. This mediation flows directly between individuals and social groups and the objects used are merely tools to aid mediation (Rabardel, 1995). From this perspective, classification of knowledge according to its kind (knowing how to do or be something) is inoperative: knowledge is first and foremost a means of acting upon and with the environment. In the same way, creating a hierarchy between behaviour, capacities, and skills is of little importance given that it is founded on analysing the result of the action rather than the processes by which the result is produced. In these
terms, a learning situation is an interaction between the task to be accomplished, knowledge available in order to do so, and the activity employed by the learner. Development of new knowledge rises from a conflicting situation in which a person cannot complete the set task by simply calling upon the knowledge he/she already has. Not managing to find a socially satisfactory solution creates an imbalance, and the individual seeks for ways to find a solution in his/her social environment. Thus, the individual calls upon new things learnt, or else develops new ways of organising things at his/her disposal in order to find a newly adapted answer which in turn constitutes new knowledge. Stabilising this new knowledge depends upon producing sense and meaning of objects, and of symbols of these objects (Vérillon, 2000).

Studying the teaching-learning process leans towards viewing and analysing classroom situations as an interactive network between pupil, teacher, and knowledge. The situation allows the pupil to face the obstacles that he/she will have to overcome in order to learn new knowledge. Pupil activity is directed through the task set by the teacher, organised to make the obstacles salient. The teacher then helps the pupils in their activity, using teaching materials to aid them in overcoming difficulties they face. In terms of research, it is a question of describing and understanding the conditions which enhance (or hinder) the teaching-learning process. This understanding is based upon a methodology which links task analysis and activity analysis (Ginestié, 2007). This analytical framework allows one to qualify the activity actually undertaken by pupils, characterise the difference between what is expected of pupils and what they actually do, and find out the difficulties they face or the obstacles they overcome.

Definition of the task is an essential element which conditions pupil activity and whether or not anything is learned. The task is the clear expression of teaching logic. It shows at the same time what is involved, the context in which the teaching is placed, what is expected of the pupil, and what he/she has to do in order to accomplish the set task. In this way, it unifies a whole range of values, models, theoretical elements, and knowledge that forms the basis of the taught subject and identifies the teacher within the teaching fraternity. Task construction therefore signifies the putting into place of a teaching curriculum in the specific context of a particular class – and this is what is analysed.

Numerous works analysing gaps between the prescribed and the real show that an analysis of the set task can allow one to characterise the fundamental components, whether epistemological, curricular, didactic, or pedagogical (Ginestié, 2005b). However, understanding the process does not stop at this task analysis, which needs to be supplemented by an analysis of pupil activity. For example, students may first read the instructions associated with a particular task. This analysis will in turn result in action being taken. In a formal way, the initial description of the task allows the pupil to analyse the goal to be reached, the way of reaching it, and the tools at his/her disposal for doing so. From this basic plan, he/she organises his/her actions by planning them in an active strategy and by giving him/herself the means of checking that the action to be taken is taken at the appropriate time, that it allows him/her to move towards achieving the goal, and that the partial result of this action contributes to progress (Andreucci, 2008; Chatoney, 2006). Of course, such an action process which is supposedly expertly mastered by the person defines an expert strategy, that is to say, of one who knows. In many cases, the pupil efficiently puts into place a clear strategy in order to successfully carry out a given task. Like any expert, he/she proceeds in a precise way in accordance with a series of routine procedures which he/she masters with perfection (Mioduser & Kipperman, 2002). In other words, he/she does the job of a pupil by accomplishing ordinary scholarly tasks by using a routine strategy for doing so.

A description such as this does not take into account the acquisition of new knowledge that the pupil has not yet mastered. Bringing new knowledge into play leads to the creation of a new task, one that the pupil cannot solve by using the usual process. In this sense, he/she will have difficulty
in using actions which will no longer help him/her to accomplish the set task. Effective teaching materials have to help him/her to identify these problems, get the new resources needed in order to progress, and integrate them into a new problem-solving strategy. Research in this case moves towards recording the information relevant to the pupil’s activity through his/her way of describing the task (what he/she does or does not find out, and what he/she knows about the teaching environment and hence the resources available), and the action that is subsequently taken in carrying out the task. By observing the pupil’s activity, the researcher is able to describe the pupil’s task, the strategy used and how it is planned, the pupil’s method of planning what he/she is going to do, the difficulties faced, and how these are dealt with (Ginestié, 2005a).

The crossover between task and activity allows one to highlight pupil activity in relation to the characteristics of the task. Hence, one can develop a better idea of the difficulties faced by the pupil and identify those arising from difficulties inherent to the context (task structure, organisation of study conditions, etc.) and those resulting from obstacles to learning. In this way, analysing study conditions in technology education allows us to identify and characterise differences between what is ordained and what is real, whether at a micro or macro level. It is a question of fitting out the conditions of study in technology education. This arrangement bases on the analysis of the impact of the school organizations on the processes of teaching and learning of this knowledge.

SOME PARTIAL CONCLUSIONS …

How is research in technology education different from other educational research, whether scientific, mathematical, literary, historical, artistic, physical, or sports-based? The first response is to note that it is different because the reference knowledge is different. In this sense, it is the epistemological boundaries which organise academic subject areas, including technology education. However, the kind of reference knowledge, the different ways of separating these references, and the points of view adopted in order to separate them, constitute many specific factors that are not found in other epistemological fields serving as references for other academic disciplines. Thus, from a scholarly point of view, it is interesting to take note of just how fragile and unstable the existence of ‘technology education for all’ is. At the same time, we cannot ignore just how regularly in everyday life we are confronted with objects, systems, and setups that require our understanding. Technology education research into references available for such an education sheds light upon this question through, for example, philosophy of techniques, of their history, and the sociology of the setups for whom and due to whom these techniques exist.

The process of academically passing on reference knowledge into taught knowledge is specific to technology education. An important area of research has thus been to try to characterise this uniqueness in relation to other school subject areas. Whether it is a matter of defining curricular organisation or analysing the mechanics of transforming reference knowledge to construct academic knowledge to be taught in the classroom, all the results published to date point to the specificity of technology education and technology education research, as well as ways in which they can enrich other subject areas.

A third area of research focuses on studying classroom situations in order to gain a greater understanding of the teaching-learning process in technology education. Focused on questions regarding the effectiveness of tools used in the classroom, this research tends to adopt research methodologies used in work psychology and leans on the theory of activity. This area of research highlights the advantages to be gained from linking the psychological process of knowledge acquisition to the social process of passing on this knowledge. However, these works – as
promising as they are – are still under-developed and very few teams in Europe, and around the world, are heading in this direction.

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Jacques Ginestié
*Gestepro – UMR ADEF*
*Aix-Marseille Université*
*IUFM Aix-Marseille – Université de Provence*
*Marseille, France*
TAPANI KANANOJA

5. TECHNOLOGY EDUCATION IN GENERAL EDUCATION IN FINLAND

INTRODUCTION

Teaching practical skills and technology in general education occurred in central Europe as early as the seventeenth century as ‘education for work’, providing skills necessary to society. These techniques were first introduced in Finnish schools at the end of the nineteenth century as ‘handicraft education’, which involved using materials and skills to produce objects and artefacts. At the same time, the student learned how to ‘work according to the rules’ and developed various skills needed for working life. Such ‘handicraft education’ combines carefulness and perseverance, with consequential development of the whole personality.

