INTERNATIONAL TECHNOLOGY EDUCATION SERIES

Positioning Technology Education in the Curriculum

Marc J. de Vries (Ed.)

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INTERNATIONAL TECHNOLOGY EDUCATION STUDIES

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.

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PREFACE

This book is a spin-off from the international Pupils' Attitudes Towards Technology (PATT) conference that was held in Delft, the Netherlands in 2009. The main theme of this conference was the same as what has now become the title of this book. All participants were asked to reflect on the way Technology Education, in whatever form, should be positioned in the school curriculum. In recent international discussions about this, it has become clear that the position of Technology Education in the curriculum is never to be taken for granted. Even though very good practices have been developed in many countries, the place of Technology Education in schools is still easily questioned when curriculum changes are foreseen. For that reason there is a constant need for technology educators to think about the best way for teaching technology as part of the total education of future citizens and future workforce. The chapters in this book are a selection of the PATT conference papers, based on their proximity to the theme and on their quality. All papers have been reviewed and rewritten in order to get a coherent book of high quality.

I want to thank all the authors for their cooperation. It was a pleasure to work with you because I hardly had to chase any author for keeping to my deadlines. I also want to thank Machiel Stam and Arjan Verheij for their work on correcting the lay-out errors that the authors had left for us. Thanks also to Sense Publisher's Peter de Liefde who was willing to take up this publication in the International Technology Education Studies series. Our field is most grateful to have you as a publisher who is willing to invest in publishing scholarly material on Technology Education, even in a series especially dedicated to this.

We hope that readers will enjoy reading this book and that it will serve a useful purpose in supporting the case of Technology Education internationally. The authors believe that technology is too important for being not given a decent and recognizable place in the school curriculum.

March 2011
Marc J. de Vries

TABLE OF CONTENTS

MARC J. DE VRIES

INTRODUCTION

TEACHING ABOUT TECHNOLOGY: DEFENDING THE OBVIOUS

If there is anything easy to justify in schools, it is the teaching about technology. Technology is so important in society that one would expect it needs no defence to have it is the school curriculum. A term like 'technological literacy' sells well. Of course we need to make sure that all people have it. One would expect it to have a prominent position in the school curriculum, next to (linguistic) literacy and numeracy. As we all know, this is by no means the case in general. Technology teachers are in constant need to explain why their subject would have to be on the timetable.

The discussion about technology can easily become a narrow one if it is limited to frustrated technology teachers defending the position of technology education as an independent school subject. One could seriously ask the question if teaching about technology in a separate subject is the only option for developing technological literacy. That is certainly not the stance taken by the well known document "Standards for Technological Literacy" that was published in the USA. Deliberately the term 'technological literacy' was chosen to make clear that the standards described in the document are not meant to be for a separate school subject called 'Technology education' only. The implication of the document title is that technological literacy is something that can and needs to be developed in various parts of the curriculum. It is not only the technology teacher who contributes to technological literacy development with learners. In fact, the difficulties that technology teachers often have in moving away from the past in which this dedicated school subject with technology in its name was focused on the teaching and learning of handicraft skills mainly. There was certainly a value in that, which somehow must be kept active, but the contribution to technological literacy was fairly limited in that type of technology education. No wonder that school board and policy makers often looked in other directions for positioning the teaching about technology in the school curriculum.

In this book the position of technology education in the school curriculum is highlighted from different angles. The aim of the book is to get the discussion about the place of technology education in the curriculum above the level of anger and frustration about the 'wicked world' not understanding the importance of technology and therefore denying technology education a place in the curriculum as a separate subject. What we will do is study the various factors that should have an influence on the decision about where and how to position technology education in the curriculum. Different contexts may lead to different decisions about that, and

M.J. de Vries, Positioning Technology Education in the Curriculum, 1–7.

for good reasons. There is no quick and easy answer to the question whether or not technology education should be a stand-alone school subject. In primary education, for instance, the focus is on children, not on school subjects. In that context, insisting on technology education being taught separately may alienate it from the rest of the curriculum. It can then easily get the same status as physical education: often taught by a specialist teacher and seen as useful but never a reason for having children fail a class. Likewise, other factors can cause differences in decisions about the place of teaching technology in schools. From now on I will use the term 'technology education' not to indicate only a separate school subject, but as exchangeable for other terms like 'teaching technology' or 'teaching about technology'.

DEVELOPMENTAL ASPECTS

The teaching about technology has changed substantially in the past decades. In many countries a craft-oriented school subject grew out to become a broader subject in which modern technology got a lot of attention, as well as more cognitive aspects of the subject. Of course, the teaching about technology is not unique in that respect. All school subjects go through changes that are often caused by changes in the social context of education. But technology teaching has less of a tradition than other subjects and that makes changes in the subject often more problematic because it is difficult to distinguish would should be regarded as the constants in time and what can be changed without losing the true nature of the subject. Even though, this is the case, we can nowadays see 'histories' of teaching technology being published in various countries. These are based on relatively short periods of time mostly, as technology teaching often hardly has a history, depending of course on what one reckons it to be. Writing histories about the way technology has been dealt with in a national school curriculum can be a useful means to identify what so far has been seen as essential for teaching technology and what is more a matter of preferences that may change over time and hopefully due to growing insights. The chapters by Martin and Halstrom contribute to reflecting on change and development as a factor that influences how technology is taught in schools. Like technology itself, teaching about technology cannot be static in time. New times demand new developments and it makes no sense to try to keep things as they were just because 'that is the way we always did it'. Martin described change as a contemporary and constant challenge for teaching abiout technology and Hallstrom offers a nice example of a history of technology education, namely the Swedish version of it.

DEFINING TECHNOLOGY EDUCATION

Another important factor in discussion the place of technology in the school curriculum is the way it is defined. In the past it was often taken to be the processing of materials by means of tools and machines. The way technology was taught reflected that. Later on the concept of technology education widened and we began to understand that technology has a social embedding, a human dimension, it has gone through a certain history, and so on. The philosophy, history and sociology of technology and design methodology are academic disciplines that can be useful as inputs for defining what technology itself is as well as on what technological literacy could be and what the teaching of technology could encompass. Two chapters in this book focus on that aspect, namely the ones by John Dakers and Lars Adiels. Both make use of the philosophy of technology in particular to support their ideas about how the teaching of technology should be conceptualised. They are complementary in that Dakers is more oriented towards the Continental philosophy while Adiels has a more analytical approach. Although the difference between Continental and analytical philosophy is problematic, no one will deny that there are certain differences in accents and tendencies. Both are needed if one wants to have a proper underpinning in the process of conceptualising the teaching of technology.

TECHNOLOGY, ENGINEERING AND SCIENCE EDUCATION

One of the important debates in defining technology is its relation with science and in this debate often engineering is mentioned as a sort of ‘in between’. Engineering can be taken to be different from technology in that engineering only comprises the profession of developing and producing technology, while the broader concept of technology also has the user dimension. Another difference is that engineering is a combination of intervention in reality and the scientific study of that intervention. This makes engineering ‘a’ science, next to natural and human/social sciences. This has implication for positioning technology education in the curriculum. It is necessary to reflect on the relation between the teaching of technology, of engineering, and of (natural) science. One option is to teach technology and engineering in a combined school subject (‘Technology and Engineering Education’ or ETE), or to combine all three. In certain school types one may even want to have them all three separately taught. Three chapters deal with this debate. Barlex discusses the rapidly emerging term ‘STEM’ as an even wider combination that includes mathematics also. Using the recent developments in England he shows the pros and cons of this new integrative approach. Lebeaume writes from a French perspective. Starting with a short history of technology education in France, he shows how the relation between teaching science and teaching technology has shifted over time and what conceptual confusions can play a role in this. John Williams focuses on the relation with engineering. There seems to be a shift towards making technology education more ‘solid’ by adding elements of engineering, like modelling, working more quantitatively, using more input from physics, chemistry and biology, and the like. He poses the question if this is ‘good’ for technology education. The answer to this questions is by no means obvious and may be different for different levels of education.

FORMAL AND INFORMAL TECHNOLOGY EDUCATION

School is not the only place where technology is taught. There is a growing supply of informal learning opportunities. Museums are active in developing special activities for school children. Various social organisations organise activities for youth to offer them opportunities for experiencing technology. Schools can ignore this and stick to their own curriculum, but that means a loss of good chances for extending the teaching about technology in ways that schools with their limited resources cannot offer. Technology education should be positioned in a combination of school curriculum and informal learning opportunities. This, of course, has an impact on what one sees as the optimal embedding in the school curriculum, given the fact that technology teaching takes place elsewhere too. The chapters by Männikö-Barbitiu and by Hantson and Van de Velde deal with this factor related to the positioning of technology education in the school curriculum. Both use examples from their respective countries: Sweden and Belgium. It is obvious that for technology this is an important factor, as technology in the sense of development and production of new devices takes place outside the school and in order to get an impression of that, one cannot stay within the limits of what schools can offer. Also informal education often has the advantage of high tech devices being available for teaching about technology. It must also be stated that informal education should not ignore the school curriculum in order to prevent the informal learning to be alienated from what schools teach. Formal and informal education should pass on consistent ideas about technology, and if this is not the case, neither will result in effective learning.

CONTRIBUTING TO RESPONSIBLE CITIZENSHIP: ETHICS AND SUSTAINABILITY

Another factor in positioning technology in the school curriculum is the issue of responsible citizenship. This is seen as an important dimension in technological literacy, although this is often not reflected in practice. Teaching about technology should motivate and enable future citizens to live with technology in a responsible way, that is, in such a way that the wellbeing of others, including future generations, is enhanced rather than threatened. This means that ethics of technology should have a place in the curriculum. The way technology education is positioned in the curriculum is directly related to the question how responsibility in dealing with technology can be learnt best. “In a separate school subject”, can be the answer to that question, but not necessarily. One could argue that the links to other domains such as religious education and/or social school subjects is so important for this that a stand-alone subject called ‘Technology Education’ cannot do this job properly. Parikka, Rasinen and Ojala discuss the issue of ethics in technology education in a general way but with references to their country, Finland. Elshof is well known for his focus on environmental issues as a necessary concern for technology education. It is quite useful to read his considerations on the barriers that hamper the introduction of environmental issues in education, and also in our behaviour in general. There is still a lot to be gained here, and fortunately the number of initiatives for this increases rapidly.

TEACHING TECHNOLOGY AS A CONTRIBUTIION TO LITERACY

Teaching about technology not only helps learners acquire an understanding of what technology is and how to deal with it, but it can also contribute to the learning of other domains. Literacy and numeracy are generally seen as perhaps the two most essential components in the school curriculum. In primary education especially, they are very much the focus of most of the teaching that takes place. What teachers often do not realise is that teaching about technology can enhance learning the basic skills of 'reading, writing and arithmetic'. The relation with numeracy has already been dealt with to some extent in the section on STEM relations. The relation with literacy in the sense of learning how to read and write is the focus of Van Dijk's and Van de Velde's chapters. Both show how language learning and learning about technology can go hand in hand when technology education is positioned in the curriculum in a way that allows for this to take place. Technology is an activity in which communication place an important part. The biblical story of the Tower of Babel offers a nice illustration of that. Rather than smashing the tower by lightning, the Lord confuses the communication between the people and this brings about the immediate ending of the building process. Without communication (to due confused language), technology does not flourish. Vice versa, when learners do technological activities, by necessity they have to exploit language skills, thereby enhancing them in the same process. Developing technical terminology, giving names to devices, discussing design decision, all of these and many other symbolic and linguistic activities can be used for that. Given the great weight that is awarded to literacy in schools, the connection between learning about technology and the development of literacy can be an important consideration for positioning technology education in the curriculum.

PROGRESSION IN THE CURRICULUM

Considerations about how to build up a school curriculum are not in the least concerned with the issue of progression. What progress is made in learning when a learner makes his/her way through the curriculum in the consecutive years of school attendance? This question is also relevant for positioning technology education in the curriculum. Where does it come in so that it fits with the overall progression that has been defined for the curriculum? How does it continue from there? When is it completed (if ever learning can be said to be 'completed')? What types of progression can be defined? Compton and Compton in their chapter offer a view on that from the New Zealand perspective. New Zealand is a country that has realised significant progress in a relatively short time in recent years. The New Zealand colleagues have extensively gained from experiences and insights that were developed elsewhere. The result of that is an impressively well founded curricular thinking. The theoretical basis for the technology education curriculum has been derived from various disciplines also (including the philosophy of technology). This has also resulted in a sound underpinning for how progression in the New Zealand technology education curriculum has been defined.

POSITIONING TECHNOLOGY EDUCATION IN DEVELOPING COUNTRIES' SCHOOL CURRICULUM

The final section of this book deals with a specific context for curriculum debates, namely that of developing countries. Here, the debate is often dominated by concerns of lack of resources, lack of well educated teachers, lack of references to real-life technology practices, and the like. These issues make the proper positioning of technology education in the curriculum an even more problematic one than in developed countries. It is often difficult in that context to have a balanced view on the role of technology in society. Often there is an overoptimism about what technology alone can do for a country. This can easily lead to overambitious plans for teaching about technology that ignore local strength and needs. That then leads to frustrations as these ambitions appear to be unrealistic and in the end technology education suffers rather than benefits from these high expectations. Two examples are described in this section. Banks discussed developments in Bangladesh. Feng, Siu and Gu describe the situation in China. The two countries are very different as 'developing countries'. Yet, in both countries the introduction of modern technologies is still ongoing, certainly when compared to western industrialised countries. This justifies having both in this section, even though the differences are big. Both chapters show the challenges that technology educators meet in positioning their subject in the school curriculum.

THE FUTURE OF TECHNOLOGY EDUCATION IN THE SCHOOL CURRICULUM

In the sections above we have considered eight factors that influence the positioning of technology education in the school curriculum. All of them have to be taken into account when discussing technology education and its contribution to the overall education of learners. The future of technology education will largely depend on the extent to which we are able to get a more in-depth insight into the mechanisms that determine the impact of each factor individually and the factors in combination on how technology can best be embedded in school curricula. The contributions in this book offer such insights. But this knowledge seems to be still fragmented and more research is needed to develop more comprehensive ideas about the consequences of certain choices in positioning technology education for its sustainability and stability in the curriculum. We need to get beyond the stage in which the place of technology education depends too much on a lack of understanding of its nature among decision makers, be it politicians or school boards. We need to produce solid evidence for what works and what does not work. The impact of technology on our lives and the urgent need to educate future citizens in dealing with technology justifies our continuous efforts in bringing about that evidence.

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DEVELOPMENTAL ASPECTS

GENE MARTIN

A CONTEXT FOR CHANGE – A CHARGE TO CONSIDER

INTRODUCTION

A cursory review of the chapters included in this book provides ample evidence that the international community of technology educators is interested in a range of topics in order to better position the profession well into the 21st century. Each of the topics, at least from a global perspective, needs the profession's immediate and undivided attention. Positioning the profession will include, but not be limited to, seeking answers to questions that focus on whether the profession should (a) establish strategic curricular alliances with other academic areas (e.g., science and engineering), (b) seek monetary support to further advance technology education research initiatives (e.g., philanthropic organizations such as grantmakers and professional organizations), and (c) increase awareness of the need to promote and gain political and/or public support. Only time will reveal the ways the profession used its resources to address a *"context for change"* while at the same time setting a future direction for technology education.

Regardless of the array of topics included in this book, a common thread running throughout all the chapters is the important role of research in positioning the profession. Every author in this book, directly or indirectly, references research in their chapters. A premise of this chapter on "*a context for change – a charge to consider*" is that technology education leaders need to become more proactive and provide key leadership to position technology education into the mainstream of education. Meaningful research is one very important way, but not necessarily the only way, to increase the relevancy of technology education.

PRECEDENTS

A number of rather significant events occurred in technology education over the past several years that helped frame its present status. These events included, but are not limited to, (a) the establishment of standards for technological literacy; (b) an increased recognition by the profession of the importance of professional student organizations; (c) the introduction of new curriculum initiatives; (d) the continuing debates over the definition of technology education; (e) the identification of issues in technology education; (f) an increased number of professional development initiatives; and (g) expanded research horizons. However, just as the global community continues to face an uncertain future, technology education professionals and their programs are also confronted with an uncertain future.

M.J. de Vries, Positioning Technology Education in the Curriculum, 11–19.

Today, many areas of education are being attacked by self-interest groups including influential politicians. Bold and purposeful change has become a prerequisite for the profession's mere existence and the profession is being challenged now more than ever before to set aside some of its long held traditions and beliefs and move back into the mainstream of education where it has not navigated in recent years. Whether the profession will be a viable, robust, goal-oriented collection of professional educators in the future remains to be determined as there is a cloud of uncertainty in profession's future. The profession's leaders, whether they be classroom teachers, supervisors, and/or teacher educators, need to step forward and either recalibrate the profession's current path or set a whole new direction. This chapter provides a foundation for *a context for change – a charge to consider*.

Arguably, there are two very large and significant issues currently confronting the profession. These issues focus on (a) leadership development and (b) scholarly inquiry. With regard to leadership and leadership development, there remains a nucleus (albeit small) of individuals in the profession who appear unwilling or unable to step to the forefront to provide meaningful and purposeful leadership. Maybe part of the problem in the lack of demonstrated leadership has come about as a result of a dwindling number of individuals who are pursuing technology education as a professional career, regardless of their level of involvement in technology education (e.g., elementary education, secondary education, post-secondary education). Another aspect of a result of dwindling numbers is the closing of technology teacher preparation programs, particularly in the United States but not necessarily just the United States. For whatever reason, there does not appear to be a passing of the importance of leadership and leadership responsibilities in the profession from one generation to the next.

With regard to research or scholarly inquiry, there is evidence of quality research efforts that have the potential to culminate in important and meaningful changes in technology education. This book provides significant evidence of some of these research initiatives. These efforts, unfortunately, may appear at first glance to be somewhat isolated geographically as they have not brought about any significant cross-cultural changes in technology education on any type of global scale. In fact, a cursory review of journals published just in the United States by and for technology education teachers, supervisors, and teacher educators indicates that several of the current research-based articles are being authored by graduate students who are nearing completion of their doctoral studies or neophytes who have only recently completed their doctoral degrees. Sometimes, their major advisors have joined them in a co-authorship. In the 49th CTTE Yearbook, Streichler (2000) focused attention on the "nature, quality, and amount of research products being produced by the senior faculty" (p. 11), particularly at the doctoral degree granting institutions. His concern, which is a concern of many others in the profession, rests with the lack of research (quantity and quality) being conducted by those directly responsible with supervising our graduate students.

The focus of this chapter, therefore, is to underscore the importance of furthering a meaningful discussion by the international community on a direction for future research in technology education while at the same time to heighten a definite sense of urgency. Today, more than ever before, there is an important role and maybe even a responsibility for the international community of leaders and scholars to participate in a coordinated effort to establish a baseline of research data about technology education and to recommend a future research direction by establishing a research plan or agenda – that's a charge for the profession to consider. It's time for the profession's leaders and scholars to step forward as one body and address the critical shortage of research that characterizes the profession today.

A CONTEXT FOR CHANGE

The last half of the 20th century provided significant evidence that the profession's leaders (many but not all who come from academic faculty at teacher preparation programs) were devoting their scholarly time and energies to developing new curricula and supporting strategic teaching initiatives. In the United States, for example, state departments of education and local school systems were the most direct and immediate beneficiaries of these efforts. Today, however, the focus in higher education is on research and a call for increased levels and types of scholarly research within the technology education profession is occurring. Typically, research that is financially supported by external grants is judged as being more important than research that is not financially supported. There appears to be an even greater sense of urgency than in the past for the profession's members to address different methods (i.e., quantitative and qualitative) of scholarly inquiry and to present the results of their inquiries to their peers and education decision makers.

In the last decade of the 20th century, Waetjen (1992) admonished the profession to emerge from its protective shell and provide significant and noteworthy evidence to the rest of the academic world that technology education leads students to learn something different than what they may learn in other curricular areas. Waetjen further indicated that technology education would never be recognized as a bona fide academic discipline unless it first established and implemented a comprehensive research agenda. Waetjen spent a significant amount of personal time and energy through his professional presentations and scholarly publications framing his argument that the profession needed to conduct research on (a) outcomes of technology teacher education, (b) determining how political decisions are made and in particular those decisions that might have the greatest impact on technology education, and (c) students' competence in and attitudes toward technological studies and attitudes about themselves (pp. 29–30). Furthermore, Waetjen noted that the profession at that time was "inundated with survey research," some of it he referred to as "questionable utility" (p. 30). He challenged the profession to conduct more quantitative research, specifically experimental research, and to look for and identify cause and effect relationships. He believed that studies that demonstrated significant cause and effect relationships would most influence people who were in decision making authority over technology education. At first glance, it appears that the profession's members were both listening to Waetjen's message and expressing a willingness to meet his challenge. Unfortunately, however, his challenge has not been met by any significant increase in scholarly inquiry.

In a presentation before the First American Society for the Advancement of Science (AAAS) Technology Education Research Conference, Foster (1999), who was serving as Dean of the College of Technology at Indiana State University, admonished the technology education profession to make research a priority and, equally so, make it a priority for our professional organizations (e.g., International Technology and Engineering Educators Association [ITEEA], Council on Technology Teacher Education [CTTE]). He argued that while leaders in the profession had identified critical issues appropriate to the environment at that time, these same leaders had not supported their positions with appropriate high quality and engaging research. Foster's forthright position on the important role for technology education leaders may also be equally applied to our professional associations. Arguably, the professional associations most closely associated with technology education in the United States have in recent years ignored the important role that research serves in advancing the profession. Evidence of this lack of attention may be found in the publications of the technology education associations and on their websites. In addition, just as the professional associations have a very important role to perform in advancing the profession through meaningful scholarly inquiry, the doctoral degree granting institutions have an equally important role. A reduction in the number of programs and an accompanying reduction in the size of the workforce at the doctoral degree granting institutions in the United States have further contributed to a reduction in the overall research productivity of faculty at the institutions that were revered by the technology education profession for decades. Today, for example, the programs at the University of Missouri and University of Maryland are part of the profession's history as they are no longer in existence and the program at The Ohio State University is being supported by one fulltime faculty member. Some of the other doctoral degree granting programs have witnessed staff reductions as staff have either retired or moved to other positions in their universities. It would appear that Old Dominion University (ODU) may be the most vibrant technology education related graduate program in the United States today. Its faculty are professionally active through their scholarly publications and presentations at professional meetings. The faculty have also used different modes of instructional delivery to meet a diverse group of students.

Streichler (2000) held a somewhat different but equally important perspective on the need to conduct significant (breadth and depth) scholarly inquiry in the profession. As executive director of The International Honor Society for Professions in Technology (i.e., *Epsilon Pi Tau*), he positively used his leadership position as a platform to not only espouse the ideals of *Epsilon Pi Tau*, but he became a very influential force in the United States in trying to stimulate interest among all members of the technology professions (not just technology education, but also industrial technology and engineering technology) of a greater need to conduct meaningful and purposeful research. As executive director of *Epsilon Pi Tau*, it appears that he viewed at least part of his leadership agenda as an opportunity to bring people together in all areas of the technology community so that these individuals might collaborate, interact, cooperate, communicate, and conceive research programs that would yield benefits to all members of the profession.

In retrospect, it appears that Streichler's sense of urgency has been ignored, or not fully accepted, or not fully understood by the profession at large. Streichler viewed the profession as a dwindling population of researchers and the individuals who were actively conducting research were new members of the profession who were exiting the doctoral programs to become full-fledged college-level faculty. He tried to heighten the profession's awareness of the importance of its doctoral candidates being exposed to "rigorous interaction experiences" (p. 11) and having the opportunity to challenge, discuss, and review different research designs and appropriate statistical tests. He concluded by stating that "I fear also that they may leave doctoral programs without a proper attitude toward research and that they may not view research as a lifelong and primary professional activity" (p. 11).

Sanders (1999) expressed similar views to those of Streichler, and maybe even some frustrations. He noted that there really hasn't been a climate for research in the profession as the profession's members historically devoted their efforts to teaching and service. His frustrations may best be captured from his presentation at the First AAAS Technology Education Research Conference.

> I'm here today to open (actually re-open) a conversation about the "culture of research" that exists in our field today. While I believe developing a research agenda is indeed critical to the 'technological literacy for all' movement, I believe it will take more than a revised agenda to conduct the volume of research for which people are now calling. We just don't have the horses in the technology education community to get the job done. I realize there are others who are joining in on the effort, and I think we're very fortunate that they're interested in doing so. But one of my points today is that we will need to 'grow' our research culture in technology education if we hope to contribute to the body of research that is likely to develop around the issue of technological literacy over the next quarter-century. (para. 3)

Martin (2008) strongly encouraged the profession's members to address their current position in the school environment by conducting meaningful research, regardless of its level of sophistication. He noted that the word research is almost totally absent from the list of programs at the annual conferences sponsored by ITEEA and CTTE as research is simply not part of the profession's "comfort" zone. He stated that research is not part of the core mission of the profession. He also noted that it's quite possible that the challenges before each country's technology education leaders are also the challenges shared by leaders in other countries and that leaders should seek to identify common threads of research interests. He recommended that the international community should come together at a common location and time to develop a research plan or agenda that had as its foundation the interests of all who serve the technology education profession. A research agenda developed by the international community could be a driving force in each country's professional education community to bring about purposeful change. He stated that the profession could no longer afford to ignore the warnings expressed by prior leaders and key decision makers and that it was time to take action in a very positive, systematic, and sustained way (p. 19).

The first decade of the 21st century has witnessed a revival in interest towards the values and ideals of technology education, specifically as they might relate to technological literacy. Part of the increased interest must be attributed to the work of the International Technology Education Association and its publication *Standards for Technological Literacy* (ITEA, 2000). Some of the interest may also have arisen from what is commonly thought to be the engineering-related communities. For example, in the early part of the decade, the National Science Foundation, Battelle Memorial Institute, and the National Academy of Sciences co-sponsored a project (Pearson & Young, 2002) under the auspices of the National Academy of Engineering and the Center for Education, part of the National Research Council. The charge was to develop a "common understanding of what technological literacy is, how important it is to the nation, and how it can be achieved" (p. vii). The project's leaders sought input from a diverse group of stakeholders. When the final report was published, one of its four recommendations was to develop a research base including (a) the development of assessment tools for monitoring the state of technological literacy among students and the public and (b) determining ways people learn about technology. The funded project, as appropriate, was directed to the United States community including, but not limited to, leaders of schools of education, schools of engineering, K-12 teachers and organizations, and developers of curriculum.

The National Science Foundation continues to be aggressive as a grantmaker in seeking proposals from the technology education community including classroom teachers and teacher educators. One very important funded project emanating from National Science Foundation funding was the establishment of the National Center for Engineering and Technology Education (NCETE). This project has as its mission to "build capacity in technology education and to improve an understanding of learning and teaching of high school students and teachers as they apply engineering design processes to technological problems" (http://www.ncete.org/flash/ index.php, para. 1). The NCETE staff states that one of its three major goals is to propose research and they identify three purposes for conducting research. The staff states on its website that it seeks to conduct "research, with the help of doctoral-level partners, that improves the understanding of teaching and learning engineering and technology subjects" (http://ncete.org/flash/about.php, para. 3). More than 40 of its research studies have resulted in publications and an even greater number has resulted in professional presentations and poster sessions. The NCETE project may represent one of the profession's last remaining hopes to establish the importance of research and the important role it serves in helping the profession define its future and set a direction. The exemplary work of the staff has served as a model for the profession. Several technology educators across the

United States continue to perform important roles in the success of the project. The funded project has brought together the collective expertise and wisdom of professors from nine different universities (four of these institutions are doctoral-degree partner institutions). The NCETE project is further evidence that when a common problem is identified and addressed, people will collaborate, regardless of their philosophical differences, to reach consensus on solutions.

A CHARGE TO CONSIDER

While the snapshot of *"a context for change"* described in the preceding paragraphs is directed specifically to technology education in the United States, the context may also describe the current state of affairs in other parts of the world. Unfortunately, while research activities (albeit limited) to date are significant and noteworthy, they appear to be isolated efforts by a select group of academically talented individuals and organizations to bring about purposeful change. Ultimately, questions must be asked: (a) "Has the profession purposely spent too much time and effort in other areas at the expense of conducting meaningful, far-reaching, high impact scholarly research?" (b) "Has the profession continued to ignore the need to develop a culture of research among its members?" (c) "Has the conduct of scholarly research become peripheral to other professional activities and responsibilities of its members?" (d) "Does the profession have a critical mass of members to initiate and sustain scholarly research initiatives?" If one is to believe the positions of Waetjen, Foster, Streichler, Sanders, and Martin, the answers to these questions might be (a) Yes, (b) Yes, (c) Yes, and (d) No.

If technology education leaders and scholars from countries other than the United States provide the same answers to the aforementioned questions, then it's time for all leaders and scholars to come together and develop an international technology education research agenda. A proposed activity of this magnitude would require these individuals to gather for a common purpose and a common goal and to speak as one voice. These individuals would need to live the challenge of inquiry, assimilation, collaboration, compromise, and consensus.

The first step in this *"a charge to consider"* is to decide who should participate in such an international effort. Who are the key stakeholders and what is the process to be followed to select each country's leaders and scholars? There are precedents for such a selection process and the process must be perceived as being fair and inclusive by the international community. Once the "who" will participate is resolved, the "where" must also be addressed. A venue for the scholars and leaders to initially come together to discuss their country's research inventory and to formulate a research agenda must be selected. Pre-PATT, pre-TERC, pre-ITEEA, pre-CTTE, and/or pre-MVITE conferences are examples of venues that most support the mission of such an initiative. Invited participants would commit to attending and participating in a pre-conference meeting, regardless of the venue.

The second step is for the participants to take stock of the most significant research that has been conducted in each of their countries in the past decade. Each participant must develop a research inventory of his/her country's most significant research projects in technology education. For example, what research projects in each country led to a greater understanding of what that country's leaders and scholars know about its students, teachers, and administration; its curriculum; its instructional strategies; its programs; etc.?

The third step is for the leaders and scholars to collectively create a research agenda that identifies the most critical areas that need to be researched in technology education. The creation of the agenda will lead to a list of coherent and significant topics that most need the attention of technology educators. While the idea of developing an agenda may at first appear to be a novel or even a potentially controversial one, the idea is not totally new to the technology education profession. At the First AAAS Technology Education Research Conference, a paper entitled *Towards a Research Agenda* was presented by Ahlgren (1999) and at the Second AAAS Technology Education Research Conference, Pellegrino (2001) presented a paper entitled *Setting Research Agendas in Science, Mathematics, and Technology Education: The National Research Council's How People Learn Report*.

The fourth and final step is to take the inventory and agenda and communicate their contents and importance to the global community of technology educators. Equally important, there needs to be a feedback loop in the communication system so that every time a research project is completed, the results of the project are fed back into the system for the benefit of all people who call themselves technology educators.

CLOSING THOUGHTS

The preceding two sections outlined *"a context for change"* and *"a charge to consider"* when searching for purposeful direction. There is a sense of urgency that something must be done to further technology education and no one country has the human and financial resources to do it on its own at least in the near future. In a presentation at the Camelback Symposium that was sponsored by the Technical Foundation of America, Waetjen (1992) stated that "technology education is at a watershed point. It cannot continue on its present course, for it is not thriving" (p. 30). Waetjen's words ring true today. The *charge to consider* as proposed in this chapter represents one possible approach to developing a solution, but it's not the only approach. Leaders and scholars of the international community need to come together to speak as one voice with one common message. It's time to build consensus and work collectively towards addressing a very significant challenge facing the international technology education community. Establishing a baseline of research data on technology education is an area that the profession's members should never relinquish to another group of individuals or discipline. Equally important, helping to establish a research agenda for the future direction of technology education should be a responsibility of every member of the technology education profession.

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LOOKING BACK IN ORDER TO MOVE FORWARD

The Position of Technology Education in Past Swedish Curricula

Being a fairly young school subject, technology education has yet to attain a firm position in the curriculum. Therefore, there is a need for a retrospective look at earlier developments in order to understand why and how the current position was achieved (cf. Karlsson, 2004). David Layton suggests that the subject of technology in the school has developed by balancing "a range of competing influences", and that a number of "stakeholders" have been and still are important for its evolution (Layton, 1994, p. 13). By talking of stakeholders, Layton questions a traditional view of the development of subjects, namely that they are more or less copied from corresponding academic disciplines. The stakeholder perspective, on the other hand, implies that school subjects develop by means of a school-oriented logic, in the interplay between different societal actors – stakeholders (cf. also Layton, 1972, 1973). Within the same tradition one finds Thomas S. Popkewitz, who claims that "the history of school content is an intersection with social, cultural, political and economic interests" and that much of the research on school subjects is too narrow and limited in perspective (Popkewitz, 1987, p. 3):

> Most histories of the formation of the school subjects ignore these relations by locating the broadening of the curriculum . . . to the formal functioning of professional committees and administrative problems of schools . . . (Popkewitz, 1987, p. 3–4).

Ivor F. Goodson has studied the development of several school subjects, for instance, biology, geography, and technology (Goodson, 1988, 1994), and his arguments are similar to those of Layton and Popkewitz:

> It would seem that, far from being timeless statements of intrinsically worthwhile content, subjects and disciplines are in constant flux. Hence the study of knowledge in our society should move beyond the a-historical process of philosophical analysis, towards a detailed historical investigation of the motives and actions behind the presentation and promotion of subjects and disciplines (Goodson, 1988, p. 165).

Research in technology education as a means of strengthening technology in the school curriculum could thus benefit from Goodson's creed of "detailed historical investigation". Research on the historical background to technology as a knowledge domain and practice in the school is still in its infancy, and most of this research is carried out within the fields of the history of education, curriculum

M.J. de Vries, Positioning Technology Education in the Curriculum, 21–38.

history, and technology education. In the latter field, this research was initiated only in recent years. In UK and US technology education there has been historical research for a while and it has essentially been aimed at sketching a background to and shaping the identity of technology in schools. It has not been unusual for researchers – including David Layton, Edgar Jenkins, John Pannabecker, Stephen Petrina and others (see, for example, Layton, 1973; Jenkins, 1979; Pannabecker, 2004; Petrina, 2002) – to have connections both to technology education and the history of education, which has strengthened both the educational and historical linkages to technology in the school.

To a great extent, the positive effects of such linkages for present-day technology education have yet to be seen. However, the aim of this chapter is to explore three possible areas in which historical research on technology education could strengthen the position of the present subject in the school curriculum – *knowledge base*, *teachers,* and *external stakeholders.* The chapter will also give an analysis of a Swedish historical case, technology in civic education. Three main questions are posed: How should technology curriculum be studied as a historical phenomenon? Why and how did civic education come to include technology in the Swedish continuation school curriculum in the 1920s and 1930s? What are the possible benefits of historical studies for the present technology curriculum?

THE NATURE, METHODOLOGY, AND HISTORIOGRAPHY OF SCHOOL TECHNOLOGY

Goodson (1994) writes that “subjects are not monolithic entities but shifting amalgamations of subgroups and traditions which through contestation and compromise influence the direction of change” (Goodson, 1994, p. 42). Consequently, if one is looking for the nature of a school subject it is not easy to find a clear-cut answer, since a subject is amorphous and could be defined on various levels and from different perspectives. Depending on what aspects of a school subject are to be studied the theories, methods, and histories will therefore differ.

If the technology curriculum is seen as the manifestation of the subject in the school, there are three areas or aspects of the curriculum in particular that are important in order to historicise the technology subject. First of all, there is the *knowledge base*. This has been termed “technological literacy” in recent years and refers to the knowledge in and about technology that students should learn, which also often includes some notion of *how* they should learn. Technological literacy cannot only be restricted to a subject called “technology” because there is potential technological knowledge embedded in most school subjects. This is particularly true of historical periods prior to the introduction of technology in general education. In order to pinpoint technological knowledge in other subjects one needs to be guided by a fairly broad and timeless philosophical definition of what technology is (although a philosophical definition is naturally also built upon historically accepted views of technology). A wide, comprehensive definition of technology, sufficient for the purpose of this study, is taken from Ginner (1996). He claims that technology is everything that humans put between themselves and their environment in order to fulfil different needs, as well as the knowledge and skills that they develop and manage in this problem-solving process. Kline (2003) is more specific in defining technology as artefacts, sociotechnical systems of manufacture and use as well as knowledge, technique, know-how or methodology (Ginner, 1996; Kline, 2003).

Secondly, there are the *technology teachers*, or teachers of other subjects, depending on educational and historical context. They are the ones who put the technology curriculum into practice, together with the students. They are also the foremost defenders of school technology, with their own views of what the curriculum should be like, and they are therefore stakeholders who are internal to the school. Thirdly, there are the various societal, *external stakeholders* who have an interest in promoting their views of technological literacy and thereby influencing the content and form of the technology curriculum.

This means that the primary focus in terms of source material is the *specified curriculum*, that is, the curriculum as found in national curriculum documents and statements. The *delivered*, or rather, *enacted curriculum*, that is, teachers' interpretations and knowledge of technology that they use to plan and implement their teaching, is also addressed, for example, in journal articles, handbooks, and textbooks. Historians base their research primarily on documents and, if possible, interviews with people such as former students, retired teachers, or politicians. As much as one would want to be able to ask questions about the *experienced curriculum*, that is, student learning, it is probably too late in this case. Consequently the experienced curriculum is left out of the analysis (Banks & McCormick, 2006).

The source material used in this chapter is, first of all, primary material concerning civic education: official reports, statutes, curriculum documents as well as relevant handbooks, textbooks, and journal articles. In curriculum and educational history, curriculum documents and textbooks are seen as authoritative texts or genres that have a decisive impact on the content of a subject, although textbooks lie closer to classroom practice. This is not to say that textbooks completely determine what is taught in the classroom, but they are still one of the most important factors shaping the enacted curriculum (Englund, 1986; Hultén, 2008; Selander, 1991). Textbooks have therefore been selected as examples of authoritative texts but also stakeholder views of what should be taught in the classroom. The actual selection of textbooks has been based upon their impact, that is, the most widespread books are the primary object of analysis. Journal articles are not systematically analysed but selected as examples of stakeholder views at a particular time. Secondly, secondary material is used, mostly for the research overview but also to some extent in regard to civic education. A hermeneutic method is employed when analysing the material, that is, single texts are related to the whole body of texts, the genres, and historical context in a reciprocal, re-interpretive way (Anshelm & Kylhammar, 1996; Anshelm, 2000).

A history of the technology curriculum in either one of the three areas would gain from a historiographic conceptualisation in terms of the breadth of analysis, and for these purposes internalist and externalist perspectives, originating within the history of science, are employed. The former perspective had long dominated research in the history of science and even historical studies of technology, but this was being questioned from the 1930s onward in both these fields. In the internalist perspective, technological innovation is seen as driven mainly by individual scientists and engineers and/or technical innovation/improvement. The centre of interest is the artefact, but very seldom the system itself, unlike the externalist perspective, in which society and its social, cultural, economic, and political forces dominate and are seen as the main driving forces (Hansson, 2002; Hallström, 2002; Shapin, 1992). Staudenmaier (1985) adds a third perspective – contextualist – which constitutes a recognition that the internalist and externalist perspectives need to complement one another, that is, one needs to look for the driving forces of technology in and around the artefacts and systems themselves and also in the broader societal and cultural context. The contextual perspective could be said to acknowledge technological as well as non-technological actors and factors in shaping technology (Staudenmaier, 1985).

David Edgerton criticises contextualist histories of technology in two ways. First of all, he claims that these histories presuppose a common context that all historians agree upon, when in fact they do not. Secondly, he argues that the existing historical work used to build up context often has an implicit view of technology and technological development that may lead the historian to contradictory conclusions about technology. Consequently, he proposes a "post-contextualist" historiography that writes the history of content and context together (Edgerton, 2010). I still adhere to the contextualist perspective, although I am fully aware of the limitations of context that Edgerton points out.

However, like Pannabecker (1995) I use these perspectives somewhat differently compared to Staudenmaier. My interpretation differs even from Pannabecker's and Edgerton's. In this chapter the perspectives are used as conceptual tools for analysing strengths and weaknesses of histories of technology education in the above three areas. Thus, the internalist perspective signifies a more narrow focus on what could be considered as internal factors and actors in technology education. These include the technical knowledge base that is to be taught and the actors/stakeholders directly associated with this, namely the teachers, without connection to context outside the school. The externalist perspective, on the other hand, focuses on stakeholders who are not directly involved in technology education and are consequently regarded as external, together with broader societal factors. Thus, the contextualist perspective encompasses the whole range of actors and factors, both internal and external, that affect the evolution of technology education.

WRITING THE HISTORY OF TECHNOLOGY EDUCATION IN TERMS OF KNOWLEDGE BASE, TEACHERS, AND EXTERNAL STAKEHOLDERS – A COMMENTED RESEARCH OVERVIEW

The concept of technological literacy is used in technology education as a way of establishing what the *knowledge base* of school technology should be and thus what students should know about technology. In curriculum development and research the meaning of this concept has been the object of much discussion in recent years, although due to its manifold meanings it has been difficult to agree upon common epistemological ground (Jenkins, 1997; Waks, 2006; Williams, 2009). To a great extent the problem of finding common ground is explained by the multifaceted historical roots as well as the different educational contexts across the world, which make it difficult to define exactly what the epistemological core of technology education should be. On the other hand, the complex nature of technological knowledge and activity makes it unlikely that there will ever be a uniform, universally acknowledged definition of technological literacy (Herschbach, 1996; Lewis and Zuga, 2005). Nevertheless, it is crucial to historicise the knowledge base of technology, not least in order to understand the present complex debates.

The most common way of writing the history of the technological knowledge base in schools has been to view it as a miniature version of academic engineering or vocational technology. This is particularly true of histories of the industrial arts, engineering, and vocational education in schools during the nineteenth and twentieth centuries (see, for instance, Bennett, 1937; Anderberg, 1921). While there certainly is a need for such detailed research on the administrative and historical development of technology in the school, from its early precursors to the various interpretations of technological literacy in curricula around the world today, the above examples seem too internal, narrow, and limited. It is essential, first of all, to analyse technology as a complex domain of knowledge which is not limited only to the subject of technology. Secondly, it must be set against the educational, social, cultural, and political context of each historical period (see, for instance, Westlin, 2000, p. 132–159).

Since technology is a young subject in schools, historical research naturally needs to go back beyond the past 20–30 years and explore the epistemological foundations of predecessors such as craft, industrial arts, educational sloyd, civic education, natural sciences etc. as they were conceived earlier during the 19th and 20th centuries. In the Swedish case, for example, educational sloyd was arguably seen as an early counterpart to technology in general education in the first half of the 20th century, through its pedagogical focus on developing the student by means of manual training and the vocational focus on the use of tools and craftsmanship. Although educational sloyd was only one of many influences and also needs to be seen in its particular historical context in the transition between a rural and an urban-industrial society, it still constituted an important early predecessor to the obligatory subject of technology that was introduced in the 1980s (Elgström & Riis, 1990; Hallström, 2009b; Hartman, et al., 1995).

To broaden the scope of the historical analysis it also needs to include the principal actors in the history of technology education – *technology teachers*. They can be called internal actors or stakeholders operating within the educational system. Indeed, beyond the discursive and epistemological aspects of the technology curriculum it is the teachers who constitute the subject. Depending on the historical and geographical context, technology teachers influenced the political and educational processes of establishing a technology curriculum to varying degrees, and they were the ones who would teach the curriculum in the classrooms.

As Foster (1995) and Pannabecker (1995) point out, American histories of technology education have often been, in Staudenmaier's terminology, internalist in that they have had a very narrow conception of technology education and have primarily focused on the contributions of single "educator-heroes" (Foster, 1995; Pannabecker, 1995; Staudenmaier, 1985). One cannot deny the historical influences of Pestalozzi, Dewey, Salomon, Cygnaeus, Della Vos and many others, nor is it possible to omit single influential teachers, principals, etc. who have, through their work and devotion, made an impact on the history of technology education in different countries. However, such histories often become narrow in the sense that they relegate the evolution of technology education mainly to the efforts of single – internal – actors and thereby largely ignore the wider societal context.

One way of avoiding such historical reductionism would be to study subject associations, since they constitute collective efforts of teachers to defend their subjects in the curriculum, in schools, and in society. However, even such studies can become internal and focus principally on the associations themselves and their effect on the curriculum. Lindholm (1991), for instance, studies the Swedish Association for Mathematics and Natural Science Teaching (*Föreningen för matematisk-naturvetenskaplig undervisning*), which later came to include even technology teachers, during the mid-twentieth century. The focus is internalist, even introspective, in that the association and its activities are hardly related to the societal context at all. The work of the association is seen as an internal affair, even when it comes to the political struggle over the curriculum (Lindholm, 1991).

In contrast, Knight (1996) studies both inward and outward activities of the English Geographical Association and the National Association of Teachers of Home Economics and Technology as part of a broader educational, social, and political context. Similarly, Layton (1984) expounds on the social and political history of the English Association for Science Education and its precursors from the early 20th century until the 1970s, and describes the advent of autonomous school technology, relating it to a wider societal complex (Layton, 1984).

However, even a broad history of technology teachers as a collective in the form of subject associations and the like, which takes into account the external, societal factors that influenced them, would give insufficient background detail regarding the introduction of technology subjects in general education. In many countries there were either no or few technology teachers and the ones that existed were not always organised. For instance, in Sweden a compulsory school for the children of all social classes and both sexes was introduced in the early 1960s. Science teachers were organised in two rather influential subject associations, but still the natural sciences were reduced as regards weekly teaching hours.[1] On the other hand, several voluntary vocational technology subjects were introduced in lower secondary education – the most comprehensive being *teknisk orientering*. The first ever independent technology subjects in general education in Sweden thus came at a time when there were only very few vocational technology teachers to promote them. Consequently, if one wants to understand this momentous shift one has to look for other *stakeholders*, actors external to the school (Hallström, 2010; Lgr 62; Westlin, 2000; cf. Lebeaume in this volume).

There are several historical studies which deal with the influence of both internal and external stakeholders on the development of technology education, for instance, Elgström & Riis (1990), Hallström (2009b), Layton (1984), Lövheim (2010) and McCulloch, et al (1985). A few of the contributions in de Vries & Mottier (2006) might be included in this category, although they do not really employ historical methodology.[2] The main reason for such a broad approach is the fact that the curriculum is a political product, and in order to analyse technology education history all the various political and other societal influences on the development need to be identified. In the next section I will elaborate on the external stakeholder influences on both knowledge base and teachers, in order to provide a more contextualist and integrative history of technology education.

TOWARDS A CONTEXTUALIST HISTORY OF TECHNOLOGY EDUCATION – SWEDISH CIVIC EDUCATION 1920–1935

In this chapter it is suggested that a history of technology education could be carried out fruitfully in three areas in particular – the knowledge base, teachers, and external stakeholders of technology education. Several examples of more or less successful histories of these kinds have been related in the above overview. In this section, the three historiographic perspectives from the history of science and technology will be discussed in relation to an empirical example of history writing regarding technology education: a Swedish case of technology in civic education in the 1920s and early 1930s. This was a time when there was no technology subject in general education, but increasingly there were cries from stakeholders for educational attention to technological literacy – in Swedish, *teknisk allmänbildning* or *teknisk bildning*. These discussions are essential in order to understand the introduction of voluntary technology subjects in the 1960s and compulsory technology in the 1980s as well as current debates on technological literacy in Sweden (Cullert, 1986; Hallström, 2009a; 2009b; Westlin, 2000).

In the newly-industrialised Sweden, universal suffrage was introduced from 1918 to 1921. Parallel to the processes of industrialisation and democratisation there was also an intense period of educational reform, the outcome of which was a modern elementary school curriculum and new vocational schools, among them the mandatory continuation school (*fortsättningsskola*). The aim of this type of school was to be both comprehensive and vocational, and many continuation schools were consequently vocational-technical and considered as part of the technical educational system, which means that there were probably expectations from certain stakeholders of some form of technological literacy in terms of knowledge base (*SFS* 1918, No. 1001; Englund, 1986).

These schools and their different subjects were affected by the current societal transformation. Two new civic subjects were introduced as a result of democratisation: home region instruction (*hembygdskunskap*) for the elementary school and civic education (*medborgarkunskap*) for the continuation school. The former subject included technical items right from the start. Examples of technical content were clothes, different kinds of materials, houses and their heating and lighting, furniture, and household utensils, transport technology, and aspects of working life such as agriculture, trade, and industry (*Undervisningsplan för rikets folkskolor*, 1947, p. 70–79). Efvergren (2010) has studied the earliest teacher handbooks in home region instruction, which were used by teachers all over Sweden as soon as the subject was introduced. From his study one can conclude that there was a manifest and fairly extensive technical content in home region instruction from the start.

On the other hand, in the subject of civic education for the continuation school, technical issues were largely ignored initially, at least when looking at the preceding official investigation and the statutes for the continuation school. The investigation emphasised solidarity and responsibility towards others in society as the key aspect of the subject. The cornerstone of the subject (and society) was the family, from which other larger social units emanated (*Folkundervisnings-kommitténs betänkande V*, 1914). According to the statutes, civic education should include the organisation of Swedish society, the working of various units of social life such as the family, the municipality, the church and the state, as well as civil rights and responsibilities in this society. Civic education, just like the other subjects in this type of school, had to take as its starting point the local working life; the teaching thus had to focus on vocational aspects as much as possible (*SFS* 1918, No. 1001).

In 1919, the National Agency for Education (Skolöverstyrelsen) issued curriculum examples for all the subjects of the continuation school, to be used as a model when drafting local curricula. A national curriculum document was intended at this point, but it never subsequently materialised. The statutes of 1918, and often the examples of 1919, therefore came to be regarded as the official, specified curriculum, on which local curricula and textbooks were based. On the whole, they were very similar; the curricular examples were based on the statutes but were more detailed. For instance, in the examples, the Agency specified items for civic education – home hygiene (clothing, housing, sanitation), home economics, municipal concerns and their politics, administration and economy, church administration etc. – although it was pointed out that they were not obligatory. The curricular examples for the non-vocational continuation schools contained slightly more technology than the vocational ones, for example, handling communications systems such as post, telegraph, and railway (Exempel på undervisningsplaner, 1919).

One of the most central actors behind the introduction and subsequent development of civic education was Värner Rydén, a very important figure in the Swedish history of education. He was originally an elementary school teacher, but had become a social democrat politician and member of parliament early on. Rydén was Minister of Education and Ecclesiastical Affairs for a short time in the late 1910s, at which time he issued the elementary school curriculum of 1919 and made the continuation school obligatory for those who did not go on to other secondary schools (*Nationalencyklopedin*, 2007). He was also the author of the single most important and widespread, but also nationalist and even propagandist, textbook on civic education during the decades after the First World War – *Medborgarkunskap för fortsättnings- och andra ungdomsskolor* (Rydén & Thomson, 1935; cf. Tingsten, 1969). Rydén thereby came to influence both the specified and enacted curriculum in civic education for decades, both as a politician, textbook writer, and in-service educator, and thus was a most significant stakeholder.

Rydén understood the influence of technification, that is, the increased use of technology, upon Swedish society in general and education in particular in the 1920s. In a radio talk he expressed the view that farmers, craftsmen, or businessmen could no longer rely solely on the knowledge of their forefathers. They had to keep up to date or succumb to the competition. Agriculture, for example, required knowledgeable and capable practitioners: "The farmer must be able to keep up with the development of his profession, study agricultural literature, have at least the most elementary knowledge of the different branches of natural science…. The same goes for the industrial worker…. Nowadays each professional needs better schooling than before – this is an inescapable truth" (Rydén, 1926, p. 926–927).[3]

Yet he does not seem to have considered civic education in the continuation school as a subject instilling the comprehensive technical knowledge needed in an increasingly technical society. The content of his textbook is closely aligned with the statutes, and focuses on the family, municipality, region, church, and nation from a historical but mainly political science point of view. It is devoid of any obvious technical content related to the civic issues that are brought up. There are references to technology, for example, municipal infrastructure such as gasworks, water supply systems, and tramways as well as military technology, but they are brief and very peripheral relative to the main political and administrative reasoning of the book (Rydén & Thomson, 1935). The same could be said about one of the other dominating textbooks – *Medborgarbok för ungdomsskolor* – although technical issues were perhaps slightly more prominent (Helger, 1930).

In order to study the further evolution of civic education one needs to move forward until the end of the 1920s, when the continuation school had become more solidly established.[4] To begin with, local teachers as internal stakeholders need to be studied. Johansson (2004) has studied the local curriculum document of 1930 for continuation schools in the city of Linköping as well as the minutes of the school board in order to see what they had to say about local teaching content. This case study indicates that the enacted curriculum in civic education was very similar to the statutes and also to Rydén's textbook. Teachers in Linköping seem not to have linked items of the curriculum in civic education to a technological knowledge domain in any conscious way (Johansson, 2004).

Elementary school teachers constituted the prime teacher group in the continuation school. A study of the mouthpiece of the Swedish Association of Elementary School Teachers (*Sveriges allmänna folkskollärarförening*), the journal *Svensk Läraretidning*, shows that there were people who questioned the current focus in civic education and Rydén's textbook. E. Borglund, for example, pointed to the importance of teaching about the home, which was a pivotal item in civic education. However, he argued that in the continuation school, the focus needed to be shifted towards the "material conditions for creating a good home" (Borglund, 1927, p. 655). Borglund described a kind of cross-curricular cooperation between the subjects of civic education, educational sloyd, and Swedish, in which his students had made drawings and models of their houses and experimented with rooms, furniture, and equipment. Essays were written about how the students reorganised and rebuilt their rooms by painting, installing tiled stoves, constructing wooden furniture, rearranging power points etc. (Borglund, 1927).

Sven Wikberg, who was a teacher educator, thought that civic education was too broad in scope and that teachers needed to delimit themselves when teaching the subject. One way of doing this was to focus on the home region (cf. the elementary school's home region instruction), particularly municipal services, and this could be done by juxtaposing history and the present.[5] He took health care as an example of a municipal service. Here, different technological artefacts and systems were observable: medical treatment in hospitals but also preventive health care through "good housing, public baths . . . sewer and water systems, public cleansing . . ." (Wikberg, 1928, p. 286). This was by no means the most central aspect of Wikberg's conception of civic education, but it is nevertheless interesting that it gained quite a prominent position.

His teacher handbook, *Handledning vid undervisningen i medborgarkunskap* (1929), was by and large an in-depth account of the same political, administrative and juridical issues that permeated Rydén's and Helger's textbooks, albeit with the teacher rather than the student as its target. However, Wikberg also questioned the current way of teaching the subject and suggested a plan for dealing with city governance. In this, the management and working of technologies such as water supply, lighting, gas, sanitation, roads, and city planning became central. Moreover, the importance of good schooling for technological innovation was emphasised and there was a section on industrialism and working class issues, in which technology played a pivotal part (Wikberg, 1929).

If the context of the analysis is widened and stakeholders external to the school in the late 1920s and early 1930s are to be studied, the engineering community seems to be a relevant choice. Engineers were generally pragmatic and focused on the engineering and industrial implications of education (see Hallström, 2009b). As a result, some engineers thought that the continuation school should be either more vocational or abolished altogether in favour of clear-cut technical-vocational schools. Alternatively, the elementary school could be extended, so that students could go directly to existing technical schools at the next level – *lärlingsskola* and *yrkesskola* (see, for example, Avdelningen för teknisk undervisning, 1927).

However, there seem to have been cries for attention to technological literacy/*teknisk bildning* in civic education from members of the engineering community at roughly the same time. In the early 1930s, the engineer Arvid Centervall made a speech entitled "Are our people interested in technological literacy [*teknisk bildning*]?", in which he questioned a notion that was commonly held in early 20th century Sweden, namely that Swedes had a strong natural aptitude for all things technical (cf. Elzinga, et al., 1998; Mellström, 2009):

> It is not unusual for both younger and older citizens to become very enthusiastic over, for instance, new innovation, and instantly want to know everything about it. It soon becomes apparent, however, that this interest is very superficial. In reality one should rather compare this with the joy and curiosity of children over new toys. This hardly constitutes a deeper thirst for knowledge, because as soon as they have learnt which button to press in order for the device to "go" . . . they usually feel satisfied. When trying to comprehend what is going on, and taking pains to understand why one should do this or that, there is generally a lack of both patience and power of concentration.
>
> A shallow interest . . . certainly exists to a great extent, and it is sufficient when it comes to using and taking advantage of technological progress. However, it is not enough for a nation that wants to carry on constructive activities in this area. . . . This requires a deeper interest, an interest that really tries to penetrate the nature of things (Centervall, 1932, p. 5).

Centervall went on to say that it was unfortunate that so many wanted to take advantage of industrial products but still considered industry itself uninteresting or even inferior. This was even true of "textbooks on civic education", by which he probably meant Rydén's, and perhaps also Helger's books (Centervall, 1932, p. 6):

> While in our public schools we learn names etc. of various cities, plants and animals, mountains and rivers in foreign countries that we will never see, the pocket watch, telephone, car, railway engine, printing presses, textile and agricultural machines . . . remain secret mysteries to most of us, despite their great practical significance (Centervall, 1932, p. 6).

Swedish society was being transformed as regards industry and technology on a grand scale in the 1920s, although this process slowed down somewhat during the depression of the 1930s. Nonetheless, it is likely that, at least regarding civic education, Centervall was right to say that modern industry was still so young in Sweden that it had not yet made an impact on the emerging school teaching about society and civic life (Centervall, 1932).

Apart from industry, however, there was greater attention to technical issues in civic education in the early 1930s, facilitated by the focus on the home region that many stakeholders advocated. A survey of what students actually learned in civic education during the years around 1930 also concluded that teachers should sacrifice political science issues and instead emphasise the home region even more than before (Lindmark & Ekeberg, 1931). Although Rydén's textbook remained virtually the same as before,[6] other books followed the new trend. Helger's classic book incorporated in its 1935 edition a whole new chapter on the road system and its administrative and technical workings, a sign that motoring had become so prevalent that it affected municipal administration and civic life by this time (Helger, 1935). There was also Thurén & Lindholm (1935), which devoted more attention to technology in the home, municipality, local trade and industry as well as health care. Especially in relation to joint concerns in the local community the authors took up several technological systems – roads, lighting, water supply, sanitation etc. Communications systems such as railroads, radio, telegraph and telephone systems were also touched upon. Furthermore, there was a large section on different professions, and even technical ones were highlighted (Thurén & Lindholm, 1935).

Two decades later, the technical domain of knowledge had become an established part of the curriculum in social science (*samhällskunskap*), the successor to civic education in the then dominating 7–9-year long period of elementary school and the 9-year compulsory school experiment. This technical knowledge was related to home and family (the house, clothing etc.), working life, trade, and industry as well as communication (*Undervisningsplan för rikets folkskolor*, 1958; *Timplaner och huvudmoment vid försöksverksamhet med nioårig enhetsskola*, 1960). In particular, the curriculum for the elementary school, whose seventh and eighth grades were intended as successors to and substitutes for the continuation school (cf. SOU 1944:20, p. 112; Marklund, 1980), contained technical elements in social science, for example, related to home and family and communications technologies:

> . . . the manufacture of cloth and clothes and the path from producer to consumer . . . appliances in the house (heating, lighting, water, sewerage and sanitation) . . . the treatment of general planning by local authorities should include . . . something about local housing . . . different ways of travelling (for example, by road and railway, by aeroplane and boat) and communication (post, telegraph, telephone, radio, film, books and newspapers) . . . (*Undervisningsplan för rikets folkskolor*, 1958, p. 105–106).

According to Englund (1986), in the transition from civic education to social science during the 1940s and 1950s the focus shifted from democratic and civic content to rational-scientific methods. However, despite the scientific dominance there were still civic values embedded in the subject: “This value base implied the gradual incorporation of the individual into a society embarked on technological and economic growth” (Englund, 1986, p. 302).

The content of the social science curriculum reflected this change, but the historical development from the mid 1930s to the late 1950s needs to be studied in more detail. Such study should not only be restricted to either the internalist or the externalist conception of historical development. Clearly a change as regards technical content in civic education started as early as the late 1920s, initiated both by internal stakeholders, such as teachers, and external ones, for example engineers and politicians, but the subject content needs to be studied in more depth beyond the mid 1930s. Such a study needs to take into account all the various actors and factors, both internal and external to school technology, that influenced the direction of change – in short, it needs to be contextualist. This seems also to be in line with Layton’s admonition not to neglect the “range of competing influences” and “stakeholders” surrounding technology education, see figure 1 (Layton, 1994, p. 13).

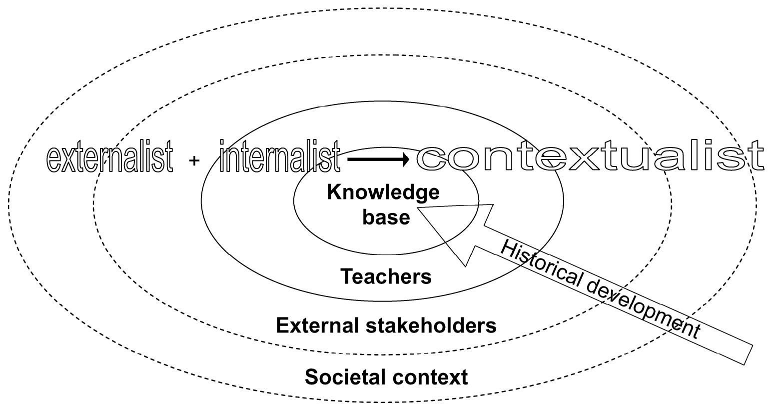

Figure 1. Internalist, externalist, and contextualist conceptions of the history of technology education. Free adaptation of Staudenmaier (1985) and Pannabecker (1995).

CONCLUSION

A first conclusion that can be drawn is that a history of any of the three areas must include a consistent analysis of the educational, social, cultural, and political context to be able to fully grasp the problems related to the evolution of technology education. In order for this to be achieved in full it is crucial that contextualist studies of technology education be carried out. As was indicated in the above research overview, several such studies already exist but many more need to be written. Secondly, one very important reason for analysing the history of technology education is to "uncover" its roots, that is, to go back before its introduction 20–30 years ago, because the complex nature of the present subject is to a great extent due to its historical heritage. This is also why writing the history of technology education is such a demanding challenge. How does one show which root preceded which branch? For example, consider the items of mundane, everyday technology that are so central to present-day technology curricula in Sweden and in many other countries - where did these originate?

Thirdly, this study suggests that in Sweden, civic schooling in the broadest sense – home region instruction (*hembygdskunskap*), civic education (*medborgarkunskap*) as well as social science (*samhällskunskap*) – probably contained the seeds of today's emphasis on mundane technology. Somewhere around 1930 there was a significant shift in the enacted curriculum of *medborgarkunskap* from focusing on more general political science items towards the administrative working of the home region, which was also central subject matter of the elementary school subject *hembygdskunskap*. This shift brought technological matters to the fore: technical appliances and systems in the home, community services, city planning, and everyday communications technologies. Apart from Centervall, the involved internal and external stakeholders probably had little ambition to convey knowledge in and about technology *per se*, but rather about civic issues as they were affected by technology. Sweden was technified on a grand scale in the 1920s and 1930s, perhaps more so than many other Western countries, and the home, in particular, was an object of technical rationalization (Elzinga, et al., 1998). Civic issues were therefore increasingly technified at this time, which is also increasingly evident in some of the studied textbooks and journal articles.

However, although there is certainly a need for Goodson's "detailed historical investigation" the historian cannot know for sure about the existence of relevant source material (Goodson, 1988). It seems to be meagre regarding subjects in which the historical actors did not explicitly include technological subject matter. There was also mundane technology in, for example, educational sloyd, so what was its contribution? Also, what role did international influences from practical and civic subjects in the rest of Europe and the USA play? It is well-known that American school conditions and educational philosophy, notably based on the ideas of John Dewey, were influential, but not much is known about their actual impact on technology (Bromsjö, 1965; Lundgren, 2010). More extended and thorough historical investigation would undoubtedly lead to more answers – this chapter is, of course, also a call for such studies – but establishing a number of basic questions to be asked would in itself be a reward. The historian would then arguably have succeeded in showing the complexity of the history of technology education, which should warn against accepting solutions that are too convenient in the present debate about technological literacy.

Nevertheless, as was also shown by Hallström (2009b), a great deal of the content of the first Swedish comprehensive technology subject of the 1980s, and its present-day counterpart, first appeared as early as the 1920s and 1930s. Modern comprehensive school technology thus did not spring from a historical vacuum, but contained elements with a long historical tradition in other subjects, although it is uncertain whether curriculum writers were always aware of this. Practical-technical elements, which were central to educational sloyd and vocational technology, still play an important part in technology education. As has been proposed in this chapter, societal aspects and items of mundane technology were at least partly derived from civics. Natural science items, such as electro-technology and mechanics, are as pivotal to the subject as ever. Today, comprehensive aspects have gained ground at the expense of "pre-vocational" items, and the definition of technology underlying the current curriculum is much broader than that which sees technology merely as being industrial arts or the application of natural sciences (Cullert, 1986; Elgström & Riis, 1990; Hallström, 2009b; *Technology Curriculum for the Swedish Compulsory School*, 2000). However, the brand new technology curriculum which is to be implemented in 2011 can be seen as an example of what Elshof terms "re-vocationalisation" (*Förordning om läroplan för grundskolan, förskoleklassen och fritidshemmet*, 2010; Elshof in this volume).