Traditionally, handicrafts have existed in the curriculum in Finnish schools from its inception in 1866. The subject usually concentrates on copying traditional handicraft objects, albeit with some scope for incorporating pupils’ own designs. At present, some schools offer effective and up-to-date technology education in the more modern sense of the word.

Changes in schools are usually quite slow; indeed, without specific incentives to accelerate development or reform of the school curriculum, proposed changes may take decades to implement. There are, however, exceptions. For example, the ‘civic school’ was created in the 1950s when Finland had to rapidly develop and diversify its industry. In addition to general education, schools needed to provide vocational training and plenty of practical education in the curriculum. At that time, the network of vocational institutions was far from comprehensive and there was a need for entrepreneurial skills. The civic school was able to develop these quickly and effectively.

Motivating pupils to keep their options open with regard to pursuing technology in further studies is mostly the task of the comprehensive and upper secondary schools. These schools need to pay particular attention to developing practical-technological education. In addition, education needs to be sufficiently versatile and flexible in order to cope with the changing industrial structure of the country. Modern technology is needed in more and more vocational branches in order to ensure the technological growth of the country. It is also needed at home. If a nation wishes to grow then it must invest in education, plan ahead, and support new technology in the general school curriculum.

While most Finnish homes and citizens use mobile phones and have access to the Internet, few teachers use these in education and it has been estimated that about half of the unemployed are ‘computer-illiterate’, lacking even basic computing skills. It has been said that we are governed by ‘techno bureaucracy’, which is trying to generalise the use of new communication gadgets only. This criticism also applies to general education. Medical science is developing machines that can crawl through the veins. Yet after four decades of human space travel, the practical-technological education at schools is often still limited to crocheting and woodwork.

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The effort to help individuals understand new technologies and thereby exercise greater control over their environments is one of the aims of technology education. Another important aim, of course, which has recently received a great deal of publicity, is the realisation of equal opportunities.

**CHANGING SKILL DEMANDS**

The school as an educational institution has always responded to the challenge of society to teach the appreciation of technology. Originally introduced as handicraft education, technology education has been developed and enhanced to take into account societal needs. These needs change rapidly, however, in step with progress in technology. In Finnish schools, the different categories of practical technological education – handicraft, ‘sloyd’, and ‘technical work’ – have traditionally represented the disciplines responsible for education for work, techniques, and technology.

Technological education began as handicraft education around the world, with Finland being the first country in which it was accepted as a compulsory school subject (Cygnaeus, 1866). Accordingly, the school should above all lead through work to work. Handicraft at that stage was connected with self-supporting agriculture. Such do-it-yourself skills continue to be part of the Finnish style of life. The school programme offered starting points at many levels, for example, even if the projects were quite vocational and connected with working life, handicrafts should serve in character building and development of the whole personality (e.g., accuracy, carefulness, and persistence in work). Such handicraft education, as outlined by Cygnaeus, formed an early model for many countries (e.g., the Nordic Countries, England, and the United States, the latter through Otto Salomon, the Swede).

In the international educational literature, handicrafts refer to reproduction and imitative making. With the development of technology, handicrafts no longer provided sufficient guidelines for practical technological education. When machining and other such techniques became more generally used in production, the importance of handicraft skills diminished. Production processes were rationalised and standards regulating the production were made. Industrial production and patent systems were generalised. Knowledge about how to produce was separated from production skills; the former developed in the form of engineering skills, the latter as manual making. The general interpretation of handicrafts as ‘non-academic’ probably emerged from this background, the main function of such works being to satisfy industrial needs. On the other hand, development of technology led to the need to apply science with handicraft skills and education systems began to include ‘industrial arts’ – officially incorporated in Finland in the 1920s–1970s in the civic school, the task of which was prevocational and vocational and which created the basis for national industrial development and entrepreneurship.

‘Technology education’, in the latest global evolution of practical technological education, often refers to education emphasising new technology. However, the new title of the subject was first launched in the world, as far as we know, by Uno Cygnaeus when planning Finnish teacher training programmes (Cygnaeus, 1861).

The formerly-taught ‘work skills’ are insufficient in modern working life. However, when we do not know exactly what kind of technical demands future industry will place on technology, the challenge must be met by emphasising the important mental processes involved in the development of technology – work tasks will be more and more based on knowledge and theoretical governance of work. The status of creativity will be increased and broad abilities become more important. The new technological world demands more effective, but less academic skills, than school currently focus on. Technological changes also mean that a greater focus is
needed on general education than on vocational education for specific roles. It must lead to improved skills in logical, analytical, and abstract thinking, and an ability to use these in practical situations.

Thus, technological development across society demands change within the education system, perhaps especially in ‘education for work’. This impacts on both general and vocational education, as well as teachers’ pre- and in-service training. The increased mobility in working life also demands workers to be more flexible and to have new attitudes.

Humankind has moved at once closer to a greater abundance of technological artefacts, and to problems caused by technology. The ongoing development of production technology requires professionals, technologists, and engineers, with better and better training in mathematics and science. Education has become a more important factor in this, and also a target for investments. The need for technological education is to understand the processes; when you learn to work on materials by hand and machine, you will also better understand the basics of controlling automated machines.

A high standard in examinations is no longer a necessary presupposition for success in the technological world (one needs only to think of Bill Gates or Linus Torvalds). Rather, a key premise in general education might be to give clues about new technology.

Changes in work have brought social changes in the whole of society. Such a technology-centered society or administration can be called ‘technocratic’. There can be a danger that some irrereplaceable values are sacrificed for technology, for example the intrinsic value of nature, and that technology will become over valued. Some fear that technological determinism might govern individual and societal actions. Decision making about technological options is, however, always based on values. These values depend on knowledge and attitudes, both of which should be fostered through education. Supporting talented pupils in studies equal to their abilities also guarantees a high standard of future engineers and technologists.

Even if the ultimate demands for technology education come mainly from industry, there are other stakeholders. For example, few would argue the importance of an individual living in a technological society and in a home with a range of electrical and electronic gadgets to know how to interact with technology and how to use it effectively, safely, and properly. Thus, the needs for modern technology education are both social and individual – as they were 142 years ago.

Urbanised societies no longer have the needs to justify retaining ‘handicrafts’ as part of general education. Artefacts are cheap when compared to living standards and teaching how to produce them does not provide meaningful learning; handicraft skills are not needed for survival in the same ways as before. Paradoxically, handicrafts education can even support elitism; artefacts have a demand mainly from the wealthy upper class. Elitism, however, was never the aim when handicrafts education was introduced to schools.

The following section explores other names for technology education, depending on the contexts. For example, ‘technological education’ is used to define technology more broadly, and tends not to be limited to a new school subject, but rather can be thought to make better connections between different subjects. The roles of terms such as ‘practical’ and ‘technical’ are historic compromises; in Finland ongoing development is rather slow.

TECHNOLOGY EDUCATION

The early American philosophy of developing technological education provided a suitable challenge for Finland. Olson (1963) highlighted that handicrafts education, wood as material and as methods the skills based on muscular power, belonged to the ‘handicrafts era’. If technology
education is supposed to reflect the actual technology of the society, then school subjects must be continuously developed.

Development

After the first initiative by Cygnaeus (1861), technology education has in Finland been proposed many times from 1973 (Kananoja, 1989). This has been motivated on the one hand by the need to internationalise the concepts and on the other hand with the needs to develop education. So far the proposals have not been fully realised.

Cygnaeus (1866) founded ‘folk schools’, primary schools with ‘boys’ handicrafts’ and ‘girls’ handicrafts’. The aim was general education; Cygnaeus wrote quite often about his fear that vocational education would take over.

Comprehensive school came into being in Finland in 1970. Civic school and academic junior secondary school were amalgamated as higher comprehensive schools. Allocation for ‘education for work’ at the primary level was diminished considerably compared to the civic school. The secondary school handicrafts curriculum was the model for the comprehensive school. It already included design, and was no longer based on materials like the civic school. The technical work curriculum in comprehensive schools aimed to realise the ideas of the folk school, civic school, and secondary school. Creativity was emphasised at the lower comprehensive level. Higher comprehensive schooling was, however, still clearly pre-vocational. Diminishing timetable allocations also meant a reduced need for teachers. A new aspect was, however, to satisfy the needs of the whole age group, to create basis for both academic and vocational technological studies. As part of the comprehensive school reform, ‘boys’ crafts’ was renamed ‘technical (handi)crafts’, the task of which was to emphasise more general education and give ‘technological basic skills’ (literacy).

In 1975 students’ options at higher comprehensive school for technical work were reduced by the Ministry of Education. The subject was renamed ‘technical work’; a new curriculum had to be developed and new guidelines for teachers were published. Aspects of work and technology were emphasised a little bit more than before. A guide for electronics was published in 1979. Computers were introduced in practical subjects from 1981. National subject guides, published between 1977 and 1988, supported subject development.

In 1991 the education administration system was reformed, the (old) National Board of General Education becoming a (new) National Board of Education. Earlier that year an expert group for Technology Education had been founded by the (old) National Board. Its task was to develop technology education in light of international guidelines (see Figure 1). The group was founded because it seemed that in the National Board there would soon be some changes in the personnel. However, the ‘Committee for Period Allocation’ (new National Board, 1992) stated, with total misunderstanding, that changing the subject title ‘handicrafts’ to ‘technology’ would result in an approach considered to be too cognitive, and the new title was not adopted! In addition, whether the main ideological background should be underpinned by science or a developed handicrafts curriculum was hotly contested. The proposal naturally was a basic initiative, and continued development has been proposed several times but so far with no full result.

Starting points for Figure 1 were global models. The ellipses describe deeper collaboration between some subjects. In 1991, textile work representatives had especially strong interest in working together with the Arts. However, in the international models textile work was generally more closely aligned with Home Economics. The basic message about the connections and the capacity of technology education as a central subject is still valid in 2008.
The (new) National Board published the *Basics for comprehensive school curriculum* in 1994 (POPS-94). It represented unifying general guidance. However, its three-page guide for handicrafts education was unfortunately written by a group with no expertise in technical work education or research. The guide emphasised equal opportunities; the common, gender-free aspects of the subject; and the possibility to emphasise teaching in different sub areas. The guide could be said to represent ‘developed handicrafts education’ – with certain reservations. ‘Hand skills’ were mentioned twice, as was ‘modern technology’. Without elaborating on teaching content, the guide is incomplete and also allows for very old-fashioned interpretations. In addition, the long term ‘new’ aims from 1970, which had not yet been properly realised at the comprehensive school level – pupil-centered teaching, creativity, adopting problem solving approaches, diminishing the influence of the gender, and integration into broader units – were not handled at all. The *Basics for comprehensive school curriculum* returned to the old subject term ‘handicrafts education’ instead of technical work and textile work. In practice, this could mean returning to the historic basic philosophy of the subject for taking care mostly of personality development and rejecting the development made in technical work during the previous 25 years.

In the *Basics for comprehensive school curriculum*, technology as a concept is represented as one of the general starting points and aims of education as well as an application in many subjects. This is particularly relevant for laboratory courses in science, the teachers of which do not necessarily have the interest or skills to advance practically-oriented technology. Even if the general part of the text is very positive toward technology as a basis for all education, technology is not so much mentioned in handicraft education. This is reflected in the problematic contradiction in understanding the term ‘technology’ in the memo of the Period Allocation...
Committee (Muistio, 1992) and in the *Basics for comprehensive school curriculum* (POPS-94, 1994). There are also conceptual contradictions between the representatives of handicrafts education. For example, textile teachers tend to interpret technology as tools, methods of work, techniques, or machine technology.

Thus, the official terminology continued to support old fashioned approaches. Many individual teachers and schools have, however, been following the international development of the subject area and eagerly adopted the contents and aims of a more-broadly defined technology education. Teacher training in technical work is also no longer limited only to handicraft training as a result of increased research and international influences.

**The Present Situation**

The writer has recently had the opportunity to discuss the subject development with teachers and teacher trainers, and to check the curricula in Helsinki schools. Both at the lower and higher comprehensive schools, the standard of teaching varies considerably. In both, very good and thoroughly thought about study units, projects, and topics can be found. There is, however, no real coordination of education because of the distributed nature of the education administration, and ‘stop-gap’ solutions are common, for example, reproduction tasks, particularly at the lower comprehensive school. There is also a lack of appropriate textbooks and near total absence of in-service training.

Materials, wood, metal, textile, machines, and electricity still generally form the basis of handicraft curricula. Some schools have begun to systematically use the revitalised term ‘handicrafts’, even if it is still divided according to traditional materials. Added to this is the way curriculum content is often described in the form of students’ or teachers’ work, for example, ‘familiarising with, constructing, teaching’ in contrast to criteria concerning what should be learnt (which would help guide assessment and evaluation).

The content of technology offered as an optional subject is in many schools based on students’ choices – what they want to produce for themselves. This naturally secures motivation and increases the number of students selecting the option, which also will guarantees a safe number of teaching periods for the teacher. This is, however, not the procedure that should define teaching content, which should rather be attached to the curriculum aims.

‘Teaching how to produce artefacts’ is still the main aim of handicrafts education. This refers either to handicraft-like or industrial-type production. There is, however, no longer such a strong need for this type of learning in Finland. Internationally, technological education has moved towards emphasising greater understanding of artefact culture and consumer needs, rather than teaching production skills as such.

Whilst integration within the subject is aspired for on one hand, connections with other subjects are also sought. Internal integration, which in this context means structuring technical work education in collaboration or closeness with technical work and textile work, has begun in schools. There have been many approaches to foster collaboration between technical work and textile work, for example, the arts and crafts spring exhibitions. According to *Basics for comprehensive school curriculum* (POPS-94, 1994) and the development of technology education internationally, it seems that ongoing integration should be pursued. This will, however, require some issues to be addressed. For example, the definition of the contents of textile work is in most curricula more detailed than of technical work. Textile work education has only one material area to take care of; the traditional scope of technical work is about five times greater. Thus, the aims and practice of teaching/learning will be implemented quite differently if the same number of periods is allocated.
to each. The need to further define the curricular needs and sub areas in the technology education curriculum seems obvious.