Finally, by writing contextualist histories of technology education in the suggested three areas it is not only possible to obtain knowledge of why and how technology education ended up where it is today; this historical knowledge could, in turn, also serve to strengthen the position of technology education in today's school curricula. This could happen in three ways: 1. We could strengthen the identity of the amorphous subject domain of technology through knowledge of the diverse historical roots. The technology subject need not take full responsibility for the development of technological literacy in the school, since there used to be, still is, and probably should be technical content in other subjects as well. Here researchers and technology educators need to rely also on input from the sociology and philosophy of technology in defining the role of the technology subject in achieving technological literacy. 2. We could learn how to act strategically today from past ways of organizing the curriculum, selecting content, building alliances with other subjects, and balancing different stakeholders and influences. 3. We could find better ways of relating the knowledge base of technology education to changes in society, for example, technological and environmental change, changing conceptions of student learning, changes in the global economy etc. By looking back, it will thus, hopefully, be possible to move forward with greater perspicacity.[7]

NOTES

1 This reduction was in relation to the previous lower secondary school *realskola* (cf. Hallström, 2010).

2 Indeed, the stakeholder perspective is not at all absent in articles in journals such as *International Journal of Technology and Design Education*, *Journal of Technology Education* and *Journal of Technology Studies* (see, for instance, Lee, 2007; Wright, et al., 2008). The difference is that these articles do not address historical problems, nor do they employ historical methodology.

3 All translation from Swedish into English has been carried out by the author.

4 The Swedish school districts had been given a few years of respite, until the end of 1926, in introducing continuation schools. By then 68% of the districts had formally started continuation schools (Fredriksson, et al., 1950).

5 The reason for focusing on the home region was that the subject matter should lie closer to the students' own experience (Lindmark & Ekeberg, 1929).

6 Despite this, Rydén's co-author, Thomson, promoted the focus on home region administrative issues at the expense of outright political science at this time (Thomson, 1933).

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DEFINING TECHNOLOGY EDUCATION

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BLURRING THE BOUNDARIES BETWEEN HUMAN AND WORLD

INTRODUCTION

Bauman (1990), claims that to some extent, whether rightly or wrongly, a significant proportion of human social activity involves erecting and maintaining boundaries. Aristotle before him claimed a hierarchical distinction, that is, that a set of clear boundaries existed between humans, animals and nature. This concept of boundaries existing between human and world has therefore formed part of the discourse for thousands of years. These boundaries have now, however, been called into question in postmodern thinking. Even more recently, a relatively new philosophy concerning technology has emerged, which has, amongst other things, begun to question whether boundaries actually do exist between humans and technology. This has significant consequences for teaching and learning about design and technology. If indeed technologies are not separate 'objects' in relation to the human 'subject', they must have some form of agency. In other words, technologies are not neutral, they have politics and consequently shape the way in which humans live in the world. This way of perceiving technology is counter-intuitive to essentialist modes of thinking.

> "In these essentialist modes of thinking, our ethics, politics, and conceptions of social reality and historical progress are founded in an anthropology in which the essence or nature of human beings is fixed. In these ways of thinking, our ethics, political order, and so forth should ideally correspond to this unique and original human nature" (Munnik, 2001: 96).

This essentialist mode of thinking has formed the dominant orthodoxy for a very long time and, it could be argued, still prevails to a large extent today. The world in Medieval Europe was classified along very clearly demarcated lines. The Great Chain of Being (scala natuae) set forth a religious hierarchy which was, for many centuries, the accepted ontological structure (in simple terms, a hierarchy that can be subdivided according to similarities and differences) of the world. Situated at the top of this hierarchy, in everlasting and spiritual form, could be found God and the Angels. Next, created in the image of God was Man (sic), followed by the animals and then various lower order forms found in nature with things like rocks occupying the bottom layers. Significantly, Man (sic) was not only given dominion over the earth, He (sic) was also instructed to 'subdue' it (Genesis I: 26–28).

Following the Medieval period, the Enlightenment saw the rise of Positivism which sought 'scientific' evidence to explain the Natural World. However, once

M.J. de Vries, Positioning Technology Education in the Curriculum, 41–52.

again, there were clear and distinct boundaries between human and world. These boundaries indeed became more and more distinct as the Industrial Revolution took hold in association with the birth of capitalism.

It was not until the middle of the Twentieth Century that the philosopher Martin Heidegger challenged the ontological views of the day in relation to technology. He did not accept that modern technology was neutral and suggested that we (Humans) have to rethink our relationship with the earth if we are to survive. Following Heidegger, a philosophy of technology has emerged which challenges the concept of boundaries between human and world. Modern thinkers in this field therefore challenge long held assumptions about the human technology interface. Winner (1992), for example suggests that artefacts have politics, Haraway (1991) insists that we are all cyborgs while Latour (2005) claims that artefacts have equal agency with humans. Ihde (1990) also argues that technologies mediate the human/world relationship and Feenberg (1999) offers us a critical way to engage with our technological world. Finally, Delueze and Guattari (1988) insist that there is indeed no difference between the human and the machine. The one thing that these philosophers of technology all reveal is that technology is not neutral and that it has, consequently, a profound impact not only upon culture, history, society but also upon us individually as human-beings-in-the-world.

In this chapter, I will (1) reveal the social, cultural and technological boundaries that are still thought to exist in the human/world interface, and w so serve to define the human-technology interface (2) discuss the philosophies offered to us by some modern philosophers of technology with respect to these boundaries (3) explore problems that are likely to emerge resulting from the delivery of a technology education programme which is what I interpret as being essentialist in nature, and finally, (4) discuss some ways in which we might incorporate the thinking from these modern philosophers into the technology education curriculum in order that we might better understand that the relationship between the human and world is not distinct and separate but rather, is very blurred.

CONCEPTUALISING BOUNDARIES: EXPLORING THE DIVIDE BETWEEN FUNCTION AND MEANING

My family is fortunate to own a small, two hundred and fifty year old cottage, situated in the Main Street of a small village in the Scottish Borders. It is a mid-terrace cottage with a manageable rectangular south facing garden to the rear. Standing in the garden facing south (your back to the cottage), our neighbours to the left are separated from us by a two metre high timber fence running the entire length of the garden. Whilst we cannot see through the fence from our garden, we are aware of them if they are out in their garden. In the summer, for example, we can hear the children playing in their garden. This fence forms a very strong psychological and material boundary and serves to restrict communication between us, limiting this to public spaces within the village. Our neighbours to the right, on the other hand, are separated from us by a small one metre high fence which results in a much weaker boundary. This lower fence facilitates a more open form of communication with our neighbours to the right. We have, consequently, come to know our neighbours on the right better than those on the left.

It is important to recognise that these two boundaries are technological constructions that have been designed and erected for a reason. One reason might be that someone in the past decided to delineate what was their private garden space by constructing a high wooden fence on the boundary. The reasons for this are situated in the past and may no longer hold sway. It may be for example, that the high boundary to the left was constructed before the present owners bought their property. This being so, the present owners will have inherited and adopted, or possibly even adapted, the format of the boundaries such that they now align with their own personal garden boundary preferences. Another possibility is that they may have adopted the format in a more casual and indifferent way, not really being bothered one way or the other. Yet another possibility is that the adopted boundary, in whatever form, was removed and the present one erected by the current owners. There are clearly many possible reasons for the existence of the fences and for the nature of the fences, some of which can be explained causally, but many of which can not.

Another example might be that in the future, our neighbours with the low garden fence elect to sell their property to new owners who may decide, for any number of reasons, to erect a stronger boundary similar to the one on the left. Thus either of the boundaries, in whatever material form, can be considered to be designed to serve as both a technologically material artefact indicating the delineation of space and property, whilst simultaneously providing a psychological indication of the owners' social preferences regarding privacy, or some other reason altogether. These multiple possible interpretations serve to problematise the formation of a reductive essentialistic explanation for the existence of the fences. Any explanation for the fences set within an essentialist paradigmatic framework would seek to limit any social, ethical or political consideration as to why the fences were erected, by reforming these multiple rhizomatic[1] explanations into a linear hierarchical structure that claimed some single essential explanation that would transcend any secondary explanations that might otherwise be offered. In other words, the essence of a boundary, or its primary function is considered to be immutable.

It is Ihde (2007) who offers us a model to explain the double aspects consequent in perceiving the fence. On the one hand, we are able to perceive the fence sensorially (see it, touch it, perhaps even smell it). It exists 'out there' in material form. For Ihde, this way of perceiving the world is what he calls micro perception (sensorial). However, as has been discussed above, in order to understand the meaning behind the material thing sensed (the fence), we need to interpret what it is and why it is. This, Ihde postulates, is macro perception and both micro and macro perception are constituent upon each other. In order for me to more fully understand what the boundary means, I need to attempt to understand it not just in its material form (a more passive and accepting role), but also to understand why it takes the form that it does (a more active and political role). In other words, how does the fence in its present form affect[2] me at the present time?

It becomes clear therefore, that material boundaries that delineate spaces have a dual aspect. We can make reasonably informed judgements about the material aspects of the boundary. In this case the high fence is constructed by using two metre high 150 x 15mm vertical wooden slats fixed both sides onto 150 x 150mm wooden posts fixed into the ground and having a top, middle and bottom set of horizontal timber rails on both sides designed to hold the vertical slats. The vertical slats are fixed to both sides of the fence in such a way that neither party can see through the fence. Taken as a single aspect, this material or purely functional aspect of the boundary can only be perceived as context free, instrumental and neutral, "as mere physical objects abstracted from all relations" (Feenberg, 1999: 213). It is this second aspect, this hermeneutic aspect that Ihde refers to as macro perception that serves to blur the boundaries between the boundaries! It is this 'why' aspect that gives meaning to the function of the boundary and these meanings are subject to multiple interpretations.

It is this meaning making aspect that is, I would contend, more difficult to deal with in design and technology education. If knowledge development in design and technology education is contained or bound and presented in an essentialist form as being purely neutral and functional, devoid of any ethical, political or hermeneutic qualities other than those prescribed from upon high, then those hegemonic structures that seek to shape the world on our behalf will evolve (and are evolving presently I would argue) and seek to guide any knowledge development in such a way as to promote a passive and compliant consumer society that accepts their technological shaping of the world uncritically[3]. Feenberg (1999) expresses serious concerns that engineers for example, tend to exhibit this restricted view of technology. He postulates that:

> "Once function is selected, the engineer has the last word on its implementation and the humanist interpreter is out of luck. This is the view of most engineers and managers; they are at home with 'function' but have no place for meaning" (84).

If Feenberg's concerns hold any validity, and I suggest they do, this has significant implications relating to epistemological development within a school subject that overtly aligns itself with engineering.

The boundary between the functional aspect of a technology and its meaning in the delivery of design and technology education exists, in my view, in a similar way to the boundaries between the gardens of my two neighbours and my own garden. From my perspective I know 'that' they exist but I do not know 'why' they exist, or at least I can only make personal assumptions. I could discuss this with my neighbours and that may get me closer to the 'truth' but what purpose would that serve? The answer for me is quite simple: it would serve to empower my (or a design and technology education student's) being in the world. If knowledge is truly power, then the development of this critical capacity, this technological literacy, is surely more important than the development of an understanding of the functional aspects of technology. A strong metaphysical boundary exists between an essentialist model of design and technology education and one having a more critical hermeneutic dimension. Personally, I favour a fusion of the two, or certainly a more convincing move from the dominant orthodoxy of essentialism towards a more normative model. Perhaps we humans are, however, as suggested by Bauman at the beginning of this discussion, genetically disposed to construct boundaries. Religious fundamentalism and politics over the centuries serve as two potent historical and contemporary examples of how human beings continue to form boundaries. However, this is by no means the full story.

CONCEPTUALISING BOUNDARIES: EXPLORING THE DIVIDE BETWEEN NATURE AND TECHNOLOGY

I have discussed the material boundaries that exist between my garden and those of my neighbours. I now turn my attention to the south facing view. This view offers a wide uninterrupted panorama of the rolling Scottish Borders' countryside. My garden in this case, is delineated from the open farmland by way of a stone dyke. On my side of the dyke is the back garden. There is a summer house with some decking, a garden hut, a vegetable plot, a lawn and a garden path. The whole garden is a technological construction in the sense that it is a humanly designed and a humanly constructed artefact. The garden may be designed to look and feel natural but it can only ever be considered from a technological perspective. In this sense I use Feenberg's (2006) definition of technology in which he differentiates between science and technology. For him:

> "Science and technology share a similar rationality based on empirical observation and knowledge of natural causalty, but technology is concerned with usefulness rather than truth. Where science seeks to know, technology seeks to control" (5).

It is particularly the aspects relating to usefulness and control that I wish to exploit in my definition of technology. In this respect, the garden is useful to me in several respects (to relax in, to potter around etc) and, whilst still open to Nature's ubiquitous and irrepressible ministrations (the seasons, lack of rain spoiling my flowers, dandelion seed being blown into the flower beds etc), it is nevertheless still under my control or, in biblical terms, my dominion. I can protect the garden by constructing a greenhouse, I can use a hosepipe to water my flowers and I can weed by hand or use chemicals to control or eliminate them. The garden is in this sense, more of a technological artefact than it is a product of nature: it is denatured.

In contrast, the rolling landscape and countryside as viewed over the boundary wall may be construed as a product of nature. This, however, would be an erroneous interpretation. The landscape on the other side of my boundary wall is as much a technological construction as is my garden, the only difference being one of scale. The land is intensively farmed and the use of chemicals and other means serves to increase the 'efficiency' of the land. This emphasis on efficiency over sustainability has, and continues to form the basis of many critiques relating to the inclusion of issues about sustainability in the provision of design and technology education (see for example Elshof: 2009). The boundary between the natural world and the technological world is thus blurred, and upon further investigation, it becomes so confused that there may no longer be a natural world left. The same view over my boundary wall observed several thousand years ago (I accept that my wall would not have existed either but allow me some poetic licence) would have been curtailed by the massive and dense woodlands that covered most of the Scottish and English Borders area. These woodlands were almost completely cleared by the 1st century AD by the hands of human beings. The land was needed for arable cultivation, grazing and lumber for housing. "It is difficult to imagine today that the landscape was once filled with trees, and that humans were largely responsible for their disappearance" (Dent and McDonald, 1997: 49).

The result of this deforestation, which was clearly in the interests of serving human beings' needs, was more than just aesthetic. An entire ecosystem was destroyed. As Dent and McDonald explain:

> "Trees have an important relationship with the soils on which they grow. Their leaf litter breaks down to release nutrients which are important for the maintenance of soil structure and fertility … These nutrients are dissolved in ground water and carried up into the trees, where the water evaporates in the process known as *transpiration* (a full grown oak tree can release many gallons of water a day from its leaves in this way) and helps to drain the soil. Clearance of trees to produce arable fields or grazing effectively halts this process, with the result that the fertile *brown earths* of woodland break down into acid soils" (Dent and McDonald, 1997: 52 Italics in original).

These changes to the soil structure impact on the methods of farming employed today. Farmers use more chemicals (technologies) to enhance the soil quality. They 'force' the land to yield more crops by utilising more intensive farming methods that require more advanced technologies: high tech harvesters and computer controlled tractors for example, or the formation of larger fields. These interventions continue to change the nature of the landscape that I observe from my garden. I do not however, simply observe a subject acting upon an object: the farmer acting upon the land where the farmer is separate from the land, where the boundaries are distinctive and clear. What I see is a subject acting upon an object mediated by technology, and it is the inexorable advancement (?) of technology, as can be traced over thousands of years, that serves to blur the boundaries between human and world. Indeed, I would contend that there is no longer a natural world that is readily available to us as human beings today. If this is so there can no longer exist a boundary between the natural world and a technologically mediated one. It appears to me that we exist in the latter.

CONCEPTUALISING BOUNDARIES: EXPLORING THE DIVIDE BETWEEN HUMANS AND TECHNOLOGY

Arguments relating to the distinction, or boundary, between the subject (human) and object (non human) reached their apogee in Modernism. Postmodern thinking challenges this notion of dualism: the separation of mind and body, the separation of humans from the material world. This dualistic view of the world serves to reveal a final boundary that exists in my garden that has not yet been discussed. I am not referring to the boundary between the garden and my house which I will consider as similar to those already discussed. The boundary I now turn my attention to is that between me as the human in the garden and the world around me. The boundary in Cartesian terms, exists between my essential being (my mind) and my physical being (my body) and it is my body, or more accurately my skin that forms the boundary between my essential being and the world. I do not hold with Cartesian dualism which promotes an essentialist view of the world. I prefer Ihde's (1990) view that our relationship with the world is one of embodiment. Ihde, in opposition to Descarte's dualism - the separation of the mind from the body, argues that that we experience and know the world through our bodies: our mind and our bodies are as one. In order to consider this complex argument in more detail I will introduce two philosophers already mentioned in the introduction. They are first, the contemporary American feminist philosopher Donna Haraway and second, the French poststructuralist philosopher Gilles Delueuze who died in 1995 but whose work is now gaining a great deal of international attention.

Donna Haraway, in her seminal work 'Simians, Cyborgs and Women' (1991) uses the metaphor of the cyborg to reveal that actual natural boundaries never existed in terms of gender. Gender, as distinct from biological sex, for Haraway, is a social construction. She extends this metaphor into the realms of the boundaries between humans and non humans. The cyborg, for Haraway, is a virtual social construction. It is neither male nor female, nor is it either human or non human: it is male and female and human and non human simultaneously, making it something 'other'. The cyborg represents a being that has not been born nor has it been designed and fabricated: a machine (like a robot for example) is designed and fabricated but not born, whilst a human is born but not designed and fabricated, but a cyborg is both and none of these at the same time: it is thus not born nor is it designed and fabricated. (Some may wish to challenge this argument by arguing that the design and 'fabrication' of a human is in fact a creation of God. Haraway, however, might ask those who hold that view to consider this; where would a cyborg be placed upon in the 'great chain of being? Just under God and the Angels alongside humans which suggests a cyborg is created in the image of its maker, or with the animals or down amongst the rocks?). Considered from a Western perspective the cyborg represents the culmination of the human domination of nature: the technological fusion of human and machine. The concept of the cyborg as representing this human domination of nature is summarised by Munnic (2001):

> "The Western conception of history and progress is governed to a great extent by a particular figure of thought called 'archaeology-teleology'. History is conceived as a story with a plot. That story involves the original – pre-historical – unity or *arche*, and a fall away from this original unity. This fall begets history as such, a history that thenceforth is characterised by the dream of a lost unity. The completion of history would consist of a complete recovery, a repeal of alienation, and a return to the original unity. This

> completion is the goal (*telos*) of history; with it, the circle is complete. It is not difficult to recognise the religious sources of this structure: creation, fall, salvation, history, redemption in the New Jerusalem" (104).

Whilst a human can conceive of itself in many ways, including that described by Munnic, a cyborg cannot. It is a fabrication and as such can only consider itself in such terms. It has no history that is personal to itself: robots do not beget robots any more that cyborgs do! But what does this have to do with boundaries between humans and technology? Haraway's cyborg represents a liminal space that now exists between humans and technology much like my garden metaphor represents a liminal space between nature and technology. Humans exist and technologies exist but Haraway's cyborg represents the blurring of the space between the two. She contends that, in conventional terms, we can no longer distinguish between the two: we are no longer separate as subject (human) and object (technology or non-human) We have technologies that literally fuse into our bodies: prosthetic devices; chemicals that immunise us from disease; heart stints; xenotransplantation; genetic engineering etc. We have technologies that attach to our bodies: spectacles; hearing aids; personal stereos; mobile phones etc. We also have technological systems that are in a state of continuous development and that serve as a means of cultural formation and reformation: transportation systems; medical technologies; the internet, the disturbing possibility (likelihood) of designer babies etc. Our continuing integration with modern technologies changes the way we are as human beings and will continue to so do. The question for me is inspired by the Borg in Star Trek. Do we want to be assimilated into an evermore powerful global technological system controlled by the likes of Bill Gates in such a way that resistance becomes futile, which is another way of describing hegemonic power structures as alluded to earlier, or do we want to have some agency in guiding the process? I for one favour the latter.

In the pre-modern technological era, our technologies were less complex, took much longer to evolve and as such, had much less obvious impact upon out socio-cultural development. In this postmodern era our technologies are evolving at an exponential rate. We are becoming global cyborgs, human beings around the world linked together by technologies, kept alive longer by technologies, able to move around the world more speedily as a result of technologies, able to leave the confines of the planet as a result of technologies. There is little that we actually do that does not involve modern technology and it is also in this sense that Haraway suggests we have already become cyborg. Given that the accessible natural world which most of us inhabit has perhaps all but disappeared, this suggests for me, that we are now part of an almost completely technologically constructed world. A return to nature may be a painful, if not impossible experience for us. We are technological junkies, evermore dependent on the virtual highs afforded us by Wii entertainment systems or the hallucinatory altered states of living isomorphic avatar lifestyles in cyberspace. Whilst I would argue that Haraway's dystopic cyborg metaphor is difficult to contest, it is Gilles Deleuze that offers us a slightly different, but none the less potent way to perceive the technologically textured world.

The philosophy of Gilles Deleuze, along with his later collaborations with Felix Guattari, is not easily accessible. He considers very complex multiple concepts ranging from geometric calculus to poststructuralist philosophy. I hope to avoid as much of the complexity as possible in order to offer my interpretation of some relative aspects of Deleuze to this arguement. To begin with, Deleuze agrees that the world is open to the type of multiple interpretations alluded to earlier. This forms an important aspect of Deleuzian philosophy. In this respect he believes that there is no difference between the human and non human world. However, unlike Haraway, Deleuze does not consider our evolution as heading towards (or already having become) cyborg. Deleuze considers the world to be made up of what he calls 'machinic' assemblages. He uses the term 'machinic' as distinct from machine in order to highlight the fact that a machinic assemblage may be composed of humans and non humans. It will always involve some form of human agency, directly or indirectly. Moreover, the concept machinic is not only subject to multiple interpretations which will depend upon the interpreter's relationship with or to the assemblage, it will also serve to transform the way that the assemblage functions in the world influenced by that very relationship. In other words an assemblage, in whatever form, has agency and is consequently political.

I will use the example of a motor car in order to illustrate an assemblage. A motor car is not some detached object waiting to get from A to B. A motor car transforms our way of being in the world. It is a concatenation of many diverse components including, but by no means exhaustively, spark plugs, tyres, steering wheel, car body etc. These components are brought together in a variety of ways, hence forming multiple realisations for the design of a car[4], that when assembled constitutes for us an actualised representation of an artefact that we have come to know as a car (or automobile, or wheels, or…(yet more multiple interpretations)). Whilst this forms an assemblage in Deleuzian terms, it does so in a limited way. The car will be transformed further if we make it part of a larger assemblage by adding or incorporating other assemblages. The addition, for example, of a human being as driver, which constitutes another assemblage comprising bone and tissue, and that also has a complex autonomous cognitive ability affording it the capability to design, fabricate and operate (drive) the car, adds another transforming aspect to the newly formed assemblage. Add a road infrastructure and then a set of rules and regulations to the assemblage and yet another transformation is made possible. Oil refineries, petrochemical plants and petrol stations must be added yet again and so the list goes on. This for Deleuze is an example of a machinic assemblage. Removing or adjusting or changing just one component in the assemblage will result in a different assemblage. The difference will be a matter of degree depending upon what is removed, changed or adjusted: change the driver from a reckless one to a more cautious one and a transformation will result; change the car from a Ford Ka to a Ferrari and a transformation will result; change the spark plugs…etc. Considering these multiple and complex potential assemblages of a car, or any other technology, makes possible a multiple perspective on the concept of a car and it is this sense that design and technology education can perhaps use this Deleuzian way of thinking in terms of design.

If we consider the world in the Deleuzian terms described we are able to consider the technological world in a completely different way, a way that realises and takes account of the intersubjective relationship between human beings and their world – natural or technological. In this way of perceiving, the essential given quality of a technology (the design or original intent) is open to multiple interpretations and subsequent use (or misuse). This being so, the technology, in association with its user, in some context, in some environment (which would constitute an assemblage) has some purpose. If an assemblage was without purpose the activity would be considered to be chaotic. If there is purpose or intent, there must be agency and with agency comes judgement and ethical considerations. Boundaries in this sense are social constructions and subject to interpretation – a man with a hammer may be a carpenter (a bounded interpretation) or may be a murderer (an alternative bounded interpretation)! A man with a gun may be a policeman, a gamekeeper a bank robber a…!

To ask students in a design and technology classroom setting to design an artefact as a means to some stipulated end (a gun for example, in order to…) will determine an essentialist pedagogic framework that will serve to limit any potential creative endeavour. To consider that same design in Deleuzian terms opens up infinite possibilities, possibilities that transform something into something different which, in turn can be transformed into something different yet again, and again.

There is no optimum finite solution because there are no problems to be solved: there are only multiple possibilities resulting in the potential for multiple transformations. Questions relating to the usefulness of a technology take precedence over the consideration of its efficiency. Ought we design and manufacture more efficient guns or should we question why we need them as a culture. How might it transform an assemblage (of human and gun for example)? What does it make possible? How might the world be otherwise?

In order to incorporate Deleuzian thinking into the subject area of design and technology, we first need to consider the design and technology classroom as a machinic assemblage by asking the same sort of questions posited above. By so doing we may be able to transform design and technology education into something 'other' than its essential self as prescribed by the policy makers who also form part of the machinic assemblage. Deleuzian thinking forms a radical departure from the dominant orthodoxy that prevails today in design and technology classrooms. Design and technology education has become, and is in my view, becoming evermore a system like the Borg in Star Trek. We have all become assimilated into an essentialist mode of thinking about the technological world where students make the same artefacts and are taught the same things (Nicholls and McLellan: 2009). In this model information is bound into discrete packages set within hierarchical knowledge structures that make now allowance for multiple interpretations.

This argument does not offer any fixed solutions, how could it? Rather I have attempted to introduce some modern philosophical thinking into the design and technology domain. These are my interpretations and I welcome any feedback or counter argument. By thinking about design and technology education in this way I believe that I have become someone other than the person I was before. If by reading this you have transformed your own thinking in any way, you have also become ‘other’.

NOTES

[1] Deleuze and Gauttari borrow from the botanical explanation of a rhizome to argue for a radical departure from the Platonic idea of the tree of knowledge. A rhizome is some formation like root ginger or a pack of rats that do not follow any predictable structure. If you look carefully in the fruit and vegetable section in any supermarket you will find that a lot of vegetables and fruit have been modified and standerdised in some way in order to conform to consumer demands (or so the legislators claim, personally I like going round French markets where no two red peppers are ever the same). The cost of this standerdisation is often at the expense of taste. Root ginger cannot be standerdised. Rhizomatic systems do not conform to any prescribed system. In contrast and in educational terms, the tree of knowledge is strictly hierarchical. The basis of all knowledge is hidden and fixed within a stable root system that supports and feeds the trunk of the tree. Knowledge is brought to light by way of the trunk. This generalised knowledge is then subdivided into various separate branches of knowledge and each branch of knowledge culminates in many specialisms found at the end of the branches. Following this model, schools begin to teach the general concepts found in the trunk and later branch out into more specialised areas in a curriculum. Ultimately, learners decided which branch of knowledge they wish to pursue in order to attempt to become a specialist in that area. Where this model is teleological, a rhizomatic form of education has no end. Learning in the rhizome is not about becoming something ultimately, but is about becoming other all the time.

[2] I use the term ‘affect’ philosophically in the way that Spinoza and Deleuze suggest, as distinct from the psychological definition which relates more to feelings and emotions, although that form has an impact also. An affect, in philosophical terms, relates to empowerment or disempowerment. In the case mentioned, does the existence of the boundary, in its present form, serve to empower my neighbour and disempower me? The erection of the fence by my neighbour may afford the neighbour privacy but may block the sun from my garden. Thus the formation of boundaries is seen to have consequences.

[3] This can be seen today. Consider the way the Microsoft have shaped the way that consumers offer little resistance to purchasing Microsoft Office as their operating platform of choice. Every time Microsoft upgrade their operating system consumers rush out to purchase it. Microsoft dictate what and how an operating system will be. Contrast this with those who prefer to use Linux. The Linux operating system is (or was) free as shareware. It required some effort and understanding by the user and was subject to constant alteration by the network of users. It evolved as an operating system rhizomatically whereas Microsoft is more hierarchical in its evolution.

[4] An essentialist argument would be that the essence of a car, its primary designated function, was that of transporting people from one location to another along a network of roads. The context or background, in this view suggests that the car is simply an assembly of inert, non-human physical components that, when brought together, constitutes what we perceive to be a car. The car, considered only in this essentialistic way, is denoted as having only a narrow and universal functional dimension: to get from A to B. However, a car such as a Ferrari or an Aston Martin constitutes more than this essentialsitic functionality: these cars have a visceral emotional context inscribed into their design and this value goes well beyond ‘getting from A to B’. This metaphysical aspect designates the owner as having a certain status, wealth and sexy quality. Whilst a Ferrari will certainly serve the instrumental function of getting its passengers from A to B, they will do so in a qualitatively different way from their fellow humans who travel from A to B in a Ford Ka for example. The design aspect of an artefact must therefore take into consideration these additional

qualitative aspects as well as the purely functional aspects. To consider an artefact without its human relationship leads towards an essentialistic, and so narrowly bounded viewpoint.

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WHERE DID TECHNOLOGY GO?

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In Sweden it is possible to study for a master in engineering physics with very little content that is explicitly technology[1]. The same can be stated in other subjects, but there is a difference. In other subjects one studies a lot of specialized topics within that particular subject. Similar thoughts have been put forward by Arthur (2009) who asked the question on what technology was during engineering studies. Does this make sense? Where did the technology go?

In order to evaluate those questions we have to look at the definition of technology. Arthur (ibid.) gives us a set of definitions and develops a structure for how technology evolves in an almost Darwinistic way. Here I take a slightly different approach.

If one looks for a definition of the word technology on the web, or elsewhere, one does not find consensus on a definition. This may not be surprising as even in books dealing with teaching technology the use of the word is consistent within the books. This can even be true for books with a more philosophical approach. As an example de Vries refrains from defining Technology in his book "Teaching about Technology" [Vries (2005) p11].

> Throughout the book I will take the term 'technology' in the broad sense of the human activity that transform the natural environment to make it fit better with human needs, …

Heidegger takes the stand-point that the meaning of the word technology is well known. Although one has to be careful when translating the word technology (see below) a quote is given here. [Heidegger (1993) p.154]

We have to seek into what Greeks call τέχυη. Yet we must divorce this Greek word from our familiar term derived from it, "technology", and from all nexuses of meaning that are thought in the name of technology.

I will as an example give two definitions of the word technology from the web:

– . . .the practical application of science to commerce or industry[2]
– Technology is a broad concept that deals with an animal species' usage and knowledge of tools and crafts, and how it affects an animal species' ability to control and adapt to its environment.[3] ... (now updated)

The discourse of the word Technology has also changed in the 19th and the 20th centuries [Schatzberg (2006)]. There is also confusion since different words derived from the Greek τέχυη have developed differently in different languages [Salomon (1983–84)]. In the text by Heidegger above, he uses the word technicity

M.J. de Vries, Positioning Technology Education in the Curriculum, 53–60.

in a way similar to today's technology in English. The fact that words with same root and origin develop differently in different languages can make it dangerous to draw conclusions while comparing the use of the words between different countries. The main point here is however that in some languages there are different words for something that is normally contained in one word in other languages.

One can have different approaches to a definition. One can look at etymological or historical background. One can also try to see what everyday language averages about the meaning. However the rapid development in 'Technology' and the recent changes in discourse make historical approaches a bit limited. Technology today also includes electronics, computers, their programs and virtual artefacts in common language. The wide range of definitions found, and the many possibilities for a definition, reflects that it is difficult to discuss anything involving the word technology without agreeing on the meaning of the word. At conferences about school and in pedagogical initiatives 'Technology' always seems to go together with some other words as in 'Design & Technology', 'Math, Science & Technology' or 'STEM'. It seems as the meaning of the word 'Technology' has to be mediated with our knowledge of something else.