In some schools, a collaboration between technical work and home economics has been implemented. Teaching electronics and computers as part of technical work has been in place for a long time – electronics for 40 years, computers about 25 years. Computers, especially in lower comprehensive technical work, are, however, quite rare.

Entrepreneurship education has recently received much publicity in Finland. In technical work guides it was mentioned as far back as 1977. Surprisingly, it is not so much as mentioned in technical work curricula today. In lower comprehensive schools it should also be interpreted more as ‘enterprising activity’ or ‘primary acquaintances of schools and enterprises’. At the higher comprehensive level, some productive projects could be possible.

After completing higher comprehensive schooling, students select whether to attend vocational institutions or upper secondary (academic) schools. Motivating both groups should be considered in comprehensive school curricula and organisation. However, the vocational aspect has been diminished because of the lack of timetabled periods. Information about continuing studies in metals, wood, machines, electricity, and electronics should of course still be given.

DEVELOPMENT NEEDS

Technology should be seen as having a cultural dimension. In addition to writing, reading, and mathematical skills, skills such as computer skills have come to be regarded more and more as part of our culture. Technology should also be seen as influencing the whole of human culture. Everybody should have the opportunity to undertake a ‘basic course in technology’ at school. Its content should be to understand – in general – methods and products of technology as well as its impacts and potential impacts. Teaching should motivate students and meet their needs. Technology education should especially be organised for those who will not go on to pursue a career in technology, but who will nonetheless go on in life to make decisions connected with technological choices.

Children’s images about technology are based on artefacts which they come across in their everyday lives, including during play. Teaching should thus focus on and analyse everyday artefacts, including toys. Important, too, is that teaching does not only aim at reproduction: “We can reflect the spirit of technology, the attitude and application of search and research, the inventiveness, the creativity, the experimenting and developing, the problem solving, all of which are a part of, and fundamental to, an advancing technology” (Olson, 1963, p. 89). For teaching new technology it is no longer sufficient for the teacher to have ‘master’ skills such as in the handicrafts era. At that time, teacher training aimed at mechanical activity, which only has limited educational value.

Development of technology is of course continuing, and technological education should be accessible to everybody. The increased and increasing penetration of technology in more and more areas of human life means increased needs for abstract thinking and rationality. Essential in education in the future is, for example, connections between practical applications and using a problem solving approach.

‘Technological literacy’ is needed in order to survive in the modern society, to understand and use technology. It can be called ‘a survival skill’. Valuing computers more than technology in general, and ‘computer literacy’ beyond technological literacy has been criticised (Dyrenfurth, 1984; Otala, 1986). Rather, technological literacy includes computer skills. If technology means ‘making’, technological literacy is the skill to use technology appropriately at work and at home.
Structural changes in industry have mobilised the need to advance technological education internationally. Pioneering work has been done in France, the US, and the UK from the 1960s onwards. From the first time technology was mentioned in an educational context (Cygnaeus, 1861), it has been involved with structural changes in industry. The new title, technology education, has spread quickly through the 1980s and 1990s. It has been adopted in countries such as England, Italy, The Netherlands, Belgium, Australia, and New Zealand. In Sweden the subject is called ‘Teknik’, in Germany ‘Technik’ as a part of ‘Arbeitslehre’, education for work. The common underpinning philosophy has been preparation for survival and thriving in the changing environment, which has become more complex because of technology. It has brought to schools:

- A move from material or skill-based education to a more general education in order to guide students at their own level to understand technology;
- new technologies added to old material-based approaches (e.g., wood, metal, machines, electricity, textiles); and
- the placing of design in students hands instead of and added to the ready made drawings.
Figure 2 summarises the content of technology education for technological literacy. The core of the figure describes the teaching / learning activity, the elements of which should be materialised in every lesson. Most important is to give positive experiences in technology. These bring motivation and enthusiasm for learning, and good results. The balance between knowledge and skills will naturally become more central with increasing years of studies. The inner middle circle describes teaching/learning aims such as they are usually written in the curriculum language. The outer middle circle describes the different development stages of technical work education – from handicrafts, industrial skills, and techniques, to new technologies – which all affect education at present. The emphasis moves from the beginning of the list towards the end. The outer circle points out general background factors for technological education, which influence teaching but are not operational during every lesson. When writing the curriculum and planning education, one has to consider how these factors will impact on learning. Naturally, the basic principles of technological education also include, for example, basic concepts, processes, and systems of technology.

SUMMARY

At the beginning of the new Millennium there are plenty of challenges for the development of education. One is the modernisation of practical technological education in general education in schools. In Finland, this is called handicraft education.

At present the whole spectrum from the 143 year history of handicrafts education is reflected in Finnish schools. Whilst the best schools and teachers have developed teaching in line with current international trends emphasising technological literacy, the majority still teach mostly according to old models representing old technology.

Handicrafts education, which has the main responsibility for technological education, has no national systematic guidance or authorised curriculum. The result is that the standard is varied and uneven. In higher comprehensive schools the situation tends to be better because of the specialised subject teacher system.

At every school stage the subject contents should move from specific reproduction techniques to understanding new technologies and technological literacy. Teaching can be different at different school stages. ‘Handicraft technology’ can still be defended when it is appropriately assessed. Technology education should also be extended to upper secondary schools.

An indisputable fact remains that the main task of practical technological education in general education continues to be education for work. Also indisputable is that content of all school subjects must be updated when the respective disciplines develop and change.

Education must evolve to reflect the changing needs of society. Every production culture – whether handicraft, industrial, or automatic – seems to prioritise education for the world of work. School education must, however, emphasise content relevant to responsible citizenship as well as for direct employment needs. Internationalisation increases the need for analysing global innovations in education in order to develop a common terminology, which in turn forms the basis for communication.

Whereas handicrafts were once the foundation of production and artefact cultures, it has been replaced by electronics, computer technology, control technology, communication technology, etc. The term ‘handicrafts’ has during the last 30 years also proved to be powerless at breaking gender boundaries. In addition, innovations for ‘technical work’ implemented in the 1980s and 1990s are tumbling down under new education emphases. In Finland, any update in the contents of practical technological education needs to coincide with a renaming of the subject as ‘technology education’.

REFERENCES

INTRODUCTION

Technology education has been a school subject in the United States since the 1980s. Prior to that, it was taught as industrial arts education. Curriculum development has been accomplished primarily at the local and state levels since the Constitution of the United States of America (U.S.) mandates that education shall be the responsibility of the state and locality. However, more recently there have been some efforts to research and develop curriculum at the national level.

This chapter will briefly discuss how the U.S. transitioned from industrial arts to technology education before focusing research and development that has taken place in technology education in the United States over the past two and one-half decades. Work accomplished by the International Technology Education Association (ITEA) and its Technology for All Americans Project (TfAAP) to develop content standards for the study of technology in the U.S. (a basic ingredient of curriculum) will be presented, as will recent research findings on the status of technology education. A major effort currently underway to develop curriculum at the state and national levels will also be discussed.

TRANSITIONING FROM INDUSTRIAL ARTS TO TECHNOLOGY EDUCATION

In the United States, industrial arts education evolved from manual arts education in the late 1800s and early 1900s. Charles Richards was credited with coining the term ‘industrial arts’ in 1904 and the name served to represent the discipline until the latter part of the twentieth century.