In this text I will put forward a philosophical definition of the word technology and follow where it leads. Some philosophers claim that there cannot be only one single definition because it is context dependent [Schatzberg & Mitcham (2009).]. I will discuss this later on. This definition should include the historical path and an etymological background but still allow for the modern development. In the present chapter, I adopt a philosophical approach to the word Technology and I define it here as

A PROPOSAL FOR A DEFINITION OF THE WORD "TECHNOLOGY"

Definition of the word technology:

What man(kind) do in order to extend her physical or mental reach

With this definition I include non-physical artefacts. This also has historical relevance, since technology also used to have the meaning – grammar [Schatzberg (2006)]. When I do this, I do realize that this clashes with the point of view that technology is what engineers do. However this only represents one of the stakeholders of the word technology. This type of definition is not new and I will discuss some arguments about it below. I will first give two examples where this definition of the word technology 'clashes' with 'common' sense or view.

– With this definition writing down a character, say A, is technology. Probably you can not find a teacher who thinks that teaching a child to write the characters is teaching technology? However this is a sociocultural bias of the western world. In China calligraphy is a highly recognized form of art. Art and technology have the same origin and the word meant more or less the same thing from the beginning. Art is also a way of extending your mental reach. Still it would be an impossible and useless task to try to convince all preschool teachers that they only teach technology.

– Pure (natural) science often claims that technology is applied (natural) science. Although this seems to be a common claim arguments against it are presented by Rophol (1997) following arguments by Ihde (1997) summarized as follows:
– '. . . (Experimental) science depends on technical instruments to be invented first.'
– 'Pure (natural) science claims to exist by its own right.'

There are several examples in the literature on how the so called pure science is actually developed from technological breakthrough. Two examples in the previous references are Galileo and the development of the telescope and the Carnot cycle developed as a trial to increase the efficiency of Watt's heat engine.

Two less cited examples include the more recent Nobel Prize in physics 1984 which was shared between Carlo Rubbia and Simon van der Meer. Rubbia is an experimental physicist but van der Meer is an accelerator engineer / physicist who was able to brake the interpretation of Liouville's phase space theorem. The interpretation of this theorem, was at the time, that there was a limit on how many antiprotons could be stored in an accelerator. This particular limit was reduced by so called cooling of the stored beam.

And finally what many people claim is the ultimate theoretical scientific breakthrough in the 20th century. It is argued in Galison (2004) that Einstein's relativity theory was catalysed by his work on clock patents at the patent office in Zurich. At that time there was a high rate of new patents caused by the needs to synchronize clocks on different continents in order to facilitate train traffic on long distance. It was also the 'due' time since of today there is still a debate on who knew what about others work, since Einstein, Poincare and Lorentz did not quote each other work.

With the definition above there is no need to discuss whether science is part of technology or if technology is part of science or even if science and technology represent a mixture of each other. This definition makes science part of technology as also a purely theoretical interest would fall in the definition thus extending the mental reach of mankind. This feature to include, almost, everything in a definition or a theory's basic words is not unknown. As an example I will give a translated quote from the successful sociocultural theory [Säljö et al., (1999) (my translation)]

> But mankind has not only possibilities to develop and conduct knowledge through language. She also has a unique ability to build in her verbal knowledge in physical devices - artefacts.

With a sociocultural perspective, language is the basis for all knowledge. However with this technological perspective language it self can be seen as one artefact among others.

The aim here is not to claim supremacy for one theory over other theories. Rather we will be reminded that different stakeholders' have different perspectives. As will be seen later, claiming supremacy is not a problem since this supremacy will be reduced by giving away parts of the definition or rather bracketing it for practical purposes.

In an other chapter in this book John Dakers give arguments, reading Deluze, that technology and technological knowledge has a growth power which see no border where science try to box knowledge in controllable frames.

Bracketing the Definition for a More Useful and Practical Content in Different Contexts

Useless to add is that so far the proposed, extended definition of technology has not contributed to understanding but rather to confusion. There has also to be some ways for the definition to coexist with other domains. I will put the frame for this coexistence by briefly discussing what science is. I do not restrict my analysis to natural science as often done in English language. What science is has been debated since a long time. Often definitions try to exclude many things which are not pure natural science. Also when one uses definitions like Poppers[4] (1963) definition of science, there is the tendency to forget about all systematic collection and organization of observations needed for any hypothesis, especially if one is dealing with a new field.

One of the things that often are associated with technology is some measure of efficiency. In this text I will not put it as a restriction but merely note that this might be an important issue when we speak about technology in the context of engineering.

I will use a circular definition of science here, which is in this case somehow enough for this purpose. Science is when you use scientific methods. I will follow Fensham's (2003) argument about how new scientific fields create an identity of its own. He gives structural, intra research and outcome criteria which are to be met before a new scientific field can be said to be established. This gives us a way to absorb fields of knowledge from technology into science. This shows how we can reduce what is included in technology, once science is established. We have however to observe that what science is, needs to be determined within each scientific field. Thus science can still be considered technology for someone not in that scientific trade. Also this only brings small restrictions to the definition of technology suggested in this paper, as it shows a way to put the word technology more towards its common use.

If the purpose with a definition of technology is to know what to put in a curriculum it can seem meaningless with a definition that do not meet the laymen's view of the word. However academic subjects are, most often, accepted by layman as scientific knowledge independently if the layman know what is included or not. In the same way it is an accepted believe, among many, that most school subjects are distilled out of academic or scientific subjects. That this is not necessarily true can for example be seen from that geography started in school as a school subject and became an academic subject later on, with heritage from both the school subject and from other academic subjects. This indicates that academic or scientific knowledge from one end, and school subjects from the other end, can bracket the definition of technology when we use it for the school subjects. This bracket will be different for different age groups. There will however be some aspects which will remain technology. That is what is remaining between what is now called school subjects.

We may now think of technology as being what is remaining when we take away everything that has got its own speciality or special name.

This now enable us to bracket in what we call technology in daily speech. Did we gain anything from this exercise then? Well we are now aware of that technology change not only because of new inventions, but also because we integrate technology in different specialities such as science, school subjects or even artefacts.

A metaphor may clear this thought. We think here of technology as water a necessity for life. If technology would be all the water then when land rises, as we are used to in Sweden, we get new islands which we compare with different new specialities. In the metaphor these are the islands in the beautiful archipelago of Stockholm. Technology is the water remaining in between, but it may also remains within a speciality just as lakes reside within an island. Specialities may also grow together just as small islands may grow to a bigger one as land continues to rise. But there is also another possibility: one may take away water just as one does in The Netherlands. In the metaphor this would correspond to science. But using this metaphor we also note that one keeps some water in a controlled way such as channels to communicate between different areas of science. Here science is used in a wider meaning then just natural science. We can have one more analogy from this metaphor, water in the form of rain continues to fall everywhere in different amounts. This rain is usually quickly absorbed but occasionally is flooding or expanding previously established water reservoirs. In the metaphor this corresponds to technology popping up in specialities to be quickly incorporated into common knowledge and no longer considered technology, but just a part of the speciality. Sometimes however so much technology is generated in a short time and spread so fast, that cannot be included quickly in one local speciality.

Besides playing a supportive role for school subjects, something all school subjects do, what is the specificity in teaching technology? In the Swedish higher education in technology all universities of technology offer one program that contains only about a week of technology within a full academic program of 5 years. In those programs one studies almost only academic special subjects for the entire period. Will this strategy leave the responsibility to the students to explore on their own the interface between different scientific disciplines and technology? This is much what Arthur (2009) describes in his book. The answer to the question I pose is no. In the Swedish system, as probably in other systems, there are elements which come with the program, although they may not be explicit, that makes the program to a technology program.

– Just do it. This is not only a trade mark of a big sport manufacturer, but often the difference in approach from someone who is trained with a pure scientific background or trained within a joint scientific and technological program. There are several courses common between the joint programs at university of technology and the pure academic programs at other universities, particular in higher math. An anecdote describes the difference in student's attitude between the two kinds of universities. In non-technological university you prove that there is a solution to a problem, perhaps you can show that it is unique. Then you give an ansatz[5] to how a solution may look like. On the same course students from the technological university solve the problem whether it is solvable or not. This anecdote describe that pathological cases are often not so interesting in 'real world' problems but could also refer to the ability of understanding how to interpret a solution or which requirements are real before solving a problem. This can perhaps be compared with how the experiments which led to the 1984 Nobel Prize were made possible by challenging the interpretation of Liouville's phase space theorem.

– Complex systems. In the final years there is flexibility and different students can choose different courses. Common between those courses is that there is an element of high complexity. This can be complex mathematical modelling, environmental science, advanced strength of material courses, advanced fluid mechanics, nuclear reactor design and many more. They all serve as a good training in dealing with complex systems whether they are very theoretical or more hands on engineering like courses. There are also elements training open ended optimization. This covers engineering parts of technology but also reaches beyond, towards a broader sense of technology.
– There are not so many courses in those programs that focus on design. Design has recently become increasingly popular. However there is a discrepancy in how this word is used in the Swedish context or the English speaking context. But on the other hand it is not the same between an English (UK) and an English (US) context either. The difference can be seen in how different design is assessed in the US and the UK [Garmire & Pearson(2006) pp 106, Kimbel & Stables (2007) p22]. In the UK, the design and the design process are important parts of teaching technology, while in the US understanding and using technology is the main focus. In Sweden the design process is included in many other advanced courses such as advanced programming. Most students in those programs will thus have training in the design process. The way this is assessed in Sweden is often by open questions but within a smaller framework so it can in this sense be seen as a mixture between the systems used in the US and the UK.

This may describe that it is possible to study technology with none or very little explicit technology at higher education. But if this definition of technology is justified then it should have some bearings on how technology is or can be thought at the compulsory school levels as well. With this definition, we see that technology is used everywhere. However in daily live we tend to bracket it by specialities such as school subjects, academic subjects or simply common knowledge. Well if we continue with the metaphor we can see technology within those specialities and between them either because we have not made specialities or because we put technology there in order to improve communication between different specialities.

This way of technology remaining everywhere and also being reintroduced to reduce friction in the communication between the different specialties where one has carefully tried to take away technology indicates that technology in school has to be seen both from an "expert" point of view (by teachers specialized in technology or technology & a mediator) but also seen from within a particular school subject where technology is an integrated part. Integration does not evolve from nothing. Technology as a school subject is pretty young and thus has much less tradition than other school subjects. If there is no strong stakeholder who forces the integration of technology into the curriculum, then maybe the technology teachers have to invite other parts for collaborations towards an integration of technology into all or most of the school subjects, beside the more conventional technology education. I note that this may leave students to figure out what technology is. But this is really already the case at least partly within the Swedish system and it is also witnessed by Arthur in his book.

CONCLUSIONS:

Higher studies in technology may not reveal the nature of technology itself. The feeling for what technology is, is not always explicit and is changing as students go along with their studies.

If one tries to use a philosophical definition of technology one finds that it tends to include 'everything', at least with the proposed one. However there exist other philosophical definitions with simular features that would lead to simular thoughts. This is not so different from theories that say that 'everything' is language. In both cases it is clear that all education can not be based on such a wide definition. With this definition we also see that technology is changing over time and persons and not only by new inventions.

In compulsory school there have to be special school subjects that are different from their academic counterparts. Thus one can have a school subject without a direct heritage from academy. On the other hand it is possible with a system where all higher technology education is in a form of academic subjects springing from scientific background. There is no best way; technology will always be part of other subjects.

We have to help to build this integration of technology naturally into school subjects, as well as to push for technology as an independent school subject. If this integration is not done by means of curriculum it has to be done through an invitation from the professional technology teachers to teachers in established school subjects.

NOTES

1 In fact there are more students studying natural science at technical universities than on other universities in Sweden-

2 Available from [http://wordnetweb.princeton.edu/perl/webwn (n.d.)]

[3] Available from [http://en.wikipedia.org/wiki/Technology (n.d.)] Now updated (6 nov 2010) to read: "Technology can be most broadly defined as the entities, both material and immaterial, created by the application of mental and physical effort in order to achieve some value."

[4] Not strictly a definition. Rather a requirement that in order to be science it has to include a hypotheses that should be possible to falsify.

[5] Ansatz is a German noun but it is used in the English language in particular in the subjects of mathematics and physics.

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TECHNOLOGY, ENGINEERING AND SCIENCE EDUCATION

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THE STEM PROGRAMME IN ENGLAND

Help or hindrance for design & technology education?

INTRODUCTION

This chapter is in four parts. It is deliberately and of necessity descriptive. And the author has to acknowledge that in reporting this very short history of an episode of curriculum politics that he was actively involved in the machinations. The author is the STEM (science, technology, engineering and mathematics) consultant for the Design & Technology Association and was given the brief to develop the profile of design & technology within the National STEM Programme with particular reference to links with science. In Part 1 the chapter reports on the rationale for and progress made so far in the national STEM programme. Part 2 describes the efforts made by the Design & Technology Association, the professional association for design & technology teachers in England, to enable the school subject design & technology to be considered as an essential part of the "T" in STEM. Part 3 describes the in-service programme for design & technology teachers that is emerging as part of the National STEM Programme and the infrastructure that is supporting this. Part 4 discusses the implications of the unfolding developments within the National Stem Programme for the future of design & technology.

THE NATIONAL STEM PROGRAMME

The National STEM Programme has its roots in the report to the Government by Sir Garth Roberts *SET for success The supply of people with science, technology, engineering and mathematics skills*, April 2002, and the report by Lord Sainsbury of Turville *The Race to the Top: A Review of* Government's *Science and Innovation Policies*, October 2007, both of which indicate the need for more pupils to gain qualifications in science and mathematics.

> Scientists, mathematicians and engineers contribute greatly to the economic health and wealth of a nation. The UK has a long tradition of producing brilliant people in these areas, from Isaac Newton and Isambard Kingdom Brunel, to Dorothy Hodgkin and Neville Mott last century, and most recently to Andrew Wiles who proved Fermat's Last Theorem. The challenge we face is to continue to attract the brightest and most creative minds to become scientists and engineers. (Roberts, 2002 p..iii)

M.J. de Vries, Positioning Technology Education in the Curriculum, 63–74.

> Demand for science, technology, engineering and mathematics (STEM) skills will continue to grow. The UK has a reasonable stock of STEM graduates, but potential problems lie ahead. There has been a 20-year decline in the number of pupils taking A-level physics. The Review recommends a major campaign to address the STEM issues in schools. This will raise the numbers of qualified STEM teachers by introducing, for example, new sources of recruitment, financial incentives for conversion courses, and mentoring for newly qualified teachers. The Government should continue its drive to increase the number of young people studying triple sciences, and consider entitlement for all pupils to study the second mathematics GCSE (due to be introduced in 2010). (Sainsbury, 2007 p. 6)

In direct response to these reports the government produced a report The Science, Technology, Engineering and Mathematics (STEM) Programme Report (Department for Education and Skills and Department for Trade and Industry (DFES & DTI), 2006). As the following quote reveals the government had decided to rationalise the range of STEM initiatives and initiate a national strategy.

> However, at the current time we have far too many schemes, each of which has its own overheads. The original STEM Mapping Review in 2004 revealed over 470 STEM initiatives run by DfES, DTI and external agencies and subsequently, the STEM cross cutting programme examined around 200 of these. They are not, therefore, in total either efficient or effective and do not give a complete coverage of all schools. We need, therefore to rationalise those supported by the Government and build on the best ones. By doing so, we believe we can achieve a much better result for the same amount of money. Our proposals work towards a vision that aims to ensure that STEM support is delivered in the most effective way to every school, college, learning provider and learner. For the first time we will have: One high level STEM Strategy Group that will join up STEM across all phases of education and make recommendations to Ministers about national STEM priorities; and a National STEM Director who will drive delivery forward. (DFES &DTI, 2006 p.3)

The report makes sorry reading for the design & technology community. The report had virtually ignored design and technology. The only reference to the subject was as follows:

> It should be noted that engineering and technology are not typically considered as curriculum subjects in schools – though design and technology and ICT may count as such – but they are often college subjects. (DFES &DTI, 2006 p.10)

On what planet did the authors of this report reside, one wondered? To compound the situation the Report did not mention the Design and Technology Association as a partner which might take part in developing the T aspect of STEM. This was not an auspicious start.

Table 1. The STEM National Programme

Action Programme	*Lead Organisation*
Getting and training the right teachers and lecturers of STEM subjects in the first place	
AP1 Improving the recruitment of teachers and lecturers in shortage subjects	Training and Development Agency for Schools (TDA)
Providing the right continuing professional development for teachers of STEM subjects	
AP2 Improving teaching and learning through CPD for mathematics teachers	National Centre for Excellence in the Teaching of mathematics (NCETM)
AP3 Improving teaching and learning through CPD for science teachers	National Science Learning Centre (NSLC)
AP4 Improving teaching and learning by engaging teachers with engineering and technology	Royal Academy of Engineering (RAEng)
Providing the right activities and careers advice that bring real world context and applications of STEM into the classroom	
AP5 Enhancing and enriching the science curriculum	Science Community Representing Education (SCORE) is convened by the Royal Society. The other founding partners are the Institute of Physics, the Royal Society of Chemistry, the Institute of Biology, the Biosciences Federation, the Science Council and the Association for Science Education
AP6 Enhancing and enriching the teaching of engineering and technology across the curriculum	Royal Academy of Engineering (RAEng)
AP7 Enhancing and enriching the teaching of mathematics	Advisory Committee on Mathematics Education (ACME)
AP8 Improving the quality of advice and guidance for students (and their teachers and parents) about STEM careers, to inform subject choice	The National STEM Careers Co-ordinator (at Sheffield Hallam University)
Getting the STEM curriculum in the classroom right	
AP9 Widening access to the formal science and mathematics curriculum for all including access to triple science GCSE	Department for Children, schools and Families (DCSF)
AP10 Improving the quality of practical work in science	SCORE
Getting the STEM education support infrastructure right	
AP11 Programme to build capacity of the national, regional and local infrastructure	Department for Children, schools and Families (DCSF)

John Holman was appointed National STEM Director and under his leadership an action plan for the national programme was developed. organised into 5 themes and involving 11 action programmes overall with each action programme supported by a lead organisation (National Science Learning Centre 2008). This is summarised in Table 1. Inspection of the individual action programmes that comprise the national programme reveals a dominance of mathematics and science. Some commentators have described the programme as a SM programme as opposed to a STEM programme. The complete absence of the phrase design & technology is an obvious cause of concern for those who believe that this school subject can make a significant contribution. However, there are action programmes which can be aligned with and include design & technology and it was through this approach that the Design & Technology Association embarked on the process of raising the profile of design & technology.

ELABORATING THE T IN STEM

The situation with regard to the absence of design & technology was rectified to some extent by the report *S-T-E-M Working Together for Schools and Colleges* based on the outcomes of a workshop held at the Royal Society in May 2007 (Royal Society 2007). Richard Green, Chief Executive of the Association, was invited to make a presentation about design & technology in schools to an audience of STEM stakeholders. The response was positive and the resulting seminar report identified benefits of science, design & technology and mathematics working in a co-ordinated way, acknowledged that prevailing ‘performance culture’ forced teachers to operate in subject silos noting that the challenge was “how to bring about change while working within the existing performance culture” (p.2). Significantly the report noted that to make the most of the possibility afforded by the opportunity to establish a STEM education community “pulling in the same direction” it will be necessary:

> to avoid any suggestion of a ‘top down’ approach - all members of the community need to be treated as autonomous players;
>
> to foster a culture of co-operation, not competition;
>
> for co-ordinating bodies such as SCORE and the Science Learning Centres to recognise that they need to earn respect from organisations that have been around for a lot longer; (Royal Society 2007, p. 4/5)

This clearly opened the way for a fuller involvement of the Design & Technology Association and as a result of this the author was able to interview the authors of the report, Michael Reiss (at the time Director of Education for the Royal Society) and John Holman, for the Association and for the interviews to be published in D&T News and to appear on line (Barlex 2007a, 2008). Both interviews revealed a strong willingness on the part of these two highly influential science educators to support design & technology as a key player within the STEM programme. In response to the question “What is it that you think science might learn from design & technology?” Michael Reiss said

> When I look at the work secondary school students undertake in D&T, there are two things that stand out for me as lessons that science educators might learn. The first is the time given to designing, undertaking and evaluating a

> piece of work. One of the great sadnesses for me of the introduction of the science National Curriculum has been how we have failed to help students understand, by the time they reach the age of 16, how science is undertaken. The second … is the importance of values as being integral to every subject. There has been a tendency for some science courses to assume that values can either be ignored or treated as a sort of soft add on after all the hard science has been done. It is precisely that failure that leads so often to scientists failing to understand UK public attitudes, whether about GM crops (most people against them whatever the safety arguments) or recycling (everyone in favour of it but only 10% prepared to do anything about it unless they are forced to or it is in their own interests). Regretfully, most school mathematics is undertaken as if in a values vacuum – as if it doesn't matter whether calculated rates of change over time are for interest rates, unemployment rates or infant mortality rates. (D&T News September 2007 p.18)

In response to a question concerning the concentration on mathematics and science and the apparent disregard of design & technology John Holman explained the importance of science and mathematics both in their own right and as gatekeeper subjects for a wide range of STEM careers and importantly acknowledge that "… the low profile of design & technology does represent a lost opportunity … the role of design & technology to provide a hands on technological and engineering is very important" (D&T News April 2008 p.19)

So the stage was set for the Design & Technology Association to play a fuller part and this was achieved by the author and Richard Green suggesting to John Holman that it was important for the Design & Technology Association to be seen to be consulted, as opposed to just working behind the scenes. This resulted in John working with Matthew Harrison of the Royal Academy of Engineering (RAEng) to arrange for the Design & Technology Association to be officially invited to join the 5–19 STEM Programme Board. Hence the Association was now seen as a representative body along with the Association for Science Education, the Royal Academy of Engineering, the Royal Society and the Research Councils UK. The Design & Technology Association were now in a position where it could collaborate officially with other representative bodies and this enabled Richard Green to work with Matthew Harrison to make a submission to the STEM High Level Strategy Group (HLSG). The RAEng and the Design and Technology Association were tasked by the Department for Children, Schools and Families (DCSF) to produce a paper for the STEM HLSG meeting on 17 October 2008. This paper, *D&T: a remit for the future* built on the Offiice for Standards in Education (Ofsted) recommendations (Ofsted 2008). Having received the paper, the STEM HLSG asked that RAEng and the Design & Technology Association convene a working group to (a) identify how Design and Technology [D&T] could further support the STEM Programme goals and targets, (b) identify and prioritise what support and development within D&T would be necessary to do this and (c) identify the likely costs. Via a stakeholder meeting and the follow up work of a virtual sub group of which the author was part a briefing paper was developed and presented to the HLSG (Wright, 2008). The paper contained the following recommendation.

> The HLSG should recognise and support the requirement for D&T-led CPD provision to make mathematics and science concepts explicit in D&T teaching and learning at both Primary and Secondary phases. This may be achieved through D&T-led CPD focusing on designing informed by mathematics and science starting with, but not restricted to electronic/control product design incorporating systems thinking. (Annex C)

At this stage it remained to be seen whether this recommendation would have any effect.

THE EMERGING IN-SERVICE PROGRAMME

Whilst the Design & Technology Association was working to position itself as a body of influence with the HSLG it was also developing the digital design & technology programme. This programme was formulated by the Design & Technology Association to bring together in a coherent manner those elements of design & technology that made strong use of information and communication technology. This involved amalgamating two very successful existing programmes – the CADCAM initiative and the Electronics in Schools strategy. The result of this amalgamation has been the setting up of four support centres in each of the government regions in 2008. Two of these centres have expertise in electronics and two have expertise in CADCAM. In some of the regions this expertise is combined within a singe centre. These centres receive modest funding from the DCSF, guaranteed for three years and have the brief of providing in-service training concerning the application of digital technologies to design & technology according to local needs. Over the following three years the training pattern was expected to shift from 75/25 dedicated/integrated sessions to 25/75 dedicated/ integrated session i.e. teachers will be progressively empowered to adopt and teach a digital approach to electronic product design. Importantly there is a science learning centre (SLC) in each region so there is the possibility of these support centres working ever more closely with the SLC and providing in-service training that enables science and design & technology teachers to coordinate their work as recommended by the report S-T-E-M Working Together for Schools and Colleges (Royal Society 2007).

It was possible to use Action Programme 6 *Enhancing and enriching the teaching of engineering and technology across the curriculum* to develop a pilot programme of in-service training aimed at enabling science and design & technology teachers to work together. The theme for this pilot was modern materials and Professor John Cave of Middlesex University was commissioned to identify and source at reasonable cost a selection of such materials that would provide interesting materials investigation and application possibilities thus appealing to teachers from both disciplines. The contents of the set are listed in

Table 2. Representatives of digital design & technology support centres and science learning centres met together to explore the materials and plan possible in service programmes. These programmes were advertised through the science learning centre network but uptake proved to be very small.

Table 2. Content of Modern Materials Kit

Thermally responsive materials	Smart alloys and polymers	Optically responsive materials and LEDs
Thermochromic pigment	Shape memory polymer	Glow-in-the-dark film
Thermofilm	Smart putty	Opical fibre
Thermal paper (fax)	Rare earth magnet	UV fluid
Phase change powder	Superelastic wire	UV beads
	Memory wire	LEDs
	2-way memory spring	
Fibres and woven materials	**Special polymers**	**'Nano' materials**
Cocoons	Polymorph	QTC pills
Chopped carbon fibre	Hydrogel	Broken shells
Kevlar fabric	Expancel	Bank of England money
Carbon fibre fabric	Chromatic alginate	Chameleon nano flakes
Ripstop nylon		Smart film
Silk		
Lycra		
Eco film		
Genuine carbon fibre sheet		

Whilst this was taking place the HLSG had considered the recommendation developed by the Royal Academy of Engineering and the Design & Technology Association. The Royal Academy of Engineering offered to part-fund the recommendations with the result that the DCSF was instructed by Ministers to match fund the initiative under Action Programme 6. A total of approximately £360k available over three years was made available. At a meeting convened by John Holman at the National Science Centre in York key players discussed possible ways forward. The following were identified.

The in-service training would be available in all regions of England. The programme would be made available through both the regional science learning centres and their associated digital design & technology centres. The technical content of the in-service was identified in the first instance as focusing on systems and control featuring in particular actuation from initial thoughts tabled by Andy Mitchell of the Design & Technology Association. John Cave of Middlesex University was invited to identify and source at reasonable cost appropriate materials, components and equipment. The in-service training will be piloted with a small group of teachers over the summer term of 2009 before becoming the basis for a significant train-the-trainers event to take place in mid September 2009. This would allow for the programme to be disseminated widely through 2010. Melanie

Washington of the Royal Academy of Engineering indicated that her organisation would be able to bring strong industrial links to the applications within the courses. Pat Hughes and the author agreed to work on a parallel development in which teachers would attend the BT research and development centre at Adastral Park and become familiar with new and emerging communication technologies that they could then use in engaging pupils with developing applications for such technologies.

DISCUSSION

From a position in 2004 in which design & technology as a school subject was ignored and seen as having little if any contribution to make to the STEM programme the situation has changed. Through the work of the Design & Technology Association professional relationships were forged with figures of influence in the STEM community, particularly John Holman, the National STEM Director and Matthew Harrison, Director of Education at the Royal Academy of Engineering. The nature of design & technology and its potential to make a significant contribution was clarified and this contribution was acknowledged by the STEM High Level Strategy Group with the result that some modest funding has been made available for in-service training for design & technology teachers. This has been accompanied by the development of a national network of design & technology support centres which can work closely with the network of regional science leaning centres. Given this new position of design & technology what is the possible trajectory for the subject in the future?

To maintain its influence it is likely that design & technology will have to demonstrate the effective use of science and mathematics within the teaching and learning of design & technology so that pupils a) experience the utility of these subjects and b) are motivated to continue studying them post 16. Ainley, Pratt and Hansen (2006) made the argument for the utility of one subject informing purposeful activity in another subject with regard to the utility of mathematics. This argument has been extended by Barlex (2007b) to show the potential of cross-curricular links between design & technology, mathematics and science to enhance pupil's design activity. However the history of interaction between subjects in the secondary school curriculum has shown that this is not easy to achieve. Barlex and Pitt (2000) reported that there was little if any interaction between science and design & technology in the secondary school and that this was confounded by an erroneous perception of each subject by those teaching the other subjects. A later report (Barlex 2005) indicated that within secondary schools in England designated as Engineering Colleges this situation had not changed significantly. A small case study (Lewis et al 2007) indicated that the misunderstanding identified by Barlex and Pitt (2000) led to antagonism between the science and design & technology teachers and failure in cross-curricular activities. However with the introduction of a new programme of study for the National Curriculum in England at Key Stage 3 (pupils aged 11 – 14 years) in 2008 (Qualifications and Curriculum Authority (QCA), 2008a) there is the possibility that the situation in schools may become more conducive to cross curricular work in which individual subjects work together tackling topics which are interdisciplinary in nature. The desirability of such activity has been made even more explicit by the publication by QCA of the BIG Picture (QCA 2008b) which describes a range of whole curriculum dimensions which require collaboration between different subjects. Recently Sharkawy et al (2008) identified a set of seven criteria which needed to be met if such cross curricular work involving science, mathematics and design & technology were to be successful. Since late 2007 the Nuffield Foundation has been operating a Key Stage 3 STEM project (see www.nuffieldstem.org) which aims to provide teachers with the means to develop interdisciplinary STEM activities involving mathematics, science and design & technology. So in terms of the curriculum at Key Stage 3 there is now a positive environment and developing expertise to help schools engage in cross-curricular STEM activities in which design & technology plays a significant part. It is worth noting that interaction between pupils understanding of mathematics and science and their learning in design & technology is not necessarily dependent on cross-curricular activities. It is feasible that a design & technology teacher might deliberately develop designing and making tasks which call heavily on science and mathematics for successful completion and 'fly solo' in the actual teaching. It would of course be unwise to do this without first engaging in conversation with those who teach the pupils science and mathematics. Whether the design & technology teachers operate independently but in consultation with their science and mathematics colleagues or become part of cross curricular teams which plan and teach collaboratively the future status of design & technology is likely to be dependent to some extent on the effect that the teaching has on pupils attitude towards and ability in mathematics and science. John Holman (Barlex 2008) has indicated that in design & technology this can be achieved by providing a "hands-on technological and engineering experience". He lays down a challenge.

> …it's now up to design & technology teachers to get involved and show the rest of the STEM community just what a powerful role they can play.(p. 20)

Since John Holman made this remark the situation in England has changed. On 11th May 2010 a new UK Government took office. It has radical plans to change the education system. This is made clear by the following statement which appears on the extensive website of the previous administration.

> A new UK Government took office on 11 May. As a result the content on this site may not reflect current Government policy. All statutory guidance and legislation published on this site continues to reflect the current legal position unless indicated otherwise. To view the new website, please visit http://www.education.gov.uk

With regard to the National Curriculum (Department for Education (DfE) 2010) the intention is:

> …to restore the National Curriculum to its original purpose – a minimum national entitlement for all our young people organised around subject disciplines. Ministers are committed to giving schools more freedom from unnecessary prescription and bureaucracy. Ministers have always made clear their intentions to make changes to the National Curriculum, to ensure a focus on the basics and to give teachers more flexibility …

These plans must be put in the context of decreasing public expenditure in response to the global economic crisis and the need to reduce the budget deficit.

There are two concerns for the design & technology community arising from this new situation. First is responding to the organizing principle of subject discipline. Design & technology does not easily meet the usual criteria for being a school subject discipline. As Kimbell and Perry (2001) assert it has "an awkward insistence on being neither a specialist art nor a specialist science. It is deliberately and actively interdisciplinary. It is creative, restive, itinerant, non-discipline" (p.6). Second is the availability of funding for continuing professional development that is essential for the modernization of the design & technology curriculum. This was raised in parliamentary question time and received the following answer (Hansard 12 July 2010) from the Parliamentary Under-Secretary of State for Education (Tim Loughton).

> I agree with the hon. Member for Huddersfield (Mr Sheerman) that the quality of teachers and professional development is important. International evidence shows that teachers learn from observing good teachers, and this happens best in schools. That is why the Government are committed to encouraging schools to demonstrate a strong culture of continuing professional development, with teachers leading their own development and that of others, and sharing effective practice within and between schools. That is why we are currently reviewing our policies and existing activities to ensure that they focus on that vision. (Columns 650 and 651)

This view of professional development does not engage strongly with the need of design & technology teachers to regularly upgrade their subject knowledge in a rapidly changing field. This will not occur through observing other teachers however gifted the practitioners that are observed.

At the time of writing the future is unclear. To some extent design & technology is protected by being considered as part of STEM with the government seeing a rise in wealth creation through manufacturing and exports as part of the UK economic recovery (See for example Wall Street Journal 2010). However, this utilitarian view of the contribution to education made by design & technology is limited and could if taken to extreme undermine the position of the subject as a feature of general education for all pupils.

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BETWEEN TECHNOLOGY EDUCATION AND SCIENCE EDUCATION: A NECESSARY POSITIONING

INTRODUCTION

In general education, "Science and Technology" is the usual label for identifying an educational area and its purposes. The topic is currently important and it is a political issue. The European Commission aims to organise basic education with an associated or integrated set or a pillar of science and technological culture with mathematics, experimental sciences (biology, geology, physics and chemistry) and technology. It is also an international movement like for instance in Quebec (Barma, 2007; Hasni & Lebeaume, 2008). But Rocard's report recent proposals (European Commission, 2007) do not take into account the specific technology epistemology analysed by de Vries (2005) because of an approach only defined by Inquiry Based Science Education. Layton (1990) indicates that the three main possibilities of technology existence connected with science are applied sciences, experimental approach of devices and science-technology-society prospect.

The current context and the purposes of a knowledge society focus on a new citizenship and new qualified employments. Technology education needs are deeply changing. In general education technology education with its epistemological singularity and its differences has to be defined again in its social and educational functions.

In order to examine this major issue, the first part analyses the curricular system in France and its structure historically established as subjects-centred and where technology education required being different from science education. The second part focuses on the main confusion concerning the relationships between these school matters and mainly about the experimental approach in its epistemological and pedagogical aspects. The third part develops a frame to investigate new contents and look at the organisation of technology education in compulsory school and mainly in middle school.

TECHNOLOGY EDUCATION AS A SCHOOL DISCIPLINE: TOOLS FOR ANALYSING

In France like in most other countries technology education is integrated into school work - specifically identified after primary school (teachers, classrooms, timetables…) - but its content and teaching differ in high school (Deforge, 1993; Gradwell & Welch, 2003; Mottier & de Vries, 2006; Wright, Washer, Watkins &

M.J. de Vries, Positioning Technology Education in the Curriculum 75–86.

Scott, 2008). This situation is jointed with the history of school system and the integration of technical education in it.

Technology Education: Coherence

A model is proposed for analysing technology education (Lebeaume, 2000, 2004). It questions foundations of contents on the prototypical situation of each form. This teaching-learning is defined by tasks with their meanings and positioning: What are the pupils doing exactly? Why are they doing it? How these tasks refer to outside practices? Figure 1 illustrates this coherence in reciprocal relationships between the three components of the discipline: purposes, references and tasks.

In the past there were numerous differences between manual works. The main distinction was references: scientific knowledge and technical practices.

This internal analysis must be achieved by an external point of view to indicate the functions of school matters in educational policy. Technology education is different if it serves personal development, careers information or workers' education.

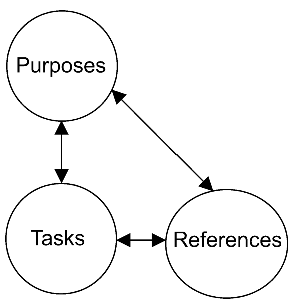

Figure 1. Coherence.

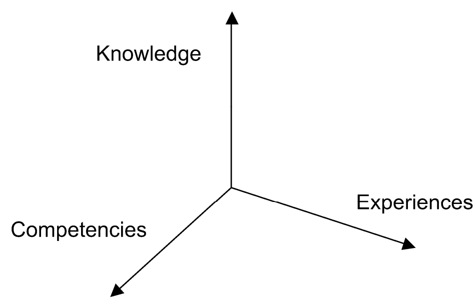

Figure 2. Contents Repartition across Curriculum.

Technology Education: Distinctions

From an analysis of the curriculum main types suggested by Ross (2000), Lebeaume (2008) distinguishes share of contents and technology education main forms according to knowledge, competencies and experiences.

On figure 2, one plan is opposed to one axis. It enables to distinguish 1) teaching-learning considered as process or products; 2) the role of pupils: knowing or acting; 3) the contents-centred pedagogical methods, the competencies-centred in new original situations and the notion of socialisation-centred. Contents are different according to say or do, understand or succeed, learn or appropriate or incorporate values and empowerment.

TECHNOLOGY EDUCATION: HISTORY AND DISTINCTIONS

Technology education does not exist spontaneously in the French school system. It has a long history in the dynamic of design and implementation of compulsory school and in the organisation of scientific school disciplines. There have been numerous tensions about its specific contents and its relationships with scientific school disciplines especially with physics-chemistry.

In order to understand the French situation, it is necessary to analyse the proposals from the Second World War when compulsory school leaving age was at 14. The analysis is based on a series of documents about political discourses and pedagogical proposals on contents (Charlot & Figeat, 1985; Lebeaume, 2008). It underlines the context and socio-economic stakes, educational policy trends, main pedagogical orientations and school matters contents and labels (see Halström in this book). From this analysis establishing different levels from policy to pedagogy, we can define five main periods (Table 1).

Five Main Periods

A brief description of the five periods focussed on innovations.

Arts and Crafts and Home Economics: 1942–1962

The beginning and the middle of the 1940's were marked on the one hand by the first project on unified school system and on the other hand by the development of technical education and its teachers' education. The accent was on pedagogical active methods for boys and girls described with concrete spirit. In workers' preparation, principles were not only limited to gestures and how to do it but were able to explain the principles of actions and the reasons of technical choices. It was usual to define technical contents in their relationships with applied sciences. At the same time there were several innovations for young pupils to define their aptitudes for their best career choice: handicrafts were implemented for their educational virtues. It was the development of home economics for young girls in order to train them for their two careers. This education was valorised in technical schools and more modestly in primary schools but was severely criticised in secondary schools preferring to teach knowledge only. Arts, crafts and home economics defined an experiences-centred education. Its establishment was supported by women and female teachers to whom a new certification for this education was recognised in 1950.

Technology: 1962–1975

Since 1959 school has been compulsory until age 16. The main issue of the educational policy was to define the new middle school and prepare pupils for their career choice especially in the new upper level after high school. At that time policy makers had to create this new education and make it different from vocational education (Deforge, 1970). It was not very easy without specialised teachers, administrative and pedagogical organisation and equipment… They defined three types of "Technology Education": experimental or scientific technology useful for good pupils who liked concrete approach, analysis of devices and graphical expression. The second technology education was more vocational and adapted to less successful pupils who had to choose between manual and technical career at the end of compulsory school and valorised technical realisations in workshops. The third technology education was home technology useful for all pupils, boys and girls, in order to prepare them to the use of new devices or products of modernity. The institutional and material conditions enabled only to design and test the first technology with two main aspects: an active, concrete and experimental approach; contents centred on functional analysis and technical drawing to understand technical thinking.

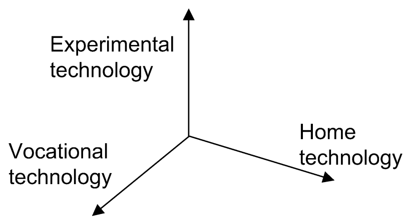

Figure 3. Three Technology Educations.

But put them in place was far more difficult because of the simultaneous implementation of science education, especially in physics and chemistry. This school matter existed already as objects lessons in high school and primary school. Numerous engaged officials criticised the gap and claimed that physics had to have the same status as biology and geology in middle school. So then middle school became a ground of conflict between technicians and physicians but on unequal terms (Harlé, 2003). The programs of physics and technology developed the analysis of devices. Some focused on phenomena studies and others on functional analysis. This proximity was the base of confusion between the two school matters: the ones judging prior sciences on technics. Technology was considered only as applied sciences or pedagogical means for science education.

Distinction Between Science Education and Technical Education: 1975–1985

When middle school was generalised to all young people, the school law limited the conflict with the implementation of the two school matters: physics and chemistry; manual and technical education. Due to economical and political circumstances scientific technology education was included in science education (physics) and technical and manual education developed vocational technology (handwork) and home technology (home economics, usual devices and products). This choice focused on differences between pupils and their career choice. But this division of contents was not really implemented and experimental technology did not exist: physics developed only a scientific approach in order to discover and learn universal laws, experimental methods and contents knowledge. There was also an alliance between biology-geology and physics-chemistry in the area labelled experimental sciences. These school matters constituted a set equal to position: a vertical coherence from kindergarten to university, contents knowledge related to mathematics, contents useful for pupils' selection. Technical and Manual Education did not have the same function and status. This course was conceived for poor children and their preparation for real life and teachers did not have university qualifications. These factors contributed to give to this version a low status. Since 1980 "Technical and Manual education" has been challenged. Technology specialists hoped to develop contents for getting the best technicians' qualifications. The challenge was about school contents and school activities judged too referenced to workshop and not to industrial process and methods.

The Coexistence Between Science Education and Technology Education: 1985–2000

In 1985 Technology was a new school matter and replaced Technical and Manual Education. It was time to position technology to its vertical organisation from kindergarten to university and engineers schools. Technology teachers certification was also a concern in middle school. The curriculum was organised with experimental sciences and technology. There were three different school matters with their own functions and their separate contents. As in the past Technology focused on school orientation and vocational orientation while the priority of biology-geology and physics-chemistry was to encourage the development of future scientists. Technology enhanced technical project process while sciences focused on knowledge. These differences are shown on figure 4.

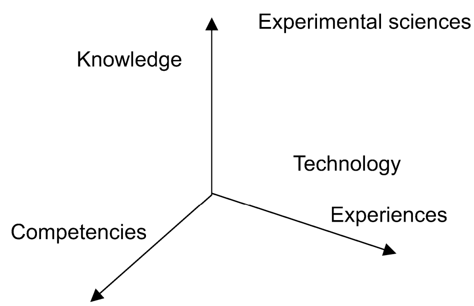

Figure 4. Technology and Experimental Sciences.

Technology is a school matter based on execution and experimental sciences are a school matter based on knowledge. The difference is also about pupils who produce either pupils or knowing pupils. Technology main choice is to answer at pupils' diversity and the possibility for them to continue to study in high school either in vocational or technological education.

In order to understand it is necessary to look at the technological education and the development need limited by the decline of pupils' number. The vertical organisation of school matters does not separate technology education from its high version and engineer's education.

Engineering Sciences and Experimental Sciences: 2000 –
With government change, development of “hands on” approach of science education in primary school (la main à la pâte), new discourses about scientists and engineers’ need, issue about students numbers at university in this area, tension between industrial and tertiary general inspectors and the proposal of a new curriculum with basic education, the idea then of integrating science and technology became obvious. Simultaneously, technology education was criticised by the minister and policymakers for its orientation towards project process and its poor accomplishment in electronics, mechanics and economics. Technology education then became illegitimate while new special courses were developed and based on information technology and information about careers.

Without particular functions, technology education integrated in scientific school matters and pressurised on the one hand by only one technology teacher for the whole discipline and on the other hand by industrial technology inspectors, became a discipline of knowledge. Nowadays official speeches encourage this fundamental change and define technology education as a smaller version of “engineering education” (Ministry of education, 2008)
The five periods are summarised below in table 1.

Table 1. Curricular organisation of science and technology education in France

Periods	*1942–1962*	*1962–1975*	*1975–1985*	*1985–2000*	*2000–2009*
Main needs	Reconstruction after the Second War World	Need of scientists and technicians	Need of unqualified employment	Need of new technological competencies	Need of scientists and engineers
School Policy	Development of vocational schools	Organisation of school system	Implementation of middle school	Generalisation of technology education	New organisation of school matters
Techniques Age: 11–15	Arts and crafts and home economics	Arts and Crafts and Home Economics Home Technology	Manual and Technical Education	Technology Education	Experimental Sciences Education
Techniques Age: 11–15	Vocational Technology	Vocational Technology			
Techniques Age: 11–15		Scientific Technology			
Sciences Age: 11–15	Applied sciences	Physics and Chemistry	Experimental Sciences education	Experimental Sciences education	
Sciences Age: 11–15	Natural Sciences	Natural Sciences			

Forty Years of Technology Education in France

History of technology education shows the conditions of its existence in the curriculum. Technology as a school matter is legitimate only when its purposes answer to educational policy, i.e. if its function in school system agrees with economical and school stakes. Then the coexistence with science education is possible because their function and content are different. In a subject-centred curriculum it is necessary to differentiate function, content and methodological orientation (Goodson, 1992).

But this is not the case at present. In order to exist, technology education needs to have the same characters as science education subjects and it includes the main key words: investigation approach, experimental method, knowledge and competencies… The area is hard to identify due to numerous confusions.

MAIN CONFUSIONS

Epistemological Confusions

One of the confusions is the experimental methods in technology education. The general opposition is science and technological process, their purposes and their characters. Most researchers distinguish the difference between discover the world and build it, understand the past and design the future, define universal laws and specify particular artefacts, study phenomena and use them or control them… This question is a false issue because the experimental spirit is part of the technical rationality. But the technical rationality is not reduced to experimental process (Lewis, 2006; Roth, 2001; Van Eicjk et Claxton, 2009).

Nevertheless the nature of the hypothesis is a fundamental difference. In science a hypothesis is a proposal built in a theoretical framework which is discussed with the findings of several experiences that bring validity. In the realm of techniques, a hypothesis do not focus on this validity but on the confrontation of a project and its feasibility, on the choice of different solutions in a complex set of constraints, on the list of potential solutions within the domain of possibility. They are the characters of practical science (praxis).

Technology education is a scientific school matter, not simply with the method of experimental science but with the foundations of practical sciences. In this sense, technology is not applied sciences because it is more than applied sciences (de Vries, 2005). But there is in France a strong ideological position with regard to scholars' and engineers' hierarchy and status (Le Châtelier, 1947).

Pedagogical Confusions

The confusions are also in pedagogical discourses. The investigation approach and the inquiry based on science education (UE, 2007) have two discourses: one concerns the epistemological point of view and the other one refers to lessons and organisation of activities. In figure 5, these two discourses exist simultaneously. This is the difference between what pupils do and what they learn. Figure 5 introduces the necessary transition from one to another in the "secondary school" process of teaching-learning (Bautier & Goigoux, 2004).

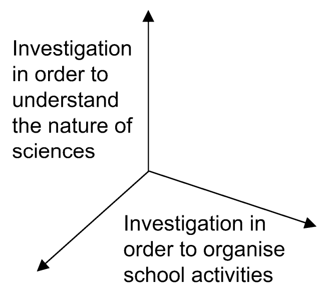

Figure 5. Investigation: epistemological and pedagogical aspects.

The same confusion happens with problem solving. Middelton (2003) showed its specificity in technical and scientific areas. It is possible for teachers and pupils to discuss its function in its pedagogical role or epistemological nature.

AN EXAMPLE FOR THINKING AND DISCUSSING ABOUT THE RELATIONSHIPS BETWEEN SCIENCE AND TECHNOLOGY

For a Theoretical Framework

In the past Black and Harrison (1985) defined a schema in order to identify science and technology. Their proposal was organised across "Task-Action-Capability". Lebeaume (2006) suggested the questioning of each school matter in their relationships concerning their integration or coordination (figure 6)

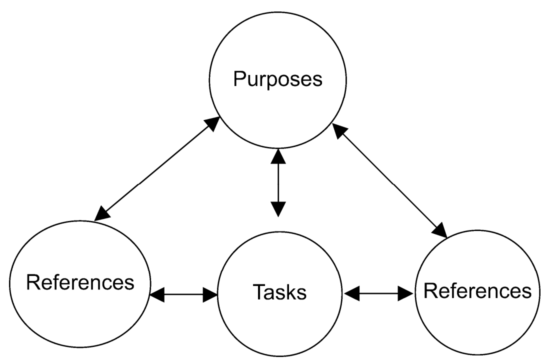

Figure 6. Coordination between school matters.

One example

This example is about Radio Frequency Identification (RFID) technology used in transports, safety, automatics and robotics and in daily life for individual identification with labels under the skin. These current uses are not challenged and are categorised as magic technology. Only a few newspapers argue about public rules needs concerning traceability means putting individuals at risk of surveillance in their private life. Despite of social and societal stakes with this kind of technology, school contents do not take them into account. The claim of the social legitimacy of this subject questions its eventual introduction in curriculum: what, how and when.

From the point of view of how it works, a label RFID is composed of one microprocessor and a brass thread antenna. The reader activates the label with radio waves. The electromagnetic field generates by induction an electric current feeding the chip and then enabling it to communicate or modify its data. Those essential and descriptive elements of this technology may become school contents for an education conceived as a monographic approach of contemporary objects like in general sciences and objects lessons in technology. However such teaching limits itself to a presentation suggesting only a reduced work of thought with all the limits of this informative approach. Other approaches are conceivable as more experimental or inquiring activities which allow to seize the conditions of functioning according to the variation of distance, electromagnetic field and components. Other activities are also possible from the model's conception enabling pupils to highlight constraints for industrial and tertiary implementation of such devices with several labels. It is also possible in another perspective to centre the pupils' activities on discussions and debates stakes on this technology involvements they use but do not know. These activities may highlight the citizen or force the thought to underline the principle of functioning, build a functional model and discover it according to several points of view. The interactions between technological and scientific contents are immediately opened on the approach of the phenomenon of induction and the transfer of information in a comprehensive prospect.

There is still the main question about when as this subject of RFID study can be analysed at once as a detached or serial activity on objects lessons progress according to Delon's distinction (1887). In other words, this question is about the registration in a continuum of this subject and the activities and thus the guiding thread where they will join: it is then about dominance-centred on the functional analysis which enhances the comparison of technical solutions with the identification problem or dominance-centred on electromagnetic spectre or still information technology.

The curricular decisions on these programmatic choices depend fundamentally on envisaged aims and references. They can thus make room for very contrasted educations with privileged ambitions: critical education of the aware citizen about societal repercussions of this technology, discovery of solutions to a technical problem, appropriation of daily life objects and systems, exploration of scientific phenomena with their applications. A composition set is also possible of course but with risks of tension born from hegemonic positions of some and others.

The main obstacle to the appropriation of the contemporary technical environment is technologies incommensurability and information and communication networks that are the most obvious but the least perceptible. How to approach and conceive this imperceptible and immaterial environment? What are the indispensable intellectual elaborations to seize them in their complexity? In this respect notion of information seems inevitably associated with notions of detectors and devices that allow then translations of technical functions and transformations of physical dimensions they operate.

The privileged point of view is the functional analysis that enables at once the study of technical solutions, their comparison and even the determination of new solutions adapted to defined constraints.

The educational and psychological stakes could then be the progressive construction of this technical systems model with the prospect of liberation of spirit. This model represents the intellectual tools of thought. On the contents point of view this proposal may be included in a set that would enhance a more experimental, practical, inventive, scientific, technological and citizenship approach in an integrated or separate education.

DISCUSSION

This presentation shows the difficulty for technology and physics to position themselves due to their mutual competition and status differences in school, social and scientific aspects (Léon, 1980). The main issue is to define and discuss the following:

– What are the purposes of technology education and science education in their school, cultural and cognitive stakes in general education? According to answers of respondents technology education may be closer to:

  - Engineering education with knowledge in mathematics, physics, chemistry, associated eventually with biology or integrated in a project approach. This is a combined solution in order to develop the experimental and technical thinking.
  - Applied sciences with the priority of science education and their applications in different areas;
  - Information about science-technology-society with a better knowledge of the sociological context of science and technology development and their epistemology;
  - Vocational education with high relationships between school and labour or enterprises;
  - Practical education in the rational use of technologies;
  - Entrepreneurship education with the development of specific competencies in order to implement projects, organise collective activities and communicate in a team…

– What are the external references of school activities?
  History has shown that technology education references were either academic subjects or social and technical practices. What are the games pupils play at

school? What are their role - engineers and technicians or scholars and scientists?

– What is the beginning and temporal organisation of science, technology and engineering education? Is it more coherent? This choice depends mainly on teachers' education such as engineers or scientists.
  - Starting with physics and mathematics before developing technology ;
  - mixing these school subjects ;
  - Not distinguishing school matters and developing a global approach.

The main question is about contents in general education. The choice of contents depends on the previous issues but it is important to take into account the current development of technology in order to understand, design, criticise, use, participate and live in the contemporary technical realm.

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ENGINEERING: GOOD FOR TECHNOLOGY EDUCATION?

INTRODUCTION

I have always been suspicious of the agendas that accompany a proposed link between technology and other curriculum areas. When Science and Technology as a subject is offered in primary schools, science is prioritized and consequently technology is not delivered well (Williams, 2001). This is a function of both inadequate primary school facilities and deficient primary teacher training. Science and Technology offerings in secondary schools tend to be quite academic rather than practical (Williams, 1996). Numerous Science, Technology and Mathematics (STM, SMT or TSM) projects that have been developed around the world produce interestingly integrated curriculum ideas and projects, but rarely translate into embedded state or national curriculum approaches. This is partly because the school and curriculum emphasis on Science, Technology and Mathematics is not equivalent across these areas. Even the earliest integrated approaches involving these subjects served the need for reform in Science and Mathematics (LaPorte and Sanders, 1993) rather than the goals of Technology. More latterly Engineering has been brought into the mix with a number of Science, Technology, Engineering and Maths (STEM) projects being developed, most significantly, in terms of numbers and influence, in the UK and USA. Again, the agenda for this type of amalgamation is not being driven by a desire to progress the goals of technology education, but a desire to improve science and mathematics education in order to increase the flow of STEM people into the workforce and to improve STEM literacy in the population (Barlex, 2008). Despite the idea that Mathematics and Science education can be improved by combining with Engineering and Technology is not proven, and the concept of STEM literacy is a bit befuddling and ill defined, nevertheless these are the stated goals of STEM proponents.

Much has been written about the synergistic relationships between Science and Mathematics, and Technology, particularly Science and Technology. A succinct summary of the roles and relationships is provided by Kimbell and Perry (1991):

> Science provides explanations of how the world works, mathematics gives us numbers and procedures through which to explore it, and languages enable us to communicate within it. But uniquely, design & technology empowers us to change the made world.

M.J. de Vries, Positioning Technology Education in the Curriculum, 87–99.

Allied with the STEM approach, is a Technology Education revisionary movement toward Engineering in schools, particularly in the US. Technology educators who promote this approach do so out of the frustration that has come from the absence of general recognition of Technology Education after many years of advocacy, and propose it as an adjustment to the focus of Technology Education (Gattie and Wicklein, 2007). The fact that William Wulf, the President of the National Academy of Engineering wrote the foreword for the Standards for Technological Literacy (International Technology Education Association, 2000) is heralded as a 'significant benediction' (Lewis, 2005) to the shift from technology education to engineering (Rogers, 2006). The rationales are various and dubious, but similar to those presented for the STEM agenda:

- Increase interest, improve competence and demonstrate the usefulness of mathematics and science (Gattie and Wicklein, 2007)
- Improve technological literacy (Rogers, 2005) which promotes economic advancement (Douglas, Iversen, & Kalyandurg, 2004, p. 3).
- Provide a career pathway to an engineering profession (Dearing and Daugherty, 2004; Wicklein, 2006)
- Improve the quality of student learning experiences (Rogers, 2006)
- Preparation for university engineering courses (Project Lead the Way, 2005)
- Elevate technology education to a higher academic and technological level (Wicklein, 2006)

There seems to be little clear discussion about the similarities, differences and relationships between Technology and Engineering as school subjects. STEM is a confused acronym: Engineering has a different type of relationship to Technology than does Science or Mathematics, because it is actually a sub-set of the broad area of technology. The Science equivalent would be to link Science, Biology and Mathematics, for example. While some apologists have developed rationales for the consideration of technology as a discipline (Dugger, 1988), it really is interdisciplinary, and relates to engineering, along with a range of other disciplines in both the sciences and the arts.

Because of my fore stated suspicion of any alliances between Technology and other subjects, my intent at the beginning of this chapter was to search Engineering and Technology curricula and other documentation and determine the differences and make consequent conclusions. However, inevitably the process was not as simple. My initial feeling, and the main focus of this chapter, was that the main areas of deviation between Engineering Education and Design and Technology resided in the nature of the process and the definition of relevant knowledge. The following section will discuss these areas.

PROCESS

Contrasted with an historical focus on engineering knowledge, the nature of the engineering process has received more attention recently (Malpas, 2000). The procedural terminology used is generally the same as that used in Design and Technology – for example formulating a problem, generating alternatives, analysing and evaluating (Eggert, 2005). In Engineering,

> 'whether we are designing a component, product, system or process, we gather and process significant amounts of information... We try to determine desirable levels of performance and establish evaluation criteria with which we can compare the merits of alternative designs. We consider the technical, economic, safety, social or regulatory constraints that may restrict our choices. We use our creative abilities to synthesize alternative designs...' (Eggert, 2005, p 2)

Both the language and the sentiment of this description of engineering design would be familiar to Design and Technology teachers. While there are many descriptions of the engineering process, just as there are of the technology process, the general and superficial judgement is that there are no significant differences.

Together with the promotion of Engineering as a focus for Technology Education, is an analysis of the nature of the engineering process. The depth of this analysis varies from 'engineering design is the same as technological design' (International Technology Education Association, 2000) to 'the engineering design process centres around the four representations of semantic, graphical, analytical and physical' (Ulman, 2003).

In his summary of design in engineering, Lewis (2005) points out that this remains an area of contention, with 'some in the engineering community believing that design lacks the definitive content and rigour [that typifies engineering], while others contend that creativity cannot be taught' (p45); and other tensions within Engineering centre on the questionable value of the hands on learning that accompanies design.

> Lewis quoted Peterson's (1990) qualification that design is not a science and has no rigorous rules for progression. This presents problems for more traditional engineering educators who see the engineering process as predictable and quasi-scientific. On the other hand Cross (2000) perceived that the design process, while variable and evolving, is tending to become formalized. To further indicate the diversity of approaches to engineering design, the Cambridge Engineering Design Centre is developing evolutionary computer based methods to optimize conflicting design criteria in a diverse range of areas such as improving hybrid electric vehicle drive systems, trading off reduction in pollutants and noise in aero-engines and designing cheaper, more compact space satellites (Cambridge Engineering Design Centre, 2009).

> Gattie and Wicklein (2007) conclude that the fundamental difference between the design processes in engineering and technology is the absence of mathematical rigour and analysis in technology that precludes the development of predictive results and consequent repeatability. This reflects Lewis' (2005) earlier discussion that if technology education is to embrace

> engineering, one implication is that more science and mathematics would need to be taught to students, so that they could approach the devising of design solutions from a more analytic frame and so enable predictability about the design outcome prior to its production.

This thinking has led a number of authors to divide design into conceptual design and analytic design, the former being common in Design and Technology education and the latter a part of Engineering. Analytic design may be utilized to ensure functionality and endurance and involves static and dynamic loads, and consequent stresses and deflections. Thermodynamic analyses may be required in order to make yield and fatigue judgements.

Conceptual design is less predictive. Success in Design and Technology is determined by what ‘works’, which is initially defined by a range of criteria, and through a process of research and idea development, a solution is produced and then judgements are made about its success. In Design and Technology, it is not possible to predict what will work with certainty because of the manifold qualitative variables involved. It is a process of experimentation and modelling that leads to a solution. In Engineering, experimentation and modelling lead to the verification of a solution, prior to its development. This is obviously essential, given the nature of engineering projects.

This difference may be illustrated by a model bridge making exercise, commonly done in both Engineering and Design and Technology Education. In Design and Technology, after developing an understanding of the design factors, students will construct a model bridge and then test it to destruction. Then they will analyse the model and the testing process to further develop their understanding, and then possibly construct another model as a result of the new information they have discovered. In Engineering, students will develop an understanding of the design factors, and then analyse all the variables to ensure that the model will conform to the design brief requirements, then construct the model. If the testing of the bridge indicates that it does not meet specifications, then the design has failed.

So in Engineering, the design criteria are more deterministic, implying that a more limited range of outcomes are possible and there is less opportunity for divergent and creative ideas to develop. In Design and Technology, the design criteria are more open permitting a broader range of acceptable outcomes.

Herein lies a key difference between Engineering design and Design and Technology. ‘The most notable difference in the design process is that engineering design uses analysis and optimization for the mathematical prediction of design solutions’ (Kelley, 2008). The use of science and mathematics to develop a body of knowledge that enables the analysis and testing of prototype solutions prior to their production is a feature of Engineering. This does not mean that engineering design is necessarily more ‘informed’ (McCade, 2006), it is just a different type of design that requires more prerequisite knowledge and is less divergent in outcome possibilities.

Petroski (1996) characterizes this difference as the importance of failure considerations: ‘the ability to formulate and carry out the detailed calculations of forces and deflections, concentrations and flows, voltages and currents, that are required to test a proposed design on paper with regard to failure criteria' (p 89). This prediction of failure, while still present in Design and Technology activities, is less pervasive and not as crucial.

A discussion of this difference needs to take place in a context of general or pre/vocational education. Engineering as a school subject that has a pre-engineering or vocational goal, which is the context for most of the cited education discussion, will necessarily employ a design process that is aligned with the nature of engineering design: one that is more analytic and based on a defined body of knowledge. However some authors and curriculum development projects promote engineering design in lower secondary and even primary schools, which at this level should not be vocational but general. A design process at these lower levels of education which prioritizes analytic design and is preceded by the mastery of a body of knowledge and consequently limits creativity and divergent thinking is inappropriate. Projects such as 'Primary Engineer' (2009) are really engaging in Design and Technology and presumably use the engineering label for reasons related to status or recognition.

TECHNOLOGY EDUCATION IN WESTERN AUSTRALIA

Prior to the application of this discussion to a specific context, a brief introduction to the Technology Education curriculum in Western Australia follows. In 2000 a state curriculum framework was introduced in Western Australia, covering eight learning areas, one of which was Technology. The Learning Areas were to be developed and trialled in schools for implementation in 2005. The Technology Learning Area Framework was a radical departure from previous curriculum in the area, which were content specific in a quite detailed way and focused on teacher inputs. The new Framework was outcomes based and specified content in a general way. It brought together a number of previously discrete subjects which had a similar process focus and philosophical basis. The subjects were Home Economics, Design and Technology, Computing, Agriculture and Business Studies.

The K-10 Technology curriculum is defined in terms of outcomes and content. The seven outcomes are:

– TECHNOLOGY PROCESS. Students apply a technology process to create or modify products, processes, systems, services or environments to meet human needs and realise opportunities.
– MATERIALS. Students select and use materials that are appropriate to achieving solutions to technology challenges.
– INFORMATION. Students design, adapt, use and present information that is appropriate to achieving solutions to technology challenges.
– SYSTEMS. Students design, adapt and use systems that are appropriate to achieving solutions to technology challenges
– ENTERPRISE. Students pursue and realise opportunities through the development of innovative strategies designed to meet human needs.

– TECHNOLOGY SKILLS. Students apply organisational, operational and manipulative skills appropriate to using, developing and adapting technologies.
– TECHNOLOGY IN SOCIETY. Students understand how cultural beliefs, values, abilities and ethical positions are interconnected in the development and use of technology and enterprise.

The following Table 1 gives an idea of the relationship between outcomes and content. The content has been developed into a scope and sequence but it is quite broad and open to interpretation.

Table 1. Design and Technology Outcomes and Content

Technology Process
- Investigating
    - Processes
    - Features, properties and use
- Devising
    - Generating and communicating designs
    - Conventions and considerations
- Producing
    - Techniques
    - Considerations
- Evaluating
    - Outputs
    - Methods

Materials
- The nature of materials
    - Form and attributes
    - Context and impact
- The selection and use of materials
    - Investigating
    - Devising
    - Producing
    - Evaluating

Information
- The nature of information
    - Form and attributes
    - Context and impact
- The creation of information
    - Investigating
    - Devising
    - Producing
    - Evaluating

Systems
- The nature of systems
    - Form and attributes
    - Context and impact
- The use and development of systems
    - Investigating
    - Devising
    - Producing
    - Evaluating

Enterprise
- Enterprising attitudes
    - Maximising opportunities
- Enterprising capabilities and skills
    - Generating ideas
    - Communicating and managing
    - Evaluating outputs
    - Evaluating methods

Technology Skills
- Organisational skills
    - Materials
    - Information
    - Systems
- Operational and manipulative skills
    - Materials
    - Information
    - Systems

Technology in Society
- Influencing factors
- Consequences
    - Process – investigating
    - Materials
    - Information
    - Systems

During the 2000–2005 period of progressive implementation of the framework, it became clear that the Framework did not encompass the the last two years of secondary school. In these years students at school either prepared for university entrance, began preparatory vocational studies for later transfer to a tertiary vocational institution, or did school designed and assessed subjects. In 2003 the government implemented a review of the upper secondary curriculum (Curriculum Council, 2001). Among the recommendations of the review were to replace the existing 270 subjects available to students with 50 Courses of Study, each of which would have the same preparatory status for either university entrance or vocational studies. The courses were to be outcomes based and consistent with the previously devised and implemented Learning Area Framework.

This was a particularly positive outcome for the Technology Learning Area, which up until this time could not offer students any upper secondary courses that they could use for university entrance; the focus was on vocational preparation for other post school destinations. Of the 50 courses proposed, those that represent a continuation of Technology studies in the lower secondary years are listed in Table 2.