The term “technology” was first used in literature in the U.S. when the American Industrial Arts Association (AIAA) titled the theme of its first conference in 1947, A Curriculum to Reflect Technology. The term was subsequently referred to numerous times in the 1970s and 1980s by curriculum development projects funded by the federal government as part of the Elementary and Secondary Education Act. In 1985, the AIAA changed its name to the International Technology Education Association (ITEA). Subsequently, most states changed the name of their state educational associations from industrial arts to technology education in the late 1980s and early 1990s.

WHAT IS CURRICULUM?

Curriculum is viewed in the U.S. as a written plan that defines how content is arranged, ordered, and emphasised (ITEA, 2005b). It provides the means by which the teacher and students interact. A curriculum is the plan for delivery of content day-by-day in the laboratory-classroom, which engages students in learning. The curriculum allows for flexibility and freedom so that individual
teachers can adapt to student needs, and ensures that the content is based on the appropriate standards.

In the U.S. the content for the study of technology is defined as what every student should know and be able to do in order to be technologically literate. This is provided in Standards for Technological Literacy: Content for the Study of Technology (STL) (ITEA, 2000/2002/2007), which will be discussed in detail later in this chapter.

Many educators view curriculum as the ‘glue’ that bonds together content (what is to be taught), instruction and methodology (how the content is to be taught), and student assessment (how well the content is being learned). In other words, the recipe for teaching includes content as the essential ingredient, instruction and methodology as the process of mixing and combining the content ingredients, and student assessment to allow for adjustments during the learning process or in preparation for the next ‘batch’.

DEVELOPMENT OF STANDARDS FOR TECHNOLOGICAL LITERACY (STL) AND ADVANCING EXCELLENCE IN TECHNOLOGICAL LITERACY (AETL)

In 1994, ITEA created the Technology for All Americans Project (TfAAP). The overarching goal was to increase the technological literacy of all students in compulsory education. Funding was provided by the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). Funding for TfAAP ended in October 2005. The two major publications produced by the project were:

– Standards for Technological Literacy: Content for the Study of Technology (STL) (ITEA, 2000/2002/2007); and

Other publications were also created by TfAAP to support STL and AETL and are discussed later in this chapter).

Creating a vision for what Standards for Technological Literacy should be

In the first funded phase of TfAAP, from 1994 to 1996, ITEA wanted to develop a document that would discuss the power and promise of technology in everyday lives. In addition, it wanted to establish a universal need of technological literacy for all people. This was very important since the study of technology in schools in the U.S. was a relatively new educational effort. ITEA did this in the first phase of the project through the publication of Technology for All Americans: A Rationale and Structure for the Study of Technology (R&S) (ITEA, 1996). This document provided a structure for what the content in the study of technology could be in the future.

In retrospect, the development of R&S was a very valuable tool in grounding the profession in what every student should know and be able to do in order to be technologically literate. The R&S document was prepared through assistance from project staff and a group of writing consultants made up from a 25-member National Commission for Technology Education. In developing the various drafts of the document, hundreds of practitioners from technology, engineering, science, mathematics, and other areas served as reviewers of the material. The document went through an extensive revision in 2006 and was retitled Technological Literacy for All: A Rationale and Structure for the Study of Technology (ITEA, 2006).
Standards for Technological Literacy: Content for the Study of Technology (STL)

From 1996 to 2000 (Phase 2 of the project), Standards for Technological Literacy: Content for the Study of Technology (STL) was developed, reviewed, published, and disseminated. STL set forth the vision that all students can and should become technologically literate. Four groups advised and provided input to TfAAP during the development of STL—(1) an Advisory Group, (2) a Standards Team, (3) a committee of the National Research Council of the National Academy of Sciences, and (4) a focus group from the National Academy of Engineering. The Advisory Group advised ITEA’s TfAAP on best practice for standards development and determined ways for the study of technology to be integrated within the total school curriculum. It was formed by key representatives of the National Council of Teachers of Mathematics (NCTM), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS) Project 2061, the National Research Council (NRC), the National Academy of Engineering (NAE), ITEA, and the Foundation for Technology Education. They met semi-annually to provide specific advice on the development of the standards and how technology education could be integrated with other fields of study, especially science and mathematics.

The Standards Team proposed, evaluated, and recommended the content of the standards. The 27-member team consisted of three subteams with nine people each (one team for Grades K–5, one team for Grades 6–8, and one team for Grades 9–12) to provide input to TfAAP staff responsible for the writing, generating, and consensus-building process of the standards. The Standards Team was made up of classroom teachers, supervisors, and teacher educators from technology education, as well as elementary administrators and representatives from science, mathematics, and engineering.

In 1999 and 2000, the NRC and a special focus group of engineers from the NAE carried out a formal review of STL. In mid December 1999, the NRC committee issued a final report stating that ITEA/TfAAP had “successfully completed the review process established by the NRC”. In early 2000, the NAE committee issued a public statement in support of STL. Additionally, the project received funding from the Technical Foundation of America in the development of three standards-related implementation publications for elementary, middle, and high schools.

Overview of STL

The STL document begins with a preface that sets the stage for the publication. Chapter 1 provides a broad perspective on preparing students for a technological world. Chapter 2 contains an overview of the features of STL as well a guide to its format. Chapter 2 also provides a section explaining the primary users of the standards and recommendations for using the standards for curriculum development. Lastly, Chapter 2 lists administrator guidelines for resources based on STL. Chapters 3 through 7 elaborate on each of the five major categories under which the standards were developed (see below). Chapter 8 is a call to action regarding how ITEA can acquire help implementing STL from others both within and outside the profession. The document also has an appendix, which includes the history of the project, a compendium that provides a quick overview of the standards and related benchmarks, and an articulated curriculum example for Grades K–12; references; acknowledgements; a glossary; and an index.
Features of STL

STL represents the collective view of hundreds of people regarding what should be the content for the study of technology in Grades K–12. In order to be as broadly valuable as possible, STL was created with the following basic features:

– It offers a common set of expectations for what students in technology should learn;
– it offers specific details about what every student should learn about technology;
– it is developmentally appropriate for students;
– it provides a basis for developing meaningful, relevant, and articulated curricula at the local and state/provincial levels; and
– it promotes content connections with other fields of study in Grades K–12.

STL is not a curriculum. A curriculum provides the specific details of how the content (STL) is to be delivered, including organisation, balance, and the various ways of presenting the content in the classroom, whereas standards describe what the content should be. Curriculum developers, teachers, and others should use STL as a guide for developing appropriate curricula, but the standards do not specify what should go on in the classroom.

In laying out the essentials for the study of technology, STL represents a recommendation from educators, engineers, scientists, mathematicians, and parents about specific skills and knowledge needed in order to become technologically literate. It is not, however, a federal policy or mandate. Nor does STL prescribe an assessment process for determining how well students are meeting the standards, although it does provide criteria for this assessment.

Format of STL

The individual standards presented in STL are organised into five major categories:

– The Nature of Technology (Chapter 3);
– Technology and Society (Chapter 4);
– Design (Chapter 5);
– Abilities for a Technological World (Chapter 6); and
– The Designed World (Chapter 7).

Standards in STL

STL includes twenty standards are distributed across the five categories (see Table 1). These are written statements about what is valued in the study of technology that can be used for judging quality. In this way, the document specifies what every student should know and be able to do in order to be technologically literate, and offers criteria to judge progress toward a vision of technological literacy for all students, from kindergarten through Grade 12.

Table 1. The 20 standards for technological literacy (ITEA, 2000/2002/2007).

<table>
<thead>
<tr>
<th>The nature of technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard 1. Students will develop an understanding of the characteristics and scope of technology.</td>
</tr>
<tr>
<td>Standard 2. Students will develop an understanding of the core concepts of technology.</td>
</tr>
<tr>
<td>Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.</td>
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</tbody>
</table>
**Technology and society**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>Students will develop an understanding of the cultural, social, economic, and political effects of technology.</td>
</tr>
<tr>
<td>5.</td>
<td>Students will develop an understanding of the effects of technology on the environment.</td>
</tr>
<tr>
<td>6.</td>
<td>Students will develop an understanding of the role of society in the development and use of technology.</td>
</tr>
<tr>
<td>7.</td>
<td>Students will develop an understanding of the influence of technology on history.</td>
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</tbody>
</table>

**Design**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>8.</td>
<td>Students will develop an understanding of the attributes of design.</td>
</tr>
<tr>
<td>9.</td>
<td>Students will develop an understanding of engineering design.</td>
</tr>
<tr>
<td>10.</td>
<td>Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.</td>
</tr>
</tbody>
</table>

**Abilities for a technological world**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>11.</td>
<td>Students will develop the abilities to apply the design process.</td>
</tr>
<tr>
<td>12.</td>
<td>Students will develop the abilities to use and maintain technological products and systems.</td>
</tr>
<tr>
<td>13.</td>
<td>Students will develop the abilities to assess the impact of products and systems.</td>
</tr>
</tbody>
</table>

**The designed world**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>14.</td>
<td>Students will develop an understanding of and be able to select and use medical technologies.</td>
</tr>
<tr>
<td>15.</td>
<td>Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.</td>
</tr>
<tr>
<td>16.</td>
<td>Students will develop an understanding of and be able to select and use energy and power technologies.</td>
</tr>
<tr>
<td>17.</td>
<td>Students will develop an understanding of and be able to select and use information and communication technologies.</td>
</tr>
<tr>
<td>18.</td>
<td>Students will develop an understanding of and be able to select and use transportation technologies.</td>
</tr>
<tr>
<td>19.</td>
<td>Students will develop an understanding of and be able to select and use manufacturing technologies.</td>
</tr>
<tr>
<td>20.</td>
<td>Students will develop an understanding of and be able to select and use construction technologies.</td>
</tr>
</tbody>
</table>

**Benchmarks in STL**

Benchmarks play a vital role in STL by providing the necessary elaboration of the broadly-stated standards. Benchmarks, which are statements that enable students to meet a given standard, are provided for each of the 20 standards at the K–2, 3–5, 6–8, and 9–12 grade levels. The benchmarks are followed by supporting sentences that provide further detail, clarity, and examples. (See Table 2 for an example.) Each student is required to meet all standards and their associated benchmarks, and teachers should feel free to add to the benchmarks to further enhance the ability of the student to meet a given standard.
Table 2. A representative standard and two benchmarks (shown in bold type in C and D).

| Standard 8—Students will develop an understanding of the attributes of design. In order to realize the attributes of design |
| C. The design process is a purposeful method of planning practical solutions to problems. The design process helps convert ideas into products and systems. The process is intuitive and includes such things as creating ideas, putting the ideas on paper, using words and sketches, building models of the design, testing out the design, and evaluating the solution. |
| D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. Technological designs typically have to meet requirements to be successful. These requirements usually relate to the purpose or function of the product or system. Other requirements, such as size and cost, describe the limits of a design. |

Research in education has demonstrated that if previously learned knowledge is tapped and built upon, it is likely that students will acquire a more coherent and thorough understanding of the processes than if they are taught them as isolated abstractions (NRC, 1999). With this in mind, the benchmarks are articulated, or ‘ramped’, from Grades K–12 to progress from very basic ideas at the early elementary school level to more complex and comprehensive ideas at the high school level. Certain content ‘concepts’ – such as systems, resources, requirements, optimisation, trade-offs, processes, and controls – extend across various levels to ensure continual learning of an important topic related to a standard.

Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Programme Standards (AETL)

In March 2003, ITEA released *Advancing Excellence in Technological Literacy (AETL)* at its 65th annual conference in Nashville, Tennessee. *AETL* is based on STL and is designed as a companion to STL. *AETL* was developed by TfAAP from 2000 to 2003.

*AETL* provides standards and guidelines that address student assessment, professional development, and programme enhancement. The primary goal of all the standards is to help students achieve technological literacy. The 11-person TfAAP Advisory Group provided valuable counsel in best practice of standards development to the project. They met annually in Washington, DC.

The TfAAP Standards Writing Team was made up of 27 people (three teams of nine). They provided detailed input in fashioning the initial draft of *AETL*, and their continued review and input added strength and quality to the final document. The development and refinement of *AETL* took place over three years and involved hundreds of educators and experts in the fields of technology, mathematics, science, engineering, and other disciplines. Their input was attained through various methods, including hearings, web-based electronic document review, and individual reviews through the mail and in person. Three formal drafts of *AETL* were developed and reviewed before the final draft was prepared in autumn 2002.

Overview of AETL

Chapters 1 and 2 of *AETL* provide valuable introductory material. Chapter 1 is an overview that presents the rationale of need and conceptually introduces Chapters 3, 4, and 5. Chapter 2
discusses relevant principles and definitions. Subsequent chapters focus on the three separate, but interrelated, sets of standards that make up AETL:

– Student Assessment Standards (Chapter 3);
– Professional Development Standards (Chapter 4); and
– Program Standards (Chapter 5).

Finally, Chapter 6 invites users to participate in the visionary basis of STL and AETL.

The standards in AETL are based upon STL. To fully and effectively implement the content standards in STL, all of the AETL standards presented in Chapters 3, 4, and 5 must be met through the guidelines. While AETL is designed to leave specific curricular decisions to educators, teachers, professional development providers, and administrators, STL and AETL should be used as guides for advancing technological literacy for all students.

**Student assessment standards (chapter 3).** The definition for student assessment presented in AETL is “the systematic, multi-step process of collecting evidence on student learning, understanding, and abilities and using that information to inform instruction and provide feedback to the learner, thereby enhancing student learning” (ITEA, 2003, p.18). The primary audience for the student assessment standards is teachers. It is important to note that the standards are applicable to those who educate students on any aspect of technology.

The five organisational topics for the student assessment standards are:

– Consistency with STL;
– intended purpose;
– research-based assessment principles;
– practical contexts; and
– data collection.

While the student assessment standards (see Table 3) define how assessment of technological literacy should be designed and implemented, Chapter 3 does not provide a test, quiz, or other handy instrument to be photocopied and used in the laboratory-classroom. This task is left – as it should be – to individual teachers and others.