Table 2. Technology related Year 11–12 Courses

Accounting and Finance
Agriculture (Animal or Plant)
Applied Information Technology
Automotive Engineering and Technology
Aviation
Business Management and Enterprise
Career and Enterprise Pathways
Construction
Design
Engineering Studies
Food Science and Technology
Materials, Design and Technology
Media Production and Analysis

The significance of the change for Technology Education is obvious in the number of technology related study options students now have in their senior schooling, compared with the former situation in which they had none. Students can select from these subjects and use their achievement as the basis for further university or vocational studies. These new Courses are being progressively implemented in schools between 2006–2011.

So Technology is taught as general education to Year 10, and then a range of more specific subjects are available for students in years 11–12, the last 2 years of their secondary education. In this curriculum, the technology process is elaborated according to stages, and the two relevant stages here are early adolescence and late adolescence – lower secondary and upper secondary. The curriculum is different at these two stages, lower secondary being a part of the K-10 general education curriculum, and upper secondary being the type of subjects listed in Table 2, more pre-vocational education. Some elements of the technology process are listed in Table 3 and indicate the difference between these stages.

Table 3. Aspects of the Technology Process

TECHNOLOGY PROCESS *Early Adolescence (Yr 8–10)*	*Late Adolescence (Yr 11–12)*
key design features and properties of technologies can determine functionality and suitability to use	mathematical and scientific analytical methods applicable when examining the functionality and suitability for use of particular technologies
strategies for generating designs and plans that meet specified standards and criteria (eg how to find appropriate standards and criteria)	ways to plan and design solutions to technology challenges that incorporate analysis of detailed factors of production (eg choices of materials, techniques and costs, people needed)
functional, aesthetic, social and environmental issues to be addressed when devising solutions to technology challenges	mathematical and scientific principles appropriate for use in developing plans and proposals
how to meet detailed specifications and standards when developing products, systems, services and environments	how to meet detailed specifications and market/ commercial standards when developing products, systems, services and environments
methods of organising and maintaining a variety of tools, resources and equipment	industry-standard risk management strategies
predetermined, detailed specifications and standards that can be used to evaluate personal work	commercial specifications and standards of quality, presentation and performance for evaluating technology products

In support of the previous literature discussion, it is clear that the process takes on a different focus when students progress beyond general Design and Technology into a more specific technological area such as Engineering: it becomes more analytical, more explicitly related to Mathematics and Science, and more focussed on industry and commercial standards. The different approaches to design taken by Engineering and Design and Technology indicate that Design and Technology is more appropriate as a component of general education.

KNOWLEDGE

My initial hypothesis was that the scope of technology is broader than that of engineering. If it is accepted that engineering is a subset of technology, and there are many technology areas that are not engineering (architecture, industrial design, biotechnology, computing), this would seem to be a plausible hypothesis. So if Design and Technology potentially dealt with the breadth of technology, then Engineering as a subject would be essentially more limited. Given that one of the virtues of technology is that teachers can choose to teach aspects that are of interest to them and relevant to their students and context, it would seem that limiting this scope would be a disadvantage.

However, the scope of engineering in some contexts is presented as being very broad. In his book on Engineering Design, Eggert (2005, p16) refers to the following roles of engineers in the product realization process: sales engineer, applications engineer, field service engineer, industrial engineer, design engineer, materials engineer, industrial engineer, manufacturing engineer, quality control engineer and project engineer. In an educational context, the New South Wales Engineering Studies Syllabus (Board of Studies, 2009) lists the following areas of engineering as those from which study modules will be developed: aerospace, aeronautical, agricultural, automotive, bio, chemical, civil/structural, electrical/electronic, environmental, marine, manufacturing, materials, mechanical, mechatronic, mining, nuclear and telecommunications. My hypothesis that the definition of the knowledge that accompanies Engineering and Design and Technology will be different, with the former both more limited and more defined than the latter, would not seem to be as plausible as I thought. Although, while this list of areas of engineering is broad, a defined body of knowledge exists for each area, which in education becomes a discrete curriculum unit.

Engineering knowledge is proposed by some to be taught prior to the application of that knowledge, because it can be defined, and then it can inform the design process. ‘The idea is that design is informed, as opposed to being the result of a guess or multiple guesses’ (McCade, 2006). For example, the New York State Centre for Advanced Technology Education propose the development of prerequisite skills and knowledge before the design process is utilized (McCade, 2006). Petroski (1998) however holds that design should be taught to students early in their engineering education which will enable them to achieve significant procedural understanding.

A similar debate exists amongst technology educators. There are those who propose that a range of manipulative skills and materials understandings should be mastered by students before they proceed to engaging in design, so that their design work can be informed, reasonable and possible. The alternative proposition is that in this approach design thinking would be constrained by the skill and material understandings that students possess, which would consequently limit creativity and innovation, so the skills involved in learning how to design should be taught and practiced at the same time as manipulative skills and materials understandings. A pedagogical argument is invoked in support of this latter approach which states that skills and knowledge are more effectively learnt if they are taught at the time of need, in this case need generated through solving problems, because this allows for immediate application in response to students felt need.

This latter approach, of concurrent experiences in the development of procedural and content knowledge, highlights the question of what knowledge is relevant in the study of Engineering and Design and Technology. If a particular context area of engineering is being taught, such as civil or automotive, then there is a defined and acceptable body of knowledge related to that area which forms the parameters for the development of design projects. However, this is not the case with technology, there is no defined body of knowledge, so the question arises, what knowledge is relevant?

The answer to this question defines a difference between Engineering and Design and Technology. In Design and Technology, the relevance of technological knowledge to a problem or design brief is defined by the nature of the problem. The information that is needed to progress the solution of a technological problem becomes the body of relevant knowledge, which of course cannot be defined prior to the analysis of the problem. This therefore also specifies the accompanying pedagogy in that content cannot be taught in the absence of a design problem. The design problem is analysed, possible pathways to a solution are projected, then the pursuit of the solution determines the knowledge that is relevant.

In Engineering Studies, the context, which defines the relevant body of knowledge, is predetermined, be it chemical, marine, automotive, etc. Because the context determines relevant knowledge, it is not dependent on the nature of the design problem, and so the task for the student is different in engineering and technology.

In the light of this discussion it is useful to examine some Engineering curriculum. In a number of Australian states, students study Design and Technology to year 10, and then have the option of progressing to study Engineering in Year 11–12, the last 2 years of their secondary schooling. A brief description of the nature of these Engineering studies follows.

In the course Engineering Studies in Western Australia, "students will explore how the design of structures, machines, products and systems have become increasingly sophisticated over time to improve our quality of life. They will develop an insight into how engineering has influenced all aspects of our lives by impacting on cultures, societies and environments. The course provides challenging, practical ways and opportunities for students with different interests to design and make things by applying engineering principles to solve problems and meet particular needs or market opportunities" (Curriculum Council, 2008, 1).

The course was originally conceived as being design focussed, broadly covering a range of engineering related areas of study in a practical way. However, during its development, some more conservative university engineer educators became involved and the course has evolved into a quite limited approach to engineering. Despite the statement that the 'course content is sufficiently diverse to provide students with the necessary foundation to meet employment needs in a range of occupations not limited to the engineering industry' (Curriculum Council, 2008, p3), there is a core and three specialist fields which provide options for study:

CORE:	Engineering design and process
	Enterprise, environment and community
SPECIALIZATION:	Mechanical engineering, or
	Electronic/electrical engineering, or
	Systems and control.

So while there are some general aspects, the focus is quite vocational.

In New South Wales, the subject Engineering Studies ‘develops knowledge and understanding of the profession of engineering’ (Board of Studies, 2009, p6) but with quite a broad focus, the rationale being that:

> No longer do engineers only formulate problems, provide solutions and integrate technical understanding. Key responsibilities for the profession now include responsible wealth creation, taking full responsibility of ethical considerations and the aim of sustainability in meeting the needs of society. With such key responsibilities, engineers now place increased importance on areas such as communication, synthesis and analysis of information, management skills and teamwork (p6).

The breadth of approach in this course is further illustrated by the modules from which it is constructed – these are in the areas of household appliances, landscape products, braking systems, bio-engineering, civil structures, personal and public transport, lifting devices, aeronautical engineering and telecommunications engineering. The study of all these modules is compulsory for each student.

In the state of Queensland, the title of the subject which is available to final year secondary students, Engineering Technology (Queensland Studies Authority, 2004), muddies the waters of this discussion further. It does not mention preparation for the engineering profession, but that this subject should benefit all students by developing their technological literacy through the provision of real-life problem-solving activities in a wide range of student interest areas. Students have to study at least four of the following areas: energy technology, environmental technology, manufacturing technology, communication technology, construction technology and transportation technology.

So in general, it seems that while the rationale for studying Engineering in the final years of secondary schooling has a pre-vocational focus, it also has a more general focus that may apply to students more interested in broad technical areas rather than specific preparation for studying Engineering at university. Universities that specify school Engineering as a pre-requisite for entering Engineering courses tend to emphasize the vocational aspect of the school subject.

CONCLUSION

The conclusion of this discussion is that the process and the knowledge related to Design and Technology and Engineering Studies are different and that Design and Technology is more appropriately a component of general education, and

Engineering studies are more vocational. The implication in terms of the school curriculum is that Design and Technology is a component of primary and lower secondary, and Engineering is part of the upper secondary schooling. This position is outlined in Table 4 below.

Table 4. K-10 and 11–12 Curriculum

Schooling	K-10	11–12
Subject	Design and Technology	Engineering
Focus	General	Vocational
Process	Designerly	Analytic, Math/Sc dependent
Knowledge	Defined by the problem	Defined by the context

The process of engineering design involves problem factor analysis which is dependent on an understanding of applicable science and mathematics. This is not a significant aspect of the type of design carried out in Design and Technology. It provides less scope for the achievement of the general goals related to creativity and lateral thinking because it is more constrained.

The knowledge needed to solve a Design and Technology problem is ill defined until the nature of the problem is fully explored and the design process is underway. The knowledge needed to solve an Engineering problem is pre-defined by the type of engineering that is being studied, so there is less scope for the student to explore and consequently define relevant knowledge.

Design and Technology is a more appropriate curricula vehicle for the achievement of general technological skills than is Engineering, but a system of education where Engineering studies at upper secondary follows a general based of Design and Technology would be a logical progression, and 'good' for Technology Education.

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FORMAL AND INFORMAL TECHNOLOGY EDUCATION

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DEVELOPING TEACHING IN TECHNOLOGY – FROM ISOLATION TO COOPERATION

INTRODUCTION

Teaching profession is not particularly popular among the young people of today in Sweden and becoming a teacher in science or technology has got almost no attraction whatsoever. At the same time, the society is increasingly dependent on technological know-how. How can we make young people more interested in science and technology studies? How can we make the teaching career more tempting in the eyes of the young? What is the role of technology as a school subject and what is the role of the teachers in promoting interest in technology? It seems that technology as a school subject is still struggling to find its identity and place in the school curriculum. The struggle has got its historical reasons as Hallström explains in this anthology, but also there are factors in the present threatening technology.

A national survey among teachers initiated by the Association of Swedish Engineering Industries in 2005 reports of the alarming state of technology education in Sweden: Technology as a subject matter is perceived as marginal in comparison with other subject matters. The study shows that the compulsory school in Sweden fails in its mission to sufficiently educate pupils in the subject area of technology. The requirements of the curriculum are not fulfilled and teachers express insecurity when it comes to teaching technology. 40% of the teachers state that they lack knowledge about the aims and goals of the technology syllabus. Nearly 30% reject the technology teaching conducted at their own school. On the other hand, a vast majority of the teachers are concerned to improve their teaching in technology. As much as 90% of the teachers would like to have in-service training in technology (subject knowledge) and technology teaching (pedagogical aspects on technology teaching). (Eriksson, 2005).

A Technology Delegation (Teknikdelegationen) was appointed by the Swedish government in July 2008 for promoting interest for university studies in mathematics, science, technology and information and communication technology. The Delegation is to investigate the future demand of scientists and engineers in the Swedish society and come with suggestions for how we can reinforce teachers and teacher education, increase cooperation between school and work life. The delegation is also to promote interest in science and technology education among children and young people through different campaigns. The Delegation aims to bring together on national level different stakeholders for a cooperation that will

M.J. de Vries, Positioning Technology Education in the Curriculum, 103–117.

lead to an increased interest towards mathematics, science, technology and information and communication technology.

The National Agency for Education in Sweden has initiated a general revision of the course syllabi including the syllabus for technology. According to the guidelines from the Ministry of Education, the syllabi should be formulated clearly and the goals should be subject specific. For grades 1–3, 4–6 and 7–9 should central contents for technology be specified. (Email communication with the National Agency for Education, 2009-06-09).

As the Technology Delegation is trying to find ways to increase interest in technology and the National Agency is engaging schools in the syllabi revision on the national level, the situation of technology education and technology teachers becomes important to discuss. This chapter presents a perspective to the situation on a local level and examines how the teacher education in Stockholm is addressing these challenges by seeking novel ways of working and building alliances between research institutions and municipalities; between teacher educators and practitioners in order to strengthen the position of technology in the compulsory school.

PROJECT DESIGN AND DATA COLLECTION

The data for this study has been collected during the development and research project Exemplary Tasks in Technology (ETT) which was initiated in 2007 by the research group at the Department of Education in Arts and Professions, Stockholm University, with the goal of producing exemplary tasks in technology together with technology teachers to be used in schools as a way of supporting and improving technology teaching. The project has engaged a number of teachers in technology in developing and carrying out tasks in technology. This means that the teachers have been active in designing the task, carrying out the task in their classes and evaluating the work process and revising the task before the following phase in the project. They have come to the evaluation session with their own experiences and shared these in the discussions. They have also been encouraged to write down their reflections and these reflections have been distributed within the project group. The design of the exemplary task was adopted from a British model (Kimbell, 2005) and adapted to the Swedish conditions. The method is similar to the so-called lesson-study (Stiegler & Hierbert, 1999) and later learning-study models (Marton et al., 2004; Gustavsson, 2008) with the exception that teachers in this study have not been observing each others' teaching. Instead of a learning object, the focus lies in an authentic problem that has been jointly defined by the participating teachers and their pupils. The frequency of meetings has also been lower than usually is the case in learning studies. This means that the participation of the teachers has not been as controlled as it is in learning studies. The looseness of the group is a direct consequence of the working conditions of the teachers. They all are engaged in the project because of their personal interest in developing technology education and their own teaching. Their engagement is voluntary and usually not subsidised by their school. They come to the sessions after their school hours and do the necessary preparations during their free time. Teachers' limited possibilities for participation in the project activities have made it necessary for us to have a flexible approach and be sensitive to the work situation of the teachers. The project has been carried out totally on their conditions.

Initially, the project engaged four teachers (three female and one male) teaching grades 2 to 6 in two different schools in Stockholm region. The number of teachers has increased over time. There are five active teachers (all female and in different schools), two of which have been in the project from the beginning. Additionally, a number of teachers have participated by carrying out the task/s but they have not been active in the planning/evaluation sessions.

Teachers' formal training in technology consists in most cases of a 7,5 credit course in technology as a part of their pre- or in-service training. Only one of the teachers has got a longer training summing up to two terms of fulltime studies in technology. They are mostly experienced teachers with a couple of exceptions with less than five years of teaching experience.

Data in this study consists of observations from the workshop sessions with the teachers, classroom observations and individual, written reflections of the participating teachers. Five of the active teachers have been interviewed of their views and understandings of technology, technology education in relation to their role as a teacher in technology, and of their experiences of the development project. The semi-structured interviews were conducted individually, and they aimed at eliciting articulations of technology education constructs based on subjective experience of the interviewees.

WHAT IS TECHNOLOGY – A CURRICULUM VIEW

In order to contextualise teachers' understandings of technology and their ways of working with technology, the syllabus for technology in the Swedish compulsory school is presented shortly. Also a couple of studies showing how young people of today perceive technology and technology studies are introduced.

Technology was introduced in the Swedish compulsory school in the early eighties as a part of science education. It was not until 1994 that a specific technology syllabus was launched. In the schedule for the compulsory school, technology is included in the subject group with biology, physics and chemistry. They have received 800 hours totally. This can be compared with mathematics with 900 hours and the group of geography, history, religion and civics with 885 hours totally.

In the syllabus for technology (SKOLFS: 2000:135), the *aim* for the subject is described as

– to increase **understanding** of how conditions of production, society and the physical environment, and thus how our living conditions are changing.
– making everyday technology as far as possible **understandable**
– citizens in a modern society need **basic competence** in technology
– the role of technological development from a **historical perspective**

- some experience in reflecting over and **solving technical problems** in practical terms
- to **analyse** and **evaluate the interaction** between people, technology and the conditions under which we will exist in the future (emphasis by the author)

The syllabus lists five central issues and perspectives specific to technology: Development, What technology does; Construction and operation; Components and systems; and Technology, nature and society. These perspectives are meant to aid teachers in their planning of teaching.

Further, the syllabus defines following *goals to aim for* in technology education: The school should aim to ensure that pupils develop:

- their **insights** into the traditions of knowledge and the development of the culture of technology and how technology in the past and the present influences people, society and nature,
- a **familiarity** in the home and workplaces with commonplace devices and working methods of different kinds, as well as knowledge of the technology which is a part of our surroundings,
- the **ability to reflect** over, assess and evaluate the consequences of different technological choices,
- the **ability to incorporate** their technical knowledge into their own personal views of the world and practical actions,
- an **interest** in technology and their ability and their judgement when handling technical issues. (emphasis by the author)

  The syllabus also describes specific *goals* that should *be fulfilled* by the end of the fifth year and the ninth year in school.

  Pupils should after the 5th grade be able:
- to **describe** in some areas of technology they are familiar with, **important aspects** of the development and **importance of technology** for nature, society and the individual,
- to **use** common devices and technical aids and **describe** their functions,
- with assistance to **plan** and **build** simple constructions. (emphasis by the author)

  Pupils should after the 9th grade be able:
- to **describe important factors** in technological development, both in the past and present, and give some of the possible driving forces behind this,
- to **analyse the advantages and disadvantages** of the impact of technology on nature, society and the living conditions of individuals,
- to **build** a technical construction using their own sketches, drawings or similar support, and describe how the construction is built up and operates,
- to **identify, investigate** and in their own words **explain** some **technical systems** by describing the functions of the components forming it and their relationships. (emphasis by the author)

The technology syllabus emphasises the understandings, insights of technology and technological developments on the one hand and the competences of planning and constructing on the other. It is not, however, specified which areas of technology or which tools, common devices/technical aids should be covered nor which methods should be applied. The aims and goals are openly defined. The syllabus thus leaves a great deal of freedom to the teachers to decide and formulate the contents and methods for their technology lessons.

PUPILS' VIEW - TECHNOLOGY IS IMPORTANT - BUT NOT FOR ME

Several recent studies show a parallel tendency among young people towards science and technology, a tendency of indifference, or disinterest.

ROSE, The Relevance of Science Education, (Schreiner & Sjøberg, 2007), is an international comparative project meant to shed light on affective factors of importance to the learning of science and technology. The survey has been carried out among 15-year olds in 40 countries and it shows that young people in the technologically most developed countries have the lowest interest in science and technology. It seems, mainly in richer countries, that the young generation is more ambivalent towards technology than the adults. Moreover, girls seem to be much more ambivalent than the boys, and the differences are most dramatic in the richest North European countries. School science seems to fail in many respects. Young people like school science less than most other subjects. School science has only to a small degree managed to show them the relevance of science and technology for our way of living. Moreover, it seems that school science has not opened their eyes for occupations and careers, and rather few think that school science will be of value for their future life. Researchers in the ROSE project argue that the findings can be explained through the values, views, and understandings that the young people hold, and the general, individualistic "zeitgeist" in the late-modern societies. The researchers mean that identity construction and interests steer educational choices of the young people in these societies, and that science and technology are not perceived as compatible with the 'late-modern' values of the young.

Another, more recent, survey among the Swedish 9th graders confirms these findings. Ninth graders consider technology as a less important subject at school and they cannot see any real coupling to or benefit for their future studies or work life. Technology is not seen as a subject with a humane dimension. Pupils reason that if they want to work with people, they cannot choose technology. Another interesting finding in this study is that the ninth graders see the competence of the teacher as crucial for increasing pupils' interest in technology (See Table 1). Answers to the question: "What makes technology more interesting for you?" show clearly that pupils want "a teacher who can explain technology, make it more connected to everyday life, and that they want to work "hands-on". (Teknikdelegationen, 2009, 11–15).

Table 1. Answers to the question: "What makes technology more interesting for you?"

More practical assignments like laboratory assignments	27 %
Teacher who can explain technology in a better and more interesting manner	25 %
The technology teaching is more connected to the everyday use of technology	16 %

This would suggest that the school subject technology is perceived as not so practical, not so concrete, and not so connected to everyday life of the young people, and that teachers hold a key role in forming the subject and making it interesting for the pupils. This brings us to the question how teachers who teach technology think of the subject and their own teaching? In the following, we will present the results from the interviews conducted with the technology teachers in our study.

UNDERSTANDING TECHNOLOGY – SOME TEACHER PERCEPTIONS OF TECHNOLOGY AS A SCHOOL SUBJECT

The teachers in the ETT project were asked what they thought of technology as a school subject. Their very first reaction was that technology indeed is important, which – considering the context – cannot be regarded as surprising. These were all teachers who found technology important enough to volunteer in the development project. It is, however, interesting to look at their further argumentation for technology as a school subject.

Technology is important because:

> Every child can manage a technology assignment…It [technology] gives the weak students opportunity to be good at something… It boosts their self-confidence. (T3)

> Technology is a practical subject …everyone can work with technology. (T1)

The value of technology is found in its "being practical" rather than "theoretical" in character. All of the teachers in the group perceive technology as a practical, hands-on subject, a making subject providing them with an attractive tool they can use in the class room in order to "*meet the needs of every child*". They find technology as a "*perfect*" subject for those who are not "*theoretically capable*", those with neuropsychiatric diagnoses, or those with less interest in school work.

This result is in the line with a Norwegian study (Bungum, 2003) which also found that teachers used technology in order to achieve social rather than academic goals in the class room.

A consequence of such a view can be that technology is transformed into an aid, or a support subject with poorly defined academic goals, or rather, the academic goals defined in the syllabus are set aside in favour of 'social goals' that are understood as more important.

Teachers also give a wider societal purpose to the subject:

> We need to keep up with the technological development… and we need to make children interested in technology from early on. (T1)

> There is so much technology around us and more and more is appearing… It is important to know that one is capable… It is good to be independent, to be able to fix things without asking for help. (T3)

> Technology is everything that people have ever made. That is why it is so important… Most of the professions are about technology…That is why it is a social issue. The competences that you train in technology…creative thinking, problem solving…you need them. (T5)

> Technology is about survival. If we [mankind] want to continue living on this planet…Without technology nothing works. We need to find new strategies, new technologies so that we don't destroy but make things better. (T2)

These utterances would suggest that the teachers give expression to the idea of general 'technological literacy' (Gagel, 1997; Pearson & Young, 2002); that pupils need to learn about technology, to manage technology in order to survive in the technological world, bur also, in order to make it better. Teachers perceive technology as important through its central position in the society.

ROLE AS A TECHNOLOGY TEACHER

When teachers were asked how they understood their role as a technology teacher, three themes became distinct. First of all, they all talk about how important it is to be interested in technology and engage pupils through one's own interest. It is teachers' mission to "*raise interest towards technology*" among pupils. They say that it is not productive to force teachers who are not genuinely interested in technology to teach the subject because they will just do it without true engagement and affect the pupils negatively. Ninth graders in the 2009 study express this in another manner – they underline the importance of teacher competence, being able to arrange for practical/laborative assignments and being able to explain technology interestingly.

Another important role for a technology teacher is to "*show the pupils how things work*", to show pupils how different technical artefacts function, how they are constructed and how they can be mended. One of the teachers described how she asked the pupils to bring their broken toys and how they examined them and 'fixed' them and how pupils came to understand various technical principles and functions.

The third aspect that the teachers emphasise is to "*talk about technology*" to and with the pupils. There is a duality to teachers' understanding of technology education: they see it as a practical subject, and at the same time, they find it important to conduct "technology talk" with their pupils.

All three aspects that the teachers mention can be seen as ways of making technology visible for the pupils, as one of the teachers expressed it:

> It is important to open their [pupils'] eyes to technology around them. They take things for granted. (T3)

In the syllabus for technology the overall aims are described as 'understandings' and 'basic competences', and the goals to aim for are defined as 'insights', 'familiarity' and 'interest'. Teachers thus express their own interpretations of the technology syllabus (Goodlad, 1979) by emphasising familiarity. These interpretations become part of the intentions teachers have concerning technology education.

Their ways of realising the intentions are by “talking technology” and by “doing technology”. It seems that the “talking technology” dominates as it is the “doing technology” which the teachers find problematic.

The way the teachers talk about technology as a school subject shows that they are rarely expressing themselves in terms of professional reflection (Schön, 1987) or in terms of “knowledge-of-practice” (Cochran-Smith & Lytle, 1999). They find it difficult to reason about the goals of their teaching in technology content wise, which would suggest a lack of technological content knowledge and pedagogical content knowledge (Shulman 2004). This is something that for example Blomdahl (2007) and Andersson (1988) also note. Lack of professional language is a hinder for meaningful reflection.

When teachers express their interpretations of the goals of technology education, the intentions that the teachers have about their teaching, we can see that their intentions are in line with the goals in the syllabus and yet, teachers are uncertain about their teaching: they do not know if they are doing the right thing and they are also pressed by the other demands placed upon them by the school leadership, the parents, and pupils.

There is a contradiction in the way teachers talk about technology and technology teaching. Technology is described as a school subject that every pupil can manage, implicitly, that technology is easy, uncomplicated enough for everyone to manage. At the same, teachers complain about the inferior or invisible status of technology among school subjects. It is not a real subject, a core subject.

It can be asked whether teachers, unconsciously, simplify technology into something that can be ‘pottered about’ with instead of making it into ‘solid science’. Superficiality in the technology projects is most likely connected with the lack of competence, too. Teachers are doing as well as they can under the circumstances.

WHY DO TEACHERS STRUGGLE WITH TECHNOLOGY?

The 2005 survey among the teachers shows that teachers are uncertain about technology as a school subject. It is not easy for teachers to describe what the school subject consists of. One of the interviewees told about her understanding of technology like this:

> I know for myself what technology is… to me it is all that man has made, so technology is so much, it is difficult to grasp and at school it is not clear what technology should be…In Swedish and mathematics everybody knows what pupils need to know and what skills they have to develop in order to be able to continue [their studies], but in technology it is not at all clear…there is no tradition, no materials…(T4)

The interviewee is pointing out a central issue. Technology is a subject without tradition and without a given place in the curriculum. Teachers’ dilemma with the subject technology can be summarised as WHAT, HOW; WHEN? Teachers' first dilemma is WHAT to teach in technology. Their uncertainty bears traces from the long debate in Sweden where diverse interests from stakeholders steer the interpretation of the content and purpose of technology education. Some say that technology should be part of science and thus have a clear theoretical direction. Others see technology as part of the sloyd-tradition with a coupling to manual handicrafts tradition and a third group perceives technology as practical, vocational knowledge in technology (Elgström & Riis 1990). Mattsson (2005) also argues that technology education needs to clear the goals as her study shows that student teachers, teachers and pupils have vague understandings of the contents in the subject. As one of the interviewed teachers expressed it:

> They [technology teachers] make the pupils build a boat and that's it. They feel that they have done the technology part… (T5)

It does indeed say in the syllabus "…to plan and build simple constructions…", but this is only one of the goals. Bungum (2006, 34), on the other hand, sees the lack of a shared culture of experiences, beliefs and expectations of the meaning of technology education as a possibility to openness for innovative approaches, but under the organisational constraints and due to the limitations of competences, it would seem that it is hard to make use of this openness.

The second dilemma for the teachers is HOW to teach technology. The majority of them have limited experience of relevant technological concepts and processes, as their training in technology education consists usually of no more than a 7,5 credit course in technology. These teachers, however, have a good knowledge of their pupils and the general pedagogical practices, which does not really help them when it comes to technology. They do not know if they are doing it "right".

From the descriptions of the teachers can be suggested that they apply two ways of teaching technology: "talking technology" and "doing technology". All of them point out how important it is to talk about technology.

> I talk a lot…all the time about technology. (T1)

They mean that in this way they can show technology, make it visible to the pupils, they can make pupils aware of technology that surrounds them. "Talking technology" is also a way to make the integration of technology into other school subjects.

Teachers also seem to feel that the schedule has its constraints making it difficult to give space for technology. One of the teachers exclaimed:

> National exams steel ALL our time! (T4).

Another one murmurs that:

> This spring we need to work on mathematics more [so there is no time for extra projects]. (T3)

It is hard to find time for technology as the core subjects are occupying the schedule. It seems that it is also easier to overlook technology when no one is asking for any results. On the other hand, the teachers seem to suffer from constant bad conscience about not having "enough technology".

At the same time, several of them talk about how important it is to integrate technology into other subjects. The teachers describe how they try to make technology visible in all the subjects how they talk technology as often as they can. Teachers are contradictory here. On the one hand, teachers say that they talk about technology a lot, and on the other, they complain that they do not have time for technology. One explanation could be the dual perception of technology teaching that the teachers have: talking technology and doing technology. They experience that they do the talking but do not have time to 'doing' i.e. to carry out experiments or projects. Sometimes teachers give the impression that they are unaware of "having technology". It may also be that the intentions and realities of teaching are intertwined in the teachers' talk about their work.

In the literature, the advocates of the integrative approach have been many over the years (for example, Hershbach, 1996; Gagel, 1997; Erekson & Shumway 2006), and, yet, the organisation of teaching in the schools still tends to hold distinctive barriers between the different subject matters.

Barnes (1992) showed the importance of frame factors for teachers' work. Blomdahl (2007) describes in her study, the working situation of two Swedish technology teachers. Strict borders between the different subjects, the fragmented timetable, the organisation of classroom space, and scarce equipment and materials, all influence the teaching. This is also the reality of the teachers in the ETT project.

The interviewees talk about their isolation and loneliness in the school when it comes to technology. It is hard to find alliances – sometimes impossible as one of the teachers describe:

> I have colleagues who teach in technology but we have no contact or exchange. I have tried without success. We have distinct boundaries …It is unfortunate. (T4)

Others have managed to create a culture of cooperation and interdisciplinary approach:

> We have a team of teachers. We have been working together for ten years now. We have Swedish, social sciences and technology integrated and we do the planning and evaluation together. It works really well. And it gives so much more for the pupils. (T2)

The relation between the national intentions of technology teaching and the technology teachers could be described in a following manner. The nationally established curriculum and syllabus for technology are interpreted by each teacher in a certain way. The interpretation is done on the basis of the personal understandings of the subject matter and the personal understanding of one's role as a technology teacher. The interpretation is also effected by the school context and societal context. The interpretation of the curriculum/syllabus is then transformed into intentions. It is the intentions that the teachers have formulated and given words to during the interviews. The intentions are then transformed by the teachers into realisations of teaching. How the realisation is carried out depends on several factors: school culture, school organisation, school leadership, colleagues, parents, and pupils. The actual teaching, the actual classroom events which are taking place are dependent on many factors, which makes teaching a delicate enterprise.

HOW CAN A DEVELOPMENT PROJECT BE OF HELP?

The research and development project "Exemplary Tasks in Technology" (ETT) has been carried out in following phases:

Table 2. Project Phases

Phase	*Activities*	*Participants*
Phase 1	Recruiting teachers	Researchers
	Planning the pilot task with a teacher manual and pupils' work book	Researchers and teachers
Phase 2	Running the pilot task	Teachers
	Evaluating the pilot task	Researchers and teachers
	Revising the teacher manual and pupils' work book	Researchers and teachers
Phase 3	Preparation for the 2nd task	Researchers and teachers
	Running the 2nd task	Teachers
Phase 4	Evaluating the 2nd task	Researchers and teachers
	Running a technology task of own choice according to the project model	Teachers

All the participating teachers are extremely positive to the project. Teachers find the working model very helpful. They feel that they receive a technology task 'for free' as they are introduced to a model of working with a firm structure for both the teacher and the pupils in the form of a teachers' manual and pupils work book[1]. As the teachers seem to constantly worry about not having enough technology and are quite uncertain about what the content should be, they welcome all initiatives that support them and help them to carry out their work. The project seems to answer the WHAT-HOW-WHEN-questions of the teachers. The following table 3 summarises the effects of the project as the participating teachers perceive them:

Table 3. Effects of the ETT project

Effects for teachers				
Concrete example of content and pedagogy	Planning/evalua tion sessions	Network Of teachers	School visits by the researchers	Project presentations to colleagues
Provides a model for work, helps define technology	Reflection on technology education with peers	Support, inspiration, ideas	Visibility, recognition	Visibility, recognition

Not just that the teachers feel that they get a technology task "*for free*" but also they have discovered that the model can be applied for other themes in technology and even in other school subjects.

They think that it has been good with the project, because it has made them to have technology.

They find the structured way of work appealing as they can feel themselves "professional" in their work. The structure gives them authority in the class room. They can say that in this project we work in this way and they are not questioned as the instructions come form "someplace else". The model also gives a clear direction for the work. It requires a careful planning which does not seem to be usual. Teachers in the Swedish school mean that their planning time is consumed by other activities such as communication with pupils, parents, colleagues, disciplinary issues, special education issues etc. which leaves them very limited resources for preparing the lessons and working on their teaching. This is why they are happy to receive a well-defined project with a theme, timetable, and materials, a kind of technology kit that they can just apply without too much extra work. Interestingly, the time that they spent planning and evaluating the technology task together with other teachers did not seem to be a burden. The work was experienced as rewarding and stimulating.

They like planning and evaluation sessions that give them opportunity to reflect upon the task in relation to the goals in the syllabus/curriculum, the working process, the pupil achievements, the institutional context, in sum, they are confronted with their own professional frames (Barnes 1992) and also the frames of their peers in a way that makes it possible for teachers to start revising their personal understandings and constructs of technology and technology education.

The project participants also constitute a collegial network which provides support, inspiration and new ideas even beyond the project frame. They appreciate the freedom of not being forced to attend each and every time unlike in-service courses which require regular attendance. Participants feel that the project has not been an extra burden in their busy schedules.

Technology teachers often complain of the invisibility and marginality of the subject. In order to support teachers, the researchers decided to visit the schools and talk about the project at the staff meetings. In some of the schools, headmasters have invited the participating teachers to talk about their projects to the other teachers. These activities have led to unexpected dissemination of the working model as the teachers of other subjects find the model appealing and want to try it. The recognition that the teachers receive in this way for their work is, naturally, positive to them as persons and teachers but it is also positive for the subject technology which receives public attention and hopefully inspires cooperation across class rooms and subjects.

CONCLUDING REMARKS

In this chapter, we have presented a research and development project ETT which aims to support teachers who teach technology through a collegial cooperation in constructing and carrying out technology tasks in their class rooms. We have discovered that teachers' understanding of the syllabus for technology is ambivalent. They underline the importance of technology but at the same time they find it hard to give technology the place they would like to due to the organisational circumstances and also because of their lack the competences required for making technology education stimulating and challenging for the pupils and developing the insights and competences defined in the syllabus. They are uncertain of their interpretation of the syllabus. As a common understanding of the nature and contents of technology is missing, an individual teacher finds it difficult to make the definitions for herself. The uncertainty about the role of technology reflects on how teachers operationalise the curriculum in their own teaching. The project has shown, however, that for sustainable technology education, cooperation is essential, cooperation across classroom boundaries, across subject boundaries and across school boundaries. Unfortunately, we are not there yet. Technology as a school subject still seeks for its form and contents and place in the school curriculum. This is the case not only in Sweden but in many other countries in the world as is shown in this anthology.

A lot of hopes has been attached to the national revision of technology syllabus this being a unique opportunity to bring about clarifications and a clearer statement on the position of technology as a school subject, a definition and guidelines that will give concrete support to teachers in their teaching effort to make the technology education interesting and challenging enough for each and every pupil. However, it seems that once again the subject technology will continue to struggle of space and time in the curriculum with the natural sciences.

The work of the Technology Delegation (Teknikdelegationen) has resulted in a report (SOU 2010:28) where they urge the government to establish a national strategy for competence in mathematics, natural sciences, technology and ICT in order to raise interest and strengthen competences within these subject areas. The Delegation suggests a Platform Technology and Natural Sciences as an operative body for coordination, funding, communication, and analysis. It remains, however, to be seen in what ways the Swedish government will take action in the lines suggested by the Technology Delegation. It is quite obvious that the various stakeholders in the industry urge for drastic measures as there is a huge need for competence in the near future due to the numerous retirements.

ETT-project has shown the importance of cooperation, cooperation between teachers teaching technology, and between teachers teaching different subjects. The integration of technology into other subjects strengthens it giving technology more space in the curriculum, and also makes the subject visible giving examples of its functions in the world. The project has also shown that when the teachers work on the definition of the technology tasks with their colleagues and also with their pupils, the relevance of the tasks increase as they become authentic in the eyes of the pupils which increases the meaningfulness of technology as a school subject.

The work with the new curriculum (Lgr11) has not been completed yet. For example, grading criteria still needs to be developed. This can be quite critical to the development of the subject technology as the grading criteria can have a negative effect and be steering of both the contents and the ways of working with technology. During the ETT-project it has become apparent that teachers wish more support in their work with assessment. This also shows the importance of formulating the grading criteria in a manner that supports teachers and gives them the space to work with technology in ways that inspire pupils and make them eager to learn more about the subject.

NOTES

[1] The first exemplary task has been described in more detail in Männikkö-Barbutiu & Skogh 2008.

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TECHNOLOGICAL LITERACY IN YOUTH ORGANISATIONS

INTRODUCTION

Today's youth organisations try to develop interesting leisure-time-activities combining playing and learning. Recently, we see an important growth in these non-formal learning activities. Professionally busy parents try to find qualitative leisure-time-opportunities for their children. Typical and traditional activities are situated in sports and arts.

The article describes COI@work, a project funded by the science and society program of the Flemish community. The project stands for 'creativity, design and innovation at work'. It is an educational instrument that consists of a number of interventions to 'play and think creatively with technology'. The games can be used in youth organizations and comparable non-formal learning settings, but also at school in project work. The materials are meant for young people aged 11 to 14 years. Girls feel not always addressed by the world of technology and think it is something for boys. By playing COI@work, they can discover that everyone is deeply and permanently involved in 'the designed world' and that every individual has useful talents to engage in this world one way or another.

This chapter describes design-possibilities for interventions using strategies for creative thinking that are intertwined with contexts derived from the designed world as they are experienced in daily life. The chapter describes also the perceived effects of some designed interventions in the COI-project.

THE COI@WORK-PROJECT

In technological design education, the importance of creativity is clearly recognized. "But in view of the consistent reports of positive lip-service tot creativity but negative attitudes towards students who display it" Cropley and Cropley (2010) advocate that there is still a lot of work to be done in education. They indicate also that meta-analyses of Scott et al., (2004) and Huang concluded that training in divergent thinking and encouragement of motivation known to facilitate creativity fostered creativity. So it can be learnt and we want to describe in this chapter that informal learning settings can offer interesting possibilities to do so.

By means of a 'science and society' design research-project 'COI@WORK' (Hantson, Pools and Van de Velde, 2009), we have explored design-possibilities for interventions combining role-play, creativity-games and technology for use in non-formal learning settings. The interventions are specifically designed to address

M.J. de Vries, Positioning Technology Education in the Curriculum, 119–129.

girls' central values. This way, young people discover that they must cooperate, debate and deliberate on technical problems. Creative thinking is also very important in technology. There we can connect in role-play to professions such as being an architect or designer that girls, but also boys, often find interesting.

Various challenging problems in the life of young people serve as motivating starting points for playing the COIatWORK-games. While playing, the participants have to think creative. Step by step they learn strategies for creative thinking. These are often unconsciously applied: 'brainstorming' is an example of this.

In professional life, a lot of strategies for creative thinking are used. They play an important role for innovation so countries can maintain their prosperity. Creative thinking is important for product and service-design and improvement, quality-, production-, safety- and environmental management.

THE FLEMISH CONTEXT OF YOUTH ORGANIZATIONS

Table 1. review of the Flemish youth organizations

the most important youth organizations in Flanders	*number of municipal member organizations*	*the most important youth organizations in Flanders*	*number of municipal member organizations*
Chiro	787	KLJ (Catholic Rural Youth Organizations)	302
EJV (Evangelical Youth Association)	54	KSJ-KSA-VKSJ (Studying Catholic Youth, Catholic Student Action, Catholic Studying Female Youth)	305
FOS (Open Scouting)	55	Landelijk Jeugdwerk (Rural Youth Organizations)	100
JIP (youth information point)	85	Parochiaaljeugdwerk (Parish youth organizations)	23
JNM (Youth League for the study of Nature and Environmental protection)	39	Scouts (Scouting)	398
KAJ (Catholic Workers' Youth)	70	Speelpleinwerking (public playground organizations)	477

Youth Network Flanders[1]: 4 647 registered organisations and 23 468 notified youth workers and youth leaders (sport organizations not included!). In Flanders there is a youth population (8–20 year) of roughly 1,2 million. The target population for COI@work is about 350.000 youngsters (K5–8).

Flemish people have a rich social life. Youth organizations and other organizations for non-formal learning play an important role in that, despite the games- and TV-culture. Today's youth organizations try to develop interesting leisure-time-activities combining playing and learning. This table illustrates the network of youth organizations in Flanders. The COI project is designed for use in these youth clubs and youth organizations. This large amount of youth organizations offers good possibilities for a broad dissemination and implementation

CONCEPTIONS OF CREATIVITY AND TECHNOLOGY

During the development and testing of the COI@work material, we have measured the perception of fifteen 11 year old participants about creativity and technology and their relationships by in-depth interviews. These young people were familiar with youth organisations. We can report that these children have naïve and traditional conceptions about 'creativity'. They think about 'making products', 'practical work', drawing, painting and decorating, making fun (with children), imagination, creating songs and dances. They believe that creativity has to do something with technology, but they cannot express clear what exactly.

> "To be creative is: seeing the same as everyone, but thinking of something else [...]: it is the ability to create new and useful ideas and generate solutions for everyday problems and challenges" (Van Leeuwen, M. en Terhürne, H.,1999).

Several misconceptions on 'creativity' are reported in literature (Byttebier, 2002):
- you are creative or you're not;
- you cannot learn creativity;
- creativity is something for artists;
- creativity is brainstorming.

Creative thinking is a form of thinking. It is the ability to think out of the box, while making new connections in our brains. The creative process consists roughly of 3 major phases (Byttebier, 2002):
- problem field: what opportunities and / or problems occur?
- the divergent phase: finding new ideas;
- the convergent phase:

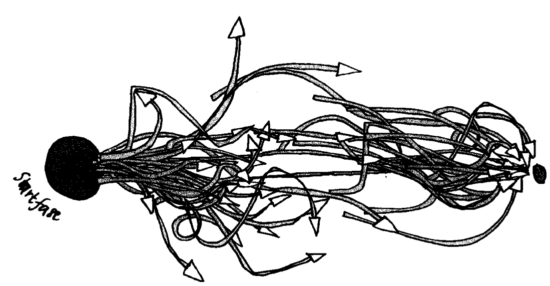
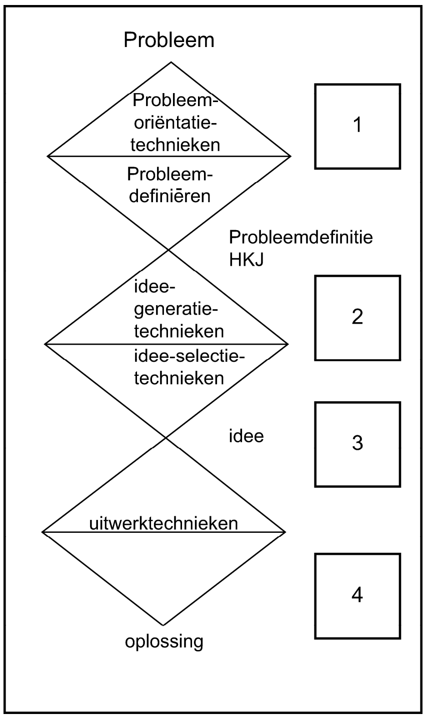


Figure 1. Model of the creative process (Byttebier, 2002).

The creative thinking process can also be represented as series of diverging and converging thinking phases. The divergent phase consists of searching opportunities and information, generating ideas and possible solutions. The convergent phase consists of electing information and decision-making.



To solve problems, we can define 4 groups of creative thinking strategies:

– strategies for problem orientation en
– orientation in the problemfield (1);
– strategies for idea generation (2);
– strategies for idea selection (3);
– strategies to elaborate ideas (4).

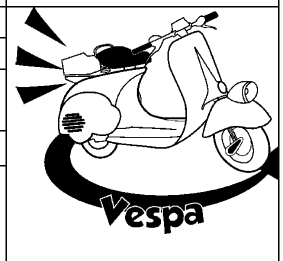
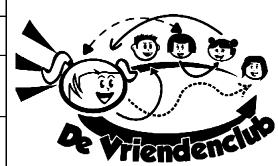
Figure 11. Use of creative thinking strategies to solve problems during the creative process (Buijs and Valkenburg, 2000).

DESIGN-POSSIBILITIES FOR INTERVENTIONS

The COI-project explored design-possibilities for interventions using strategies for creative thinking that are intertwined with contexts derived from the designed world as they are experienced in daily life. Various challenging problems in the life of young people offer interesting contexts in COIatWORK. In order to find good solutions, the players must think creative. Step by step they learn creative thinking strategies derived from professional contexts: strategies for problem orientation, generating ideas, selecting and refining solutions.

Every game is situated in a particular context in the so called 'designed world': transportation, food, communication, leisure, construction and building. The players develop a view on the various ways in which problems are solved in the world of technology. They play around to investigate requirements and effects of technology. They are designing products and a production line. In this way, they discover what people do in technological professions.

Table I1. the COI-products

Kick off			
Making a puzzle presenting 5 crucial steps in a creative process. In order to make the puzzle, several typical youth games are played.			
'VESPA'			
interaction			
technological process	**context in the designed world**	**creative thinking strategy**	
design	transport	problem orientation	
The participants have to design a scooter in team. The design game is derived from the well-known 'memory game'. By adding role-play (in the context of an Italian mafia atmosphere), the motivation for the game rises.			
'The pizza factory'			
interaction			
technological process	context in the designed world	creative thinking strategy	
Designing a production line	food, biochemistry	generation and selection of ideas	
Task: the design of a production line for food, suitable for a camp day with the parents.			
'The club of friends'			
interaction			
technological process	**context in the designed world**	**creative thinking strategy**	
use of technology	leisure, communication	selection of ideas	
Task: select a system for communication that helps to build up a club of friends.			
Club cottage 'new design'			
interaction			
technological process	**context in the designed world**	**creative thinking strategy**	
Inquiry of effects	decoration, building	generation of ideas	
Task: participants should consider 10 recommendations to redesign the local club cottage, discussing safety-matters in a badly maintained club cottage. As a trigger, they analyse two drawings of a club cottage.			
'The pink lounge café'			
interaction			
technological process	Context in the designed world	creative thinking strategy	
research of needs	food, decoration, leisure	problem orientation	
Participants are divided into groups and do interviews to make up a list of demands on the various aspects of the project: interior design, music, drinks, refreshments and entertainment.			

AN OVERVIEW OF THE COI-PRODUCTS

‘ Kick-off Game’

The goal of the game is learning the basics of creative thinking. The players have to collect ten puzzle pieces. The puzzle pieces illustrate typical moments in the creative thinking process. Therefore, they play ten short ‘team-building games’: working together is essential. During the games the children become aware of the different steps in the creative process.

‘VESPA’

The goal of this game is designing a scooter by using problem orientation strategies. Two groups of players representing two competitive Italian families, collect as much money as possible in a first game. In a second game they design an anniversary present for the daughter of the family: a scooter. Each camp has to design a model and the other group can unravel the opponents’ design by discovering typical feathers of their design. Afterwards the original and the reconstructed designs of the scooters are compared and discussed. There is also a reflection on product-design and creative thinking.

‘The Pizza Factory’

The goal of this game is the design of a production line for food useful for youth camps. Each group of players selects a recipe by using an idea-selection strategy (‘hits’): each player gives points to the selected recipes. The recipe with the highest score becomes selected. The selected recipes are brought together for a final selection by using another selection technique, namely: ‘advocate of the devil or the angel ‘. The selected recipe must be produced while making a portfolio illustrating the design of the manufacturing. The participants have to deal with a number of requirements such as production output, food-quality, food-safety.... The participants have to be creative by solving problems in designing this production line. They are encouraged to link their project with industrial food production.

‘The Club of Friends’

The goal of this game is to select a communication system that helps building a club of friends. The simulated company ‘Talk Talk’ wants to develop a new communication system that makes it easier for young people to start a new club of friends. The participants act as they are the experts. The ‘manager’ of ‘Talk Talk’ explains the game. Thereafter, the children apply idea generation and idea selection strategies. They must generate ideas on different sheets of paper for as long as three minutes. Like brain writing, they pass the paper so other participants get inspired. After four rounds, the game leader hangs out the sheets of paper revealing all ideas. Each participant scores the best ideas by using self-adhesive marks. The idea of the group with the most dots will continue in the selection process. Now the spokesperson from each group, with 2 assistants, tries to convince the 'manager' to choose their preferred idea. A jury of participants ultimately motivates the selected choice. Of course, there is a prize for the best idea.

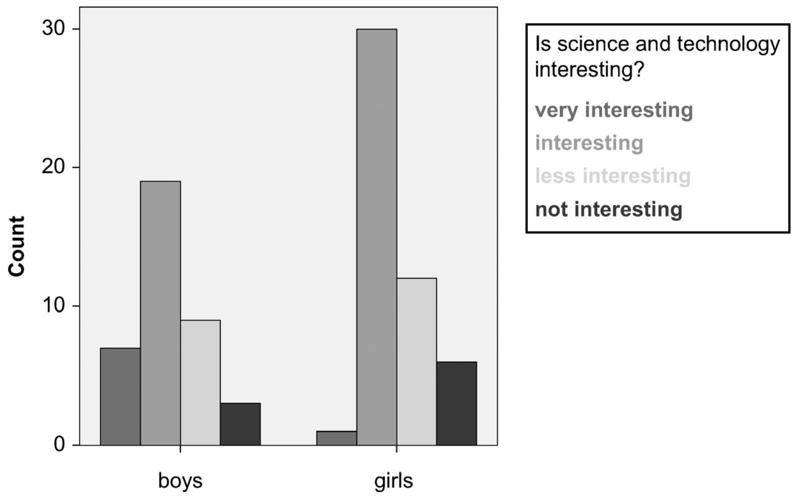
'Club Cottage 'New Design''

Goal of the game: the participants should consider 10 recommendations to redesign the local club cottage. The game works like a memory game. There are four different themes reflecting the needs of the club cottage users. The gamers become aware of the process of need identification. Issues such as safety, environment, ergonomics and decoration will be discussed by means of several games. Two drawings, one of a well-maintained and one of a bad maintained cottage trigger the creative thinking process. During the second session, each group generates and selects ideas. At the end of the session, each group presents the ideas, followed by a discussion.

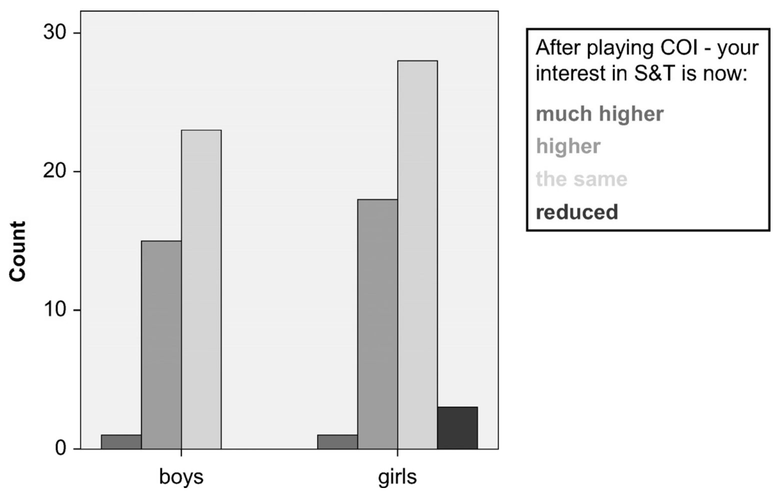
'The Pink Lounge Café'

The goal of this game: the participants should consider 10 recommendations to establish à local café. The group of participants is divided into smaller groups according to the following needs: interior decoration, music, drinks, refreshments and entertainment. The participants organise a survey to investigate the needs of the potential customers. Brainstorm techniques are used to prepare good questions for the survey. This game serves also as an introduction to the contexts food, decoration and entertainment. Problem orientation strategies are used to clarify the needs en this process results in the composition of mood boards and recommendations for a design-brief.

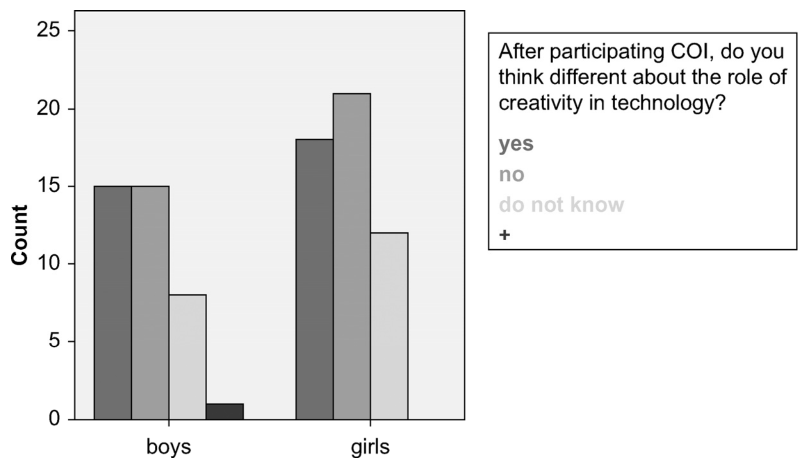
THE COI-SURVEY IN PARTICIPATING SCHOOLS AND YOUTH ORGANIZATIONS



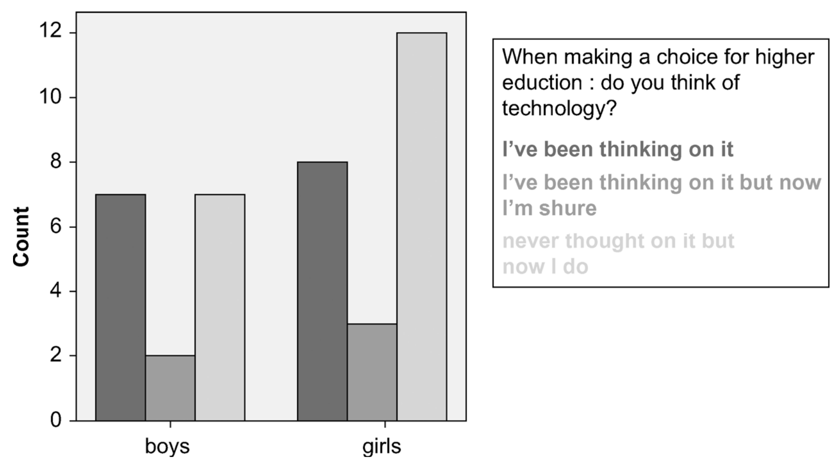
Conclusion: in general, the boys in the test group find S&T more exciting than girls. A large group of girls found S&T interesting.



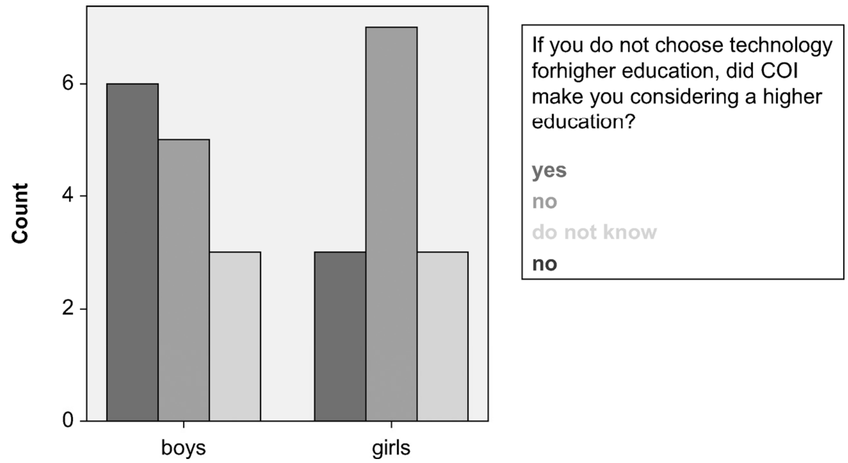
Conclusion: for the majority of the girls and the boys, after playing COI, their interest in S&T grows or remains stable.



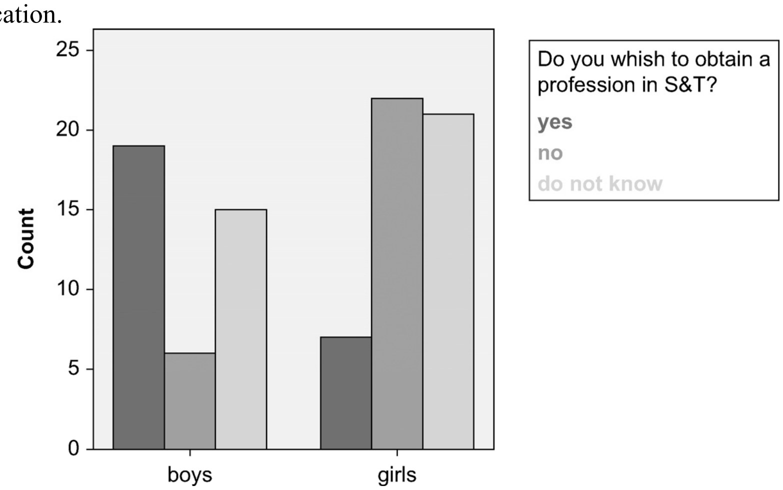
Conclusion: no significant differences between boys and girls.



Conclusion: boys and girls consider more to do a higher education in technology, and the answer is more pronounced for girls!



Conclusion: by COI, especially boys start to think about starting a higher education.



Conclusion: especially the boys are planning for a S&T professional choice. A large number of the participants are still undecided.

CONCLUSIONS

It is possible to intertwine typical games played in youth organizations with creative thinking strategies using contexts of the designed world.

The challenge lies in assuring that educational elements for developing technological literacy do not push away the gaming aspects.

During the project, we could notice a lot of enthusiasm in youth leaders and youngsters.

The survey indicates that there is a substantial effect on the perception of participants when making choices for a higher education. Certainly boys report an influence of COI@work on their views considering a higher education.

The participants' affinity with science and technology remains stable or increases when playing COI@work at school or in youth organizations.

This project illustrates some design possibilities for building on technological literacy and motivation for higher education in youth organizations. These encouraging results suggest further exploration and design based research.

NOTES

[1] Information from the network of youth organizations in Belgium. (2009) Internet: http://www.jeugdwerknet.be

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RESPONSIBLE CITIZENSHIP

MATTI PARIKKA, AKI RASINEN AND ARTO OJALA

TECHNOLOGY EDUCATION

The Ethical Challenge

INTRODUCTION

In everyday thinking and discussion, the concepts of technique (technical methods, as in a craft or in scientific research) and technology are often regarded as synonymous. On closer analysis, one realizes that this is not the truth of the matter. On the contrary, the difference in the concepts introduces the ethical viewpoint. Technique, which generally refers to tools, equipment and machines or know-how about their use or control, is an instrument which, as such, does not does not inherently have good or bad qualities. However, the results depend on where and how it is used (Parikka & Rasinen, 1994). Technique becomes technology when it is applied to a certain task. Thus, only technology can be analyzed and observed from ethical viewpoints, which in turn are related to values. For instance, in a technological system, product or service, value statements indicating both negative and positive effects are included.

Based on the above discussion, it will be challenging for schools to become conscious of and to analyze the ideals, values and ways of thinking and models of acting which are based on the essence of future technology. It will be important to look for viewpoints and methods which can be implemented in everyday school life to motivate pupils for ethical-moral studies. In this chapter, we aim to discuss the basic concepts. However, we challenge researchers, teachers and students to take a stand in their teaching amidst the present ideology of unlimited growth and "faith in technology", which is based mainly on high tech and controlled by market forces. The various ethical viewpoints are not discussed in this chapter. Here the question is rather of 'practical ethics', which hopefully can be implemented in everyday school life.

TECHNOLOGY AS A PROCESS

In a broad sense, technology can be understood as something that is ambiguous and multiply valued. To one person, it may mean everything that is good and worth aiming for, to another something threatening, something that destroys living conditions and therefore should be opposed. Both viewpoints are justified in the light of the present research in the field of developing technology education and in the light of practical experiences. At the same time, they are very prejudiced ways of examining the phenomena. To clarify the situation a wide-ranging and open

M.J. de Vries, Positioning Technology Education in the Curriculum, 133–143.

debate should take place on the values deriving from the omnipotence of technology. In schools, it means a thorough discussion on the positive and negative consequences of a technological lifestyle and changes in learning routines in different subject areas.

In several countries technology education is, at least to some extent, part of general education. In this article we consider the matter from a Finnish point of view. As early as 1994, the national framework curriculum for comprehensive schools (Peruskoulun opetussuunnitelman perusteet, 1994) stated that: “one of the aims is to develop the readiness of pupils to understand and use technology” and “it is particularly important to evaluate the impacts of technology on interaction between nature and human beings, make use of the chances it offers and understand the consequences of the impacts”. Both statements, which are contradictory, include understanding and ethical evaluation of the effects of using technology. It is not possible to analyze or discuss the “good” and “bad” or “usefulness and harmfulness”, as required by the curriculum framework, in a general manner. To be able to perform this type of analysis one has to define accurately the context to be analyzed. In other words the concept of technology has to be defined from a general and educational point of view in such a manner that the phenomenon in hand is as comprehensive and concrete as possible. The most recent National Framework Curriculum (2004) also introduces the ethical viewpoint but leaves the pedagogical solutions to the teacher.

In discussions about the development of local industry one often hears comments that there is no point in developing technology in remote villages. In this context technology is obviously understood only as high technology. The Finnish Innovation Fund (SITRA) has proposed that technological know-how should be divided into two viewpoints, one being high tech, based on knowledge, and the other one skill tech, based on skills. High tech includes information and communication technology (ICT) and automation using integrated electronics. Skill tech includes skilful use of technological devices and machines; i.e., combining skilful activities and technology in an innovative manner. In this context we would like to extend the concept of skill tech to include technology for welfare, experience, free time activities and entertainment. Then it would include, for instance, the food industry based on functional and organic production as well as tourism, fitness, hobby and entertainment services. The division proposed by the SITRA gives hope for the development of areas outside big cities at least in the field of skill tech. Our interpretation of the ideas presented by the Finnish Innovation Fund will be discussed in the following section.

If technology is interpreted broadly, it includes a host of different aspects. It is not a marginal phenomenon, although by studying the Finnish national framework curricula for comprehensive schools as well as for senior secondary schools one may get this view. In countries which have adopted a technological way of life, technology is involved in industry and production. The majority of gross national product (GNP) is produced by practical applications of technology. Nowadays, therefore, all citizens must be able at least to use technology (Parikka, 1997).

From an etymological point of view technology means, for instance, the "logos" of "teknos". This means technique supplemented with "logos", in other words, the information, understanding and rational reasoning underlying the application of the chosen technique (von Wright, 1995). *This possibility of either applying or not applying the technique in a conscious manner offers a basis for the ethical consideration of the technology concept*.

TECHNOLOGY EDUCATION

Technology can be defined in general terms to include all humanity's artefacts and accomplishments. However, when defining development, research, and the related discussion of technology education in comprehensive schools, it should be defined by emphasizing the educational viewpoint. It means that the definition should include emphasis on the technology user's and developer's interest and understanding. Based on this, Parikka and Rasinen (1994) and Rasinen (2000) defined technology as follows: "Technology means understanding the structures and operational principles of technical equipment, machines, and devices, as well as their skilful and controlled use for developing new products and services".

In technology education on one hand machines and equipment (equipment technology) and on the other hand use of tools (manufacturing technology) are studied. Knowledge of the quality of production materials connects these technologies to knowledge of technology. This definition is related to both material and mental aspects. Figure 1 illustrates these aspects in the form of a comprehensive conceptual schema. It divides technological know-how into high tech (based on scientific knowledge) and skill tech (based on everyday experiences). High tech includes information technology, and automation that is based on computer systems. Skill tech is related to technical skills where technical equipment is utilized in an innovative manner. It can be argued that the nature of technology is based on humanity's inventions and production; it is future oriented and innovative, practical, and based on commercial needs. However, it is not usually environmentally friendly and might even have a negative impact on nature.