Users of the student assessment standards should recognise that student assessment should be formative (ongoing) as well as summative (occurring at the end). Further, users should recognise that the assessment process should be informative, that is, it should inform students and teachers about progress toward technological literacy and provide data on the effectiveness of instruction and the teaching and learning programme. Teachers should use student assessment data to improve classroom practices, plan curricula, develop self-directed learners, report student progress, and research teaching practices.

**Table 3. Student assessment standards (ITEA, 2003).**

| A–1. | Assessment of student learning will be consistent with Standards for Technological Literacy: Content for the Study of Technology (STL). |
| A–2. | Assessment of student learning will be explicitly matched to the intended purpose. |
| A–3. | Assessment of student learning will be systematic and derived from research-based assessment principles. |
| A–4. | Assessment of student learning will reflect practical contexts consistent with the nature of technology. |
| A–5. | Assessment of student learning will incorporate data collection for accountability, professional development, and programme enhancement. |
Professional development standards (chapter 4). Chapter 4 presents criteria for professional development providers (including teacher educators, supervisors, and administrators) to use in planning professional development. Professional development includes a continuous process of lifelong learning and growth that begins early in life, continues through the undergraduate, pre-service experience, and extends through the in-service years.

The standards are applicable to those who prepare teachers on any aspect of technology, including teachers whose primary focus may be another subject area.

The seven organisational topics for the professional development standards are:
- Consistency with STL;
- students as learners;
- curricula and programmes;
- instructional strategies;
- learning environments;
- continued professional growth; and
- pre-service and in-service (see Table 4).

Users of this document should focus on preparing teachers to continue to pursue professional development to keep up to date with changing technologies and research on how students learn. The necessity to address issues of technological literacy is pertinent to all programmes that prepare teachers of every grade level, including K–5 elementary teachers and teachers of science, mathematics, social studies, language arts, and other content areas. Therefore, faculty members in every teacher preparation programme can use STL and AETL to determine how the technological literacy of teacher candidates can be enhanced.

Table 4. Professional development standards (ITEA, 2003).

<table>
<thead>
<tr>
<th>PD–1.</th>
<th>Professional development will provide teachers with knowledge, abilities, and understanding consistent with Standards for Technological Literacy: Content for the Study of Technology (STL).</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD–2.</td>
<td>Professional development will provide teachers with educational perspectives on students as learners of technology.</td>
</tr>
<tr>
<td>PD–3.</td>
<td>Professional development will prepare teachers to design and evaluate technology curricula and programs.</td>
</tr>
<tr>
<td>PD–4.</td>
<td>Professional development will prepare teachers to use instructional strategies and enhance technology teaching, student learning, and student assessment.</td>
</tr>
<tr>
<td>PD–5.</td>
<td>Professional development will prepare teachers to design and manage learning environments that promote technological literacy.</td>
</tr>
<tr>
<td>PD–6.</td>
<td>Professional development will prepare teachers to be responsible for their own continued professional growth.</td>
</tr>
<tr>
<td>PD–7.</td>
<td>Professional development providers will plan, implement, and evaluate the pre-service and in-service education of teachers.</td>
</tr>
</tbody>
</table>

Program standards (chapter 5). AETL defines the programme refers to everything that affects student learning, including content, professional development, curricula, instruction, student assessment, and the learning environment implemented across grade levels. The system-wide technology programme manages the study of technology in technology laboratory-classrooms as well as in other content area classrooms. The primary audience for the programme standards are twofold: (1) teachers and (2) administrators (including supervisors). As a result of this, the guidelines are divided for addressing these two audiences.
Chapter 5 in AETL presents criteria for teachers and administrators (including supervisors) responsible for the technology programme and system-wide technology programme. The standards are applicable to those who organise the learning of students on any aspect of technology. The five organisational topics for the programme standards are:

- Consistency with STL;
- implementation;
- evaluation;
- learning environments; and
- management.

Users of the programme standards should recognise that thoughtful design and implementation of technology programmes at school levels and of system-wide technology programmes at district levels are necessary to provide comprehensive and coordinated experiences for all students across grade levels and disciplines, including science, mathematics, social studies, language arts, and other content areas. The programme standards (see Table 5) call for extending technology programmes beyond the domain of the school. Technology programmes should, for example, involve parents, the community, business and industry, school-to-work programmes, and higher education as well as professionals in engineering and other careers related to technology. And finally, it is essential that adequate support for professional development be provided by administrators to ensure that teachers remain current with the evolving fields of technology and educational research.

Table 5. Programme standards (ITEA, 2003).

| P–1. | Technology programme development will be consistent with Standards for Technological Literacy: Content for the Study of Technology (STL). |
| P–2. | Technology programme implementation will facilitate technological literacy for all students. |
| P–3. | Technology programme evaluation will ensure and facilitate technological literacy for all students. |
| P–4. | Technology programme learning environments will facilitate technological literacy for all students. |
| P–5. | Technology programme management will be provided by designated personnel at the school, school district, and state/provincial/regional levels. |

Guidelines as enablers to meet the standards. Guidelines play a vital role in AETL. They are presented under each standard, and must be addressed to enable the user to meet a given standard. ITEA does not recommend that users eliminate any of the guidelines, although users may add to the guidelines if there is a need to accommodate local differences. A sample standard (A–4) with related guidelines is presented in Table 6.

TECHNOLOGY STANDARDS-BASED ADDENDA

The ITEA Addenda series (to STL and AETL) is part of the standards package for technological literacy. They were produced by the TFAAP with special assistance from ITEA’s Centre to Advance the Teaching of Technology and Science (CATTs). The addenda are based on the standards but include concrete processes or suggestions for incorporating national, state, and/or local technological literacy standards into the programmes of all students throughout Grades K–12. Additionally, all of the documents contain worksheets for educators to use to make changes specific to their locality and situation. The addenda series marks another pioneering effort.
in educational reform as it provides a supplement to educational standards that focuses on the entire picture of programme reformation rather than concentrating solely on curricula. The addenda are:

- *Measuring Progress: Assessing Students for Technological Literacy* (ITEA, 2004) (student assessment);
- *Realizing Excellence: Structuring Technology Programmes* (ITEA, 2005c) (programmes);
- *Planning Learning: Developing Technology Curricula* (ITEA, 2005b) (curricula); and
- *Developing Professionals: Preparing Technology Teachers* (ITEA, 2005a) (professional development).

**Table 6. Sample standard with related guidelines (ITEA, 2003, p.30–35).**

| Standard A—4: Assessment of student learning will reflect practical contexts consistent with the nature of technology. |
|=================================================================================================================|
| Guidelines for meeting Standard A—4 require that teachers consistently: |
| A. Incorporate technological problem solving. |
| B. Include variety in technological content and performance-based methods. |
| C. Facilitate critical thinking and decision making. |
| D. Accommodate for modification to student assessment. |
| E. Utilize authentic assessment. |

**RESEARCH BY ITEA ON THE STATUS OF TECHNOLOGY EDUCATION IN THE UNITED STATES**

ITEA conducted research on the status of technology education in the United States in 2006-07 (ITEA, 2007). This was the third study conducted by ITEA on the condition of the study of technology in all 50 states. The previous studies were completed by ITEA’s TfAAP in 2000-01 and 2003-04. The reports of the previous two studies were published in *The Technology Teacher* (Dugger, 2007; Meade & Dugger, 2004).

Questionnaires were sent electronically via e-mail in October 2006 to all 50 state technology education supervisors. In cases where no supervisor was available, alternate contacts in the state education departments were used. Two additional follow-up surveys were e-mailed in January and March 2007 to those states that had not returned their responses. Finally, telephone follow-up calls were conducted in April and May 2007 to attempt to gather unreported data from the states that had not responded and to clarify responses as necessary. There were 46 states (out of 50, or 92%) that responded to the 2007 survey.

The survey consisted of 10 questions. Questions 1, 2, and 4 were duplicated from the Newberry (2001) study and questions 5 and 6 were added in the 2004 survey. Questions 3 and 7 through 10 were added to the 2006-07 instrument. The specific questions were:

1. Is technology education in your state framework? (Yes or No)
2. Is technology education required in your state? (Yes or No)
3. If you answered Yes to question #2, is it:
   — Under local control
   — An elective
   — A requirement that is pending/proposed
   — At what grade level?
4. How many technology education teachers are in your state? _________
5. Have you used *Standards for Technological Literacy: Content for the Study of Technology (STL)* in any of the following ways? (Select all that apply)
   - Not used at all
   - Placed in your state standards
   - Adopted “as is” for your state standards
   - Used in your curriculum guides
   - Conducted workshops using the standards
   - Other, please specify

6. Have you used *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Programme Standards (AETL)* in any of the following ways? (Select all that apply)
   - Not used at all
   - Placed in your state standards
   - Adopted “as is” for your state standards
   - Used in your curriculum guides
   - Conducted workshops using the standards
   - Other, please specify

7. Are you doing *Standards for Technological Literacy* assessments in your state at this time? (Yes or No) (If Yes, please share how used).

8. What course title(s) best describe the secondary school level technology education curriculum being taught in your state?

9. Do you have a technology education state curriculum guide(s)? (Yes or No)

10. What best describes where technology education programme funding comes from in your state (i.e., relationships to local, state, national programmes)?

In response to Question 5, which asked whether and how STL was used, 42 states (91.3% of those reporting) in 2006-07 reported using STL at either the state or local school district level (see Table 7). Two states (4.3%) stated that they did not use STL; two states reported they were not sure whether they used it or not; and four states did not report. In 2004, 41 states (78.8%) reported using STL, with two states reporting “unknown.” This compares very favourably to the Ndahi and Ritz (2003) findings that 43 states (83%) were using STL. Both the 2004 survey and the Ndahi and Ritz survey showed that seven states (13.5%) were not using STL. Averaging these data indicates that STL is used by over four out of every five states across the nation. Table 8 summarises how states reported using STL. Only one state (2%) reported that STL was not used at all. There were 14 states (30%) that said that STL was placed in their state standards. When asked if STL was adopted “as is” for their state standards, 11 states (24%) reported that it was. There were 22 states (48%) that reported that STL was used in their state curriculum guides. When asked if they had conducted workshops using STL, 18 states (39%) answered in the positive. State supervisors were also asked to describe other ways that STL was used in their states. Of the 13 responses (28%), STL was used primarily as a resource or reference and as a guideline for technology and engineering education.

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<thead>
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<td>0</td>
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</tbody>
</table>

Ndahi and Ritz (2003)

Table 8. Responses from state supervisors on how STL is used.

<table>
<thead>
<tr>
<th>Questionnaire options</th>
<th># respondents</th>
<th>% respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not used at all</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Placed in state standards</td>
<td>14</td>
<td>30%</td>
</tr>
<tr>
<td>Adopted “as is” for state standards</td>
<td>11</td>
<td>24%</td>
</tr>
<tr>
<td>Used in curriculum guides</td>
<td>22</td>
<td>48%</td>
</tr>
<tr>
<td>Conducted workshops using the standards</td>
<td>18</td>
<td>39%</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>13</td>
<td>28%</td>
</tr>
</tbody>
</table>

In response to Question 6, AETL was reported as being used in 29 of the states (63% of those reporting; see Table 7). Only 13 states (28.3%) of those reporting have not yet used AETL. The difference between STL and AETL usage is not unexpected considering that AETL had been published only four years prior to the time that the survey was conducted. Table 9 indicates some of the ways that AETL may be used in states. Eleven states (25% of those reporting) said that they did not use AETL at all. Five states (11%) reported using AETL in their state standards, with three states (7%) stated that AETL was adopted “as is” in their state standards. Eight states (18%) reported that AETL was used in their state curriculum guides, while nine states (20%) said that they had conducted workshops for teachers on AETL. When asked what other ways AETL was being used, 15 (34%) of state supervisors stated that it was used as a reference or resource and as a document to provide guidance to local school districts.

Questions 8 and 9 specifically address technology education curriculum in various states. A brief summary of the major findings for these two questions are as follows:

- When asked in Question 8 – “What course titles best describe the secondary school technology education curriculum taught in your state?” – state supervisors provided a wide variety of answers. Many of the supervisors stated that the local school districts have the responsibility to provide course titles. The response that was provided the most frequent for course title(s) was “Technology Education.”
- Question 9 was “Do you have a technology education state curriculum guide(s)?” Twenty-seven states (59% of those reporting) answered that they had technology education curriculum guides. There were 19 other states (41%) that reported they did not have any curriculum guides for technology education.
Table 9. Responses from state supervisors on how AETL is used.

<table>
<thead>
<tr>
<th>Questionnaire options</th>
<th># respondents</th>
<th>% respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not used at all</td>
<td>11</td>
<td>25%</td>
</tr>
<tr>
<td>Placed in your state standards</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>Adopted “as is” for your state standards</td>
<td>3</td>
<td>7%</td>
</tr>
<tr>
<td>Used in your curriculum guides</td>
<td>8</td>
<td>18%</td>
</tr>
<tr>
<td>Conducted workshops using the standards</td>
<td>9</td>
<td>20%</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>15</td>
<td>34%</td>
</tr>
</tbody>
</table>

ENGINEERING BY DESIGN™ (EBD): A STANDARDS-BASED MODEL PROGRAMME/CURRICULUM

ITEA’s Centre to Advance the Teaching of Technology and Science (CATTSS) has developed the only standards-based national model curriculum for Grades K–12 that delivers technological literacy. The model, Engineering by Design™ (EbD), is built on Standards for Technological Literacy (ITEA, 2000/2002/2007); Principles and Standards for School Mathematics (NCTM, 2000); and Project 2061, Benchmarks for Science Literacy (AAAS, 1993). EbD publications can be viewed at www.iteaconnect.org.

CHALLENGES FOR THE FUTURE

ITEA’s TfAAP and its work to generate STL, AETL, and other related materials do not represent an end, but rather a beginning. In other fields of study, developing content standards and the resulting curriculum has often proven to be the easiest step in a long, arduous process. Therefore, getting these technology standards and curriculum accepted and implemented in Grades K–12 in every school will be far more difficult and daunting than developing them has been. Only through the combined efforts of educational decision makers throughout the U.S. will we be able to ensure that all students develop higher levels of technological literacy.

NOTES

1 Complete data tables with comments are viewable online at www.iteawww.org.

REFERENCES

DUGGER


*William E. Dugger, Jr.*  
*International Technology Education Association*  
*USA*