Until recently the relationship of human beings to different variations of technology has been *reactive.* This has meant adapting to technological innovations. Nowadays people are more critical and do not accept the idea of technology developing in the direction determined by itself. There is a demand for technology which is more human, user friendly and has fewer negative effects on the development of culture, society and nature. We expect a *proactive* approach when developing technology. In technology education, the central educational objective is to impart those technological skills that help students when they make ethical choices related to technical commodities, use technical commodities, and further develop technological solutions (Parikka, 2001). The basis for this is that the designing of technology, technological products, and also their effects are not value-free but in practice they include value choices at different levels - whether we recognize it or not.

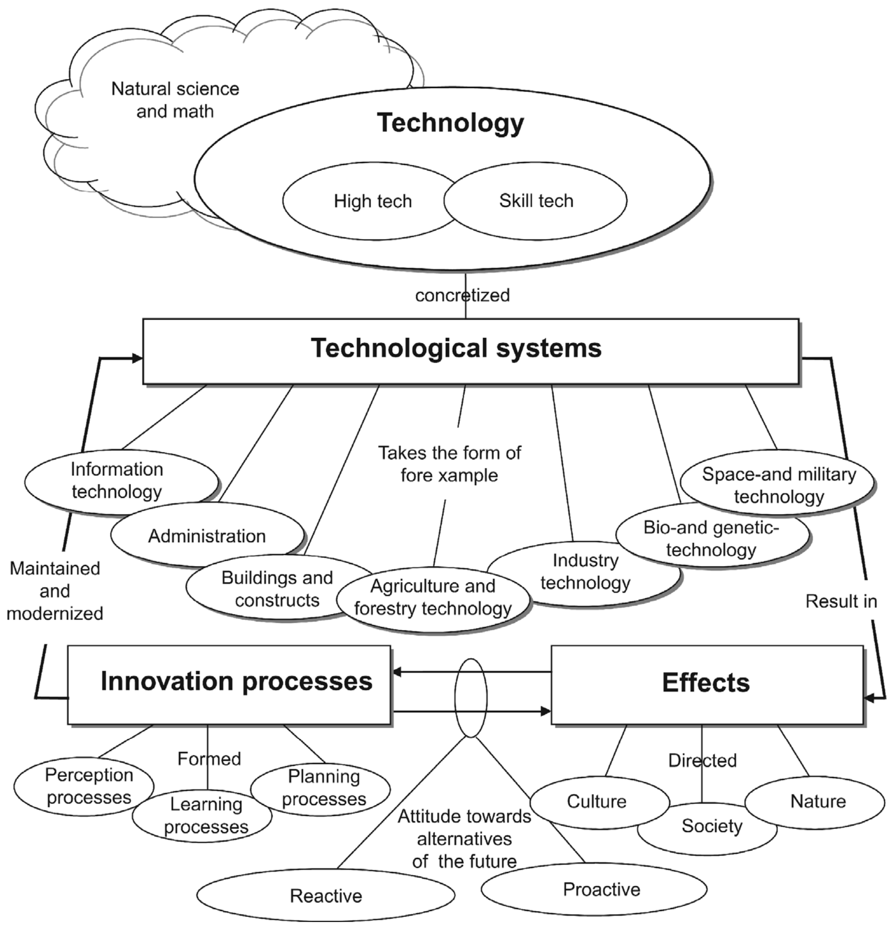

Figure 1. The concept of technology from the pedagogic viewpoint (adapted from Parikka (2001)).

Technology Education Offers Many Possibilities for Ethical Consideration

In traditional craft education the emphasis has often been on planning and producing different concrete products which are derived from our everyday life, and on following the curriculum planned by the teacher. During technology classes understanding of the relation between technology and culture, technology and society, technology and nature and the effects of technology on these should be discussed and understood. This means a conscious, critical and reflective attitude towards technology. Education becomes more meaningful and diverse when an open analysis is conducted about the values and lifestyles - the concept of humanity and the world - that the technological way of life is based on, and where the choices will lead to. This type of consideration should take place during lessons in different subjects. This in turn will challenge the pupils to consider the development trends offered by future technology and to take more responsibility for their own curriculum and work.

In schools technology should be considered from various viewpoints (science - technology - society) (Solomon, 1993). The following points of view, for instance, could be considered (Parikka, 1998):

– Integration of craft and technology introduces aspects of getting along in everyday life, experimentation, discovery and innovation (see more in Rasinen, Virtanen & Miyakawa, 2009).
– Integration of mathematics, science and technology introduces aspects of applying mathematical and scientific know-how to technology, exploration and discovery.
– Integration of entrepreneurship education and technology introduces aspects of commercial manufacture, national economy and material welfare. Without commerce technology will not advance.
– The aspect of environmental education introduces the minimization of the negative effects of technology on nature, the repairing of damage already caused and awareness of an ecological way of life; in other words, the ethical aspect of technology.
– The aspect of design and forming emphasizes creativity and innovativeness and is closely related to the aesthetic aspect of artefacts and human-made constructions.
– The international aspect introduces studies of foreign languages and history as well as the importance of knowing different cultures and their significance; in other words, the humanistic aspect.
– Professional and gender equality introduces the aspect of equal opportunities for choosing one's profession.

Ethical considerations in technology education can challenge school pupils to take a stand, at least at the attitudinal level, on what they, as active citizens, regard as meaningful aspects and what means they have of affecting these aspects. The aim is to understand technology and science as cultural phenomena that have an effect both on our society and bio-physical environment (Kantola, 1997).

The present world of experience and its values guide the interests and the future dreams of our children and youngsters. The ethical consideration of our environment is based on the fundamental values of an individual. Therefore, it is important for the teacher to familiarize her or himself with the preconceptions, intellectual world and values of the pupils.

The values, idols, hopes and dreams of today's children, as well as the environment they are growing in, has more or less completely changed compared to the times of agrarian culture. Since their birth the environment has been technological and dominated by television, computer, the Internet, and social media (Parikka & Ojala, 2008). This era is often called an information and communication era. In the case of many youngsters the situation is such that ICT devices may estrange her or him from nature and reality. In other words, there is a danger of not understanding the difference between fact and fiction. Overuse of the computer for games and the Internet may also prevent the social development of the child.

These facts should be considered when organizing teaching. All human solutions are based on value judgments. For this reason, a discussion on everyday values should take place with pupils from time to time. Sometimes the lame and tame discussion of values may be the fault of the present, hesitant educational culture. For this reason, it is important to become conscious and to clarify the basis for values. For instance, if we want to develop self-directive and intrinsic entrepreneurship among pupils, they should be encouraged to plan and decide about their own studies.

One important aspect of educational basic values is gender equality. This has been emphasized in all Finnish national framework curricula since 1970 (1970, 1985, 1994 and 2004) when Finland moved to a comprehensive school system. It means that girls and boys should acquire readiness already at school to be able to take up different professions in working life. Hopefully technology education has better chances of destroying the myths about women's and men's jobs than, for instance, craft education, which still seems to separate pupils according to their sex (Rasinen, Ikonen & Rissanen, 2008).

THE IMPERATIVES OF TECHNOLOGY

The values we ourselves have adopted from technology are connected to our opinions about the opportunities for affecting the direction in which technology develops. For instance, Niiniluoto (1986) argues that the various opportunities for solving the problem of directing technological development can be divided into two opposing views.

According to *"technological determinism"* the development of technique (technical methods, as in a craft or in scientific research) is determined by *"technical laws"* which are not dependent on the will of human beings. The eterministic viewpoint can be expressed, for instance, by stating that the development of technique (technical methods, as in a craft or in scientific research) gives humankind, via technological inventions, "orders", technological imperatives, which we cannot refuse to obey (Niiniluoto, 1986). It is simply believed that technique is developed through innovations and inventions in a direction determined by itself or by market forces. That direction cannot be predicted. Societies that trust in the potential of technology have to adopt it in as multifaceted a manner as possible to avoid lagging behind development (Manninen, 1993). According to this view the problems caused by technology can best be solved by technology. On the other hand, *"technological voluntarism"* represents a view that the development of technology does not follow any internal laws but that humanity can, according to its consideration, make decisions on the development and use of technology.

The two lines of thought are further divided by Niiniluoto (1986) into two different viewpoints on the basis of how the negative effects of technology can be avoided or minimized, and what type of attitude should be taken to the present state of development of technology. If it is believed (under determinism) that the negative effects can be eliminated only by improving technology and by increasing new technology, it becomes a question of *"technocratic determinism"*, in other words of the power of technique (technical methods, as in a craft or in scientific research) and engineering. The idea of technology being value-free and its development being able to take place without considerations of values and choices is often connected to technocratic determinism. If technology is understood to produce evil things, and correcting the situation necessitates opposing technology, then we are dealing with *"romantic antitechnology"*.

By *"technological voluntarism"* we are generally referring to a choice between the so-called hard or soft direction for technological development. The choice is always based either on conscious or unconscious values. When the values are based on the subjective value choices of the decision maker, it is a matter of *"voluntary decisionism"*. If in turn we believe that we or a certain group of experts are sure of the "correct" values or choices, we are talking about *"value objective voluntarism"* (Niiniluoto, 1986). Many international industrial trusts are examples of bodies that have a positive attitude to hard technology. Their aim is to support development projects that are commercially and economically profitable. The soft model of thinking is represented, for instance, by the green movement and the World Wildlife Fund (WWF). They believe that the direction of development can be controlled by changing values and lifestyle (e.g., Malaska, 1992; Tammilehto, 1982).

In the following figure (Figure 2), the above described viewpoints are presented in graphical form. This aims to outline the choices from amongst future technologies and the means of achieving them.

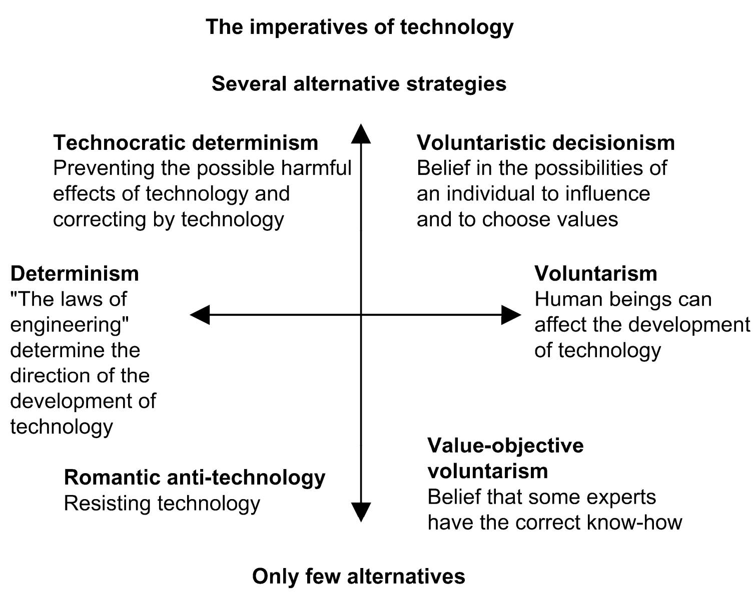

Figure 2. The imperatives of technology.

THE INTERACTION OF TECHNOLOGY, CULTURE AND SOCIETY

When speaking about culture one seldom thinks that technology is connected to it, or what the effect of technological inventions on culture is. After a moment's reflection, however, it is easy to list many technological inventions that have been important for culture. The invention of the printing machine started the era of media culture. Telephone and radio made real-time communication possible. Television and video brought the picture to the media. The microprocessor, and the computer based on this, with its various programs and the world wide web, started the development of the information (computer) society, introduced the concept of virtual reality and made possible the publication of electronic newspapers, magazines and books (see more detail in Parikka (2008)). Important inventions from the point of view of society are the steam engine, the spinning machine, electricity and its use, using the combustion engine as a power source, developing car manufacture to mass production and using the computer (microprocessor) to control automation (robotics).

The effects of technology on culture and society are interconnected and can be understood only through one another. There, is, therefore, no point in trying to study them separately. The above mentioned technological applications are regarded as positive and desirable. This is why, for instance, school textbooks do not question, let alone critically analyze the effects and the ethical considerations of these applications for culture and society. All applications of inventions also have their dark side and negative effects, which should be studied as part of learning tasks and discussions (e.g., Parikka, 1998). For instance, since human beings started using the combustion engine about 100 years ago, known oil resources have diminished to half and the amount of carbon dioxide has significantly increased. As a consequence of this the car industry must concentrate on reducing fuel consumption and developing new power sources, if it wants to maintain its position.

MORE OUT OF LESS

The views and decisions about technology have direct connections, for example, to how the interaction between nature and human beings is understood and how human beings should act to support sustainable development technology or green technology. It seems that environmental awareness, awareness of the value of nature and ecological awareness, in short the idea of a sustainable lifestyle, have become life values for many, at least young, people. However, technological development can be controlled and responsibility taken for it, only if people have a deep understanding of the negative and positive sides of technology. During school environment education lessons the negative effects of technology can be studied, for instance, under the theme of nature protection. If we think about this concept of protecting nature in an analytical manner, we can regard it as misleading. It gives, at least in an implicit way, the image that human beings are not part of nature, but above it and can justifiably control - destroy or protect - it. It is essential to understand that the concept of nature changes into the concept of environment as a result of the activities of human being.

At least the following three considerations have to be thought about in order to change the direction of developing technology towards saving nature: What is the basis of the development of present technology and what is really directing it? Will the excessive and unconsidered use of technology upset the balance of nature and will non-renewable natural resources be enough for the future generations (e.g., Mexpert, 1985)? Can the welfare of a society be based, also in the long run, only on the continuous growth of production and consumption?

The present way of production was not originally planned on the basis of minimizing the consumption of energy or material. Nowadays researchers, innovators, planners and industry are jointly developing such production methods in order to save natural resources as much as possible. When referring to environmental management of companies and ecological effectiveness of production, it is a question of producing better products and services with less energy and fewer materials (Pantzar, 1996).

To measure the consumption of raw materials and energy various measures have been developed, such as life circle analysis, material input per service unit (MIPS) and ecological footprint. With these the aim is to find out the consumption of material against the service or product produced. In life circle analysis the objective is to count the effect of the product on nature during its whole life-span. The MIPS measure is often called the "ecological rucksack". It describes how many kilograms or tons of natural resources are used in all production phases to produce a certain product or service. It is important to note that disposable products or products with a short life-span (like fashion clothes, mobile phones, computers…) increase the weight of the rucksack, while durable, long-lived and recyclable goods make it lighter (see also L. Elshof, this volume). The ecological footprint describes how large an area of Earth is needed in producing products and services including treatment of waste and pollution as well as how big an area of forest is needed to capture the carbon dioxide.

CONSIDERING THE FUTURE

Various conscious visions of the future offer starting points both for pupils and teachers to clarify their thinking and views by doubting and questioning previous self-evident truths. It is important to arouse the awareness of pupils towards technological phenomena, entrepreneurship and industry and their value and meaning; to consider the development of technology and its options in a diverse manner; and to give them opportunities to influence in many ways and in a practical manner.

It is essential in the learning process to understand how a grasp of the essence of technology affects the pupils' thinking about the future, how understanding of its functions develops their self-esteem and how understanding its effects shapes their values and outlook on life and on the world. A revolution for future awareness and future thinking is needed now. There should be a change of direction towards a more consumer oriented, culturally enriching and less environmentally exploitational (nature oriented and human technology) approach.

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TECHNOLOGY EDUCATION: OVERCOMING THE GENERAL MOTORS SYNDROME

> It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, or more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all those who profit by the old order and only lukewarm defenders in all those who would profit by the new order, this luke warmness arising partly from fear of their adversaries, who have the laws in their favour; and partly from the incredulity of mankind, who do not truly believe in anything new until they have had actual experience of it (Machiavelli, 2008, p.22).

The challenge going forward for technology education (TE) consists in part in dealing with a faltering base of support within schools and the wider community. Many technology educators and supporters appear to be incredulous that technology education hasn't garnered wider support in schools. They do so without fundamentally re-evaluating what is being taught in the discipline or how technological product-based thinking has come to dominate its practices. The emerging trends toward re-vocationalizing the subject remain deeply problematic.

The reasons for this faltering support can be attributed to a number of related factors, some of which include; a poor reputation based on the subjects history among parents and members of the wider community; parochialism and a failure of the technology curriculum to reflect values and orientations emerging within the wider community; far too much of a focus on uncritically mimicking industry practices and standards and far too little on how technology education might contribute to community-based economic development, and employment based on social justice and environmental sustainability. Of any oversight or collective lost opportunity, it is the latter which will continue to impact technological education the most. As it exists in its dominant form, technology education is certainly not perceived in the wider community as a valuable partner in educating for sustainability. If technological education is to thrive in the decades ahead it must reorient itself to emerge as an eco-technological leader within the education system.

Analogies to what is happening in technology education can be drawn to what might be termed the 'GM syndrome' of recent upheavals at 'old school' companies like General Motors. General Motors was once the largest and most profitable corporation in the world, despite a massive publically funded bailout it still struggles on the brink of survival after many years of producing sub standard products and suffering from a profound lack of vision. Complacency, insularity and

M.J. de Vries, Positioning Technology Education in the Curriculum, 145–162.

short-term thinking led General Motors into believing its own version of reality to be paramount, as a corporation it arrogantly fought against emerging trends like catalytic convertors, increased standards for fuel efficiency and safety or even acknowledging the emerging reality of global warming. It is deeply ironic that GM's failure to respond to many of these same issues has helped accelerate its near downfall. We might ask what cautionary lessons might we learn in this story to guide technological education? The ongoing trends of globalization and de-industrialization and loss of manufacturing jobs has hit G8 economies particularly hard. Although technology education has never been 'in front of the wave' when it comes to embracing emerging socio-technical trends, it is now poised to miss the green jobs revolution because it remains mired in a 20th century notion of what ends technology education should serve.

Building new constituencies for technology education will require reaching out beyond its traditional base of support to the social justice, environmental and global education communities. TE needs to urgently invite social and community activists and green entrepreneurs into working relationships to build new curricula and connections to the emerging green collar economy. The new revitalized technology education for the 21st century will be green and bioregional in orientation or it will no longer find a broad constituency. This paper will explore a few of the many ways in which a reoriented technology education might support a sustainable economy and a different vision of 'the good life'. More importantly, it will challengeTE to enculture a spirit of 'radical transparency' when it comes to teaching young people about the environment through the design and analysis of technological products and systems.

INTRODUCTION

The last thirty-six months have witnessed a series of dramatic and tumultuous changes around the world; it is worthwhile to briefly reflect on technology's role in some of these events. In 2007 the Intergovernmental Panel on Climate Change (IPCC, 2007) issued its fourth assessment report indicating that human fossil fuel use is changing the earth's climate in a way that is both dangerous and expensive to remedy. Climate change has emerged as the biggest global health threat of the 21st century putting the lives and wellbeing of billions at increased risk, its effects will exacerbate inequities between rich and poor (Costello, Abbas, Allen, Ball, 2009, Intergovernmental Panel on Climate Change (IPCC), 2007). International efforts to achieve a comprehensive climate change treaty crashed in late 2009 with the collapse of the United Nations climate negotiations in Copenhagen. Despite a profound failure of imagination on behalf of politicians to achieve a global treaty to limit carbon emissions, the decarbonization of economic development remains a priority for communities and enlightened companies around the world. Globally greenhouse gas emissions continue to accelerate, 2010 emissions will be the highest in human history (Connor, 2010; Global Carbon Project, 2010). New research indicates that global populations of marine phytoplankton, the foundation of the ocean's food web, and the organisms, which produce half the planet's oxygen, have declined 40% since 1950 due to climate change (Boyce et al., 2010).To underscore the importance of limiting carbon emissions, indications are that 2010 is on track to be the warmest year in recorded human history (National Aeronautics and Space Administration (NASA), 2010).

We were reminded (again) that technological fixes designed to ameliorate the unanticipated impacts of earlier technological creations are themselves not immune from turning into new problems. Hydrofluorocarbons (HFCs) introduced widely in the 1990s to replace ozone-depleting gases found in air conditioners and refrigerators act like 'super' green greenhouse gases, with a heat-trapping power that is 4,470 times that of carbon dioxide. By 2050 scientists estimate that the amount of super greenhouse gases in the atmosphere might be equal to six or more years' worth of global carbon dioxide emissions (Fahrenthold, 2009).

In the summer of 2008 oil prices hit an historic peak at over $140 (U.S.) a barrel, largely a result of market speculation and increasing demand from rapidly developing countries like China and India. Record oil prices enabled ExxonMobil, the largest publicly-traded American corporation, to record profits of $45 billion in net income for 2008, earning the equivalent of nearly $150 for every U.S. resident. Despite being the highest earner of all the oil companies, ExxonMobil invested the least in renewable energy—less than oneper cent compared to its 2008 profits (Weiss &Kougentakis, 2009). Overall the worlds five largest oil companies invested just 4 per cent of their total 2008 profits in renewable and alternative energy ventures.

Fears concerning 'peak oil' have become more tangible as major energy supply reports (International Energy Agency (IEA), 2009) indicated that cheap hydrocarbons are a thing of the past. The ripple-on effects of Wall Street speculation and a corn ethanol boom in North America and the E.U. led to food riots across the planet in 2007 (Food and Water Watch, 2009). The corn ethanol boom was brought about by large direct and indirect subsidies to agri-business, about 30 per cent of the 2008 corn crop was destined for cars. The biofuel demand pushed global commodity prices for corn, soybeans and sorghum much higher, out of the reach of world's poor (Food and Agriculture Organization of the United Nations (FAO), 2008).

Market fundamentalism has finally reached its nadir, at least for the moment, and the global free-fall of capital and equity markets hashaemorrhaged trillions of dollars of wealth from the world's economy and put tens of millions out of work. In October of 2008 when the world financial crisis was starting to unravel in earnest, the chair of the U.S. House Oversight and Government Reform Committee challenged Alan Greenspan the former chairman of the U.S. Federal Reserve with: "You found that your view of the world, your ideology was not right, it was not working?" Greenspan responded with: "Absolutely, precisely… You know, that's precisely the reason I was shocked, because I have been going for 40 years or more with very considerable evidence that it was working exceptionally well"(Irwin & Paley, 2008). Under Greenspan's tenure at the federal reserve banking regulations put in place by U.S. president Roosevelt to lift the country out of the Great Depression, were rolled back or eliminated entirely. In their place so-called 'sub-prime mortgages' as well as new complex and risky mechanisms for manipulating and concentrating ephemeral virtual capital emerged such as derivatives trading and credit default swaps. Information and satellite technology is central to the 'casino economy' enabling trillions of dollars to circulate around the planet in microseconds under the control of automated systems as well as speculators and commodity and hedge fund traders. In fact thetechnologically facilitated instantaneity of enormous capital fluxes have made the global economic system 'brittle' as it responds to human fear and greed with lemming like behaviour. The collapse of neoliberal economic supremacy led Nobel laureate Paul Krugman, to state that much of the past 30 years of macroeconomic theory has been "spectacularly useless at best, and positively harmful at worst"(The Economist, 2009).

The patina of respectability and responsibility has also been ripped away from many of the world's largest banks and insurance companies revealing management practices ridden with rampant greed and corruption (Lewis, 2010; Roubini&Mihm, 2010). It should come as no shock that many young people have disengaged from politics and regard government with both cynicism and mistrust.

It remains to be seen whether we are witnessing the beginning of the end of an era of 'mindless consumerism' without consequences or conscience, an end to the idea that citizens of rich developed countries can continue to emit as much carbon dioxide as their lifestyles demanded, an end to the linear paradigm of technological thinking that has all but ignored the health of communities and local and distant ecosystems and our seeming unalienable "right" to design and use machines and systems regardless of the impacts they have on the planet. What is no longer in doubt is that the future quality of life for billions will depend on how effectively we collectively come to grips with the enormous power our technologies wield.

If we take a moment to reflect on how different the world of our students will in all likelihood be, several general trends are emerging:

– Products will increasingly reflect their true environmental cost.
– The era of cheap fossil fuel energy is drawing to a close, and with it the technologies and systems that have depended upon it to fuel economic growth and rampant consumption.
– Telling the'ecological truth' about products and material and energy consumption will accelerate because as Dahle warned:
– Socialism collapsed because it did not allow the market to tell the economic truth. Capitalism may collapse because it does not allow the market to tell the ecological truth(Brown, 2009, p.243).
– The atmosphere and oceans will no longer be treated as a commons dump for waste products.
– Neoliberal economics will be transformed because it no longer works as a system that describes how the real world actually works. The precepts of 'ecological economics' will continue to spread.
– The world will continue to lose much of its biodiversity. We are currently in the midst of one of the greatest "extinction spasms" in geological history, this 6^{th}

eventbeing different from all predecessors because this one is human induced (Adams &Jeanrenaud, 2008, p.5).

– Fresh water will be the new 'blue gold'. According to the United Nations, more than one billion people on earth already lack access to fresh drinking water, and global consumption of water is doubling approximately every 20 years. Extending current trends to 2025, the demand for freshwater is expected to rise to 56 percent above the amount currently available (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2006).
– New metaphors based on an understanding of living systems, permaculture and long-term sustainability will continue to displace our 'frontier mentality' toward the natural world.
– Teaching young people to recognize and understand webs, patterns and interrelationships of technology, environment and social justice will be critical in creating broad coalitions to solve complex issues and emerging problems.

These trends force us to consider how we might reframe technological education as an integral part of community development and an essential sustainability driver.Some of the main arguments for re-aligning technological education for the green economy include:

– The moral and ethical imperative vis. a vis. unequal per capita levels of consumption and pollution by products by rich nations relative to developing ones.
– The self-interested ecological imperative. We are also animals who alsoultimately depend on healthy ecosystems.
– The pragmatic dimension, green jobs are where future employment is evolving.
– The self-interest of the technology education profession. Greening technological education presents the best opportunity to garner widespread support for the subject and to contribute to meaningful social and technological transformation in communities.

FROM A CULTURE OF PRODUCTION TO A CULTURE OF CONSUMPTION

Without energy there is no economy. Without climate there is no environment. Without economy and environment there is no material wealth, no civil society, no personal or national security. And the problem is that we have been getting the energy our economy needs in ways that are wrecking the climate that our environment needs — John P. Holdren, National Science Advisor to U.S. President Obama (Ladislaw, 2009, p.9).

North America's centres of corporate capitalism, New York's Wall Street, and Toronto's Bay Street have also been at the vanguard of dismantling and outsourcing the North American manufacturing base and with it much of the unionized high paying middle class job infrastructure that accompanied it as well (Hart, 2010; Jones, 2010). This transition was accomplished under the so-called 'imperative' and guise of unstoppable globalization to primarily serve the demands of neoliberal capital accumulation. Today in the U.S. only 9 per cent of workers hold manufacturing jobs and unions represent only 12 per cent of the workforce (Austen, 2009). The recent downturn in manufacturing in North America has been startling, in the U.S. in 2007 there were less than 14 million manufacturing jobs, between 1998 and 2007 manufacturing jobs declined by 21 per cent or 2.6 per cent annually (The Pew Charitable Trust, 2009). Consumption now accounts for upwards of 70 per cent of the North American economic activity (Suzuki, 2009). In the U.S. since 1987 manufacturing as a share of GDP has declined by 30 per cent becoming the world's leading net importer (Meyerson, 2009).

Although consumption is fundamentally both a political and a social act, there is little in most technology curricula that reflect this reality. In fact, to read some curricula documents one is led to believe that there is no urgency in addressing overconsumption and climate change for example, recycling alone will resolve most existing environmental ills (social justice concepts are rarely encountered in connection to technology and consumption) and absolve citizens from any difficult public policy debate. Sustainable production and consumption concepts are also exceedingly rare. Whether we call it the 'American', 'Canadian', or 'Australian dream' matters little, the reality is that this image of how life should be lived characterized by high material and energy consumption and enormous waste production is fundamentally an unsustainable way of life (Worldwide Fund for Nature, 2010), the notion that it can continue indefinitely is sustained largely through advertising, corporate propaganda and cultural inertia. The average person in China consumes a tenth of the energy consumed by the average North American (Rubin, 2009). The Big carbon energy producers in America's Appalachia, New South Wales Australia or the Tar sands of Alberta have little interest in challenging the energy consumption status quo, for them increased consumption of carbon-based energy equals more profits period.

> So how do we move forward when government regulations and subsidies are still weighted heavily in favor of the old grey economy? The deft hand of "politics past" is blocking humanity's path to a livable economic future (Jones, 2008, p.61).

Big carbon industry continues to do all it can in unleashing its lobbyists to maintain their privilege and power. They continue to try to drill and exploit the last vestiges of natural wildlife habitat. From the late 1990's through 2005 the North American oil industry spent roughly $50 million to $60 million a year on lobbying in the U.S. In 2008 the industry spent $129 million(Porretto, 2009). The more effectively these powerful groups employ public relations tactics to misinform citizens concerning the false choice of economy *or* the environment and to scare them about lower standards of living in moving toward a green economy, the more costly and dangerous the sustainability transition will be.

In a world that will be increasingly defined by fossil fuel scarcity, the high-energy sprawling infrastructure of suburbia that defines much of urban North America reflects a system without a long-term future (Kunstler, 2005). Technology education will be relevant to the degree it catalyses' the energy and inspires the creativity of young people to invent what amounts to a 'new' sustainable world.

Bruce Springsteen has a line in his song ‘Dead Man Walking’ that goes: *“Between our dreams and actions lies this world,”* this captures the real world problem of how life’s circumstances can derail the best of intentions (Schendler, 2009). In the book ‘Getting Green Done’ Schendler argues that sustainability ultimately depends upon people who ‘get things done’:

> We need to radically increase the ratio of grunts to visionaries, with fewer grand pronouncements made from podiums and more belly crawling through the swamps. It’s time to crack into the guts of the boiler and tune it up, fix the parts washers, replace the nasty filters in the heating system—and the broken politicians and their broken policies in the governing machine (Schendler, 2009, p.23)

Engaging students in thinking about the cultural, knowledge, skills and economic barriers to ecological design, green consumption and construction is also crucial if the eco-technological theory-practice gap is to be minimized. Some of the reasons why unsustainable practices persist include: resistance to new approaches; lack of talent or expertise; perceived barriers related to short-term costs; decades of ingrained practices with ecologically inefficient practices; poor building codes and people’s unwillingness to admit mistakes (Schendler, 2009). Psychological factors and worldviews also play a role.

The American Psychological Association Task Force on Psychology and Global Climate Change, identified numerous psychological barriers to explain the gap between climate change awareness and pro active behaviours, these included:

– Uncertainty – Research has shown that uncertainty over climate change reduces the frequency of ‘green’ behavior.
– Mistrust – Evidence shows that most people don’t believe the risk messages of scientists or government officials.
– Denial – A substantial minority of people believe climate change is not occurring or that human activity has little or nothing to do with it, according to various polls.
– Undervaluing Risks – A study of more than 3,000 people in 18 countries showed that many people believe environmental conditions will worsen in 25 years. While this may be true, this thinking could lead people to believe that changes can be made later.
– Lack of Control – People believe their actions would be too small to make a difference and choose to do nothing.
– Habit – Ingrained behaviors are extremely resistant to permanent change while others change slowly. Habit is one of the most important obstacles to pro-environment behavior (American Psychological Association (APA), 2009).

These same factors may explain in part explain the shortcomings of TE in terms of how slow it has been to incorporate and emphasize broad sustainability and eco-technological concepts (Elshof, 2009). Climate change due to our technological and development practices is already wreaking havoc across the planet. Changes in water quantity and quality due to climate change are expected to affect food availability, stability and access in some of the most densely populated regions on earth (Intergovernmental Panel on Climate Change, 2008). Despite this, the issue of climate change and how technology can be used to mitigate and adapt to its effects as a thematic area within technological education is nearly absent. Because climate change mitigation and adaptation are long term projects, it is crucial that the necessary transformational change in the way we use carbon-based energy becomes a curriculum priority for young people.

Unfortunately our consumption driven economic paradigm reinforces the mistaken notion that reality should never be an impediment to our short-term desires.Politicians at the highest level of North American governments are an example of this behaviour; they continue to preach the benefits of unrestricted economic growth while also minimalizing the grave threat that climate change poses for humanity (Oreskes& Conway, 2010; Pooley, 2010).

It could be argued that dreams are something we strive *for* while illusions are something we live *within*. A fundamental challenge for educators is to help young people understand in a critical manner the dangerous illusions that much of western techno culture perpetuates with regard to boundless consumption while also helping them develop optimistic dreams of a better, more just and ecologically sustainable future. Inculcating hopeful dreams without the critical understandings of how existing systems of power, influence and social inertia gravitate to the status quo is a recipe for cynicism and despair. TE then has a crucial role in encouraging young people with their ubiquitous social networking tools, to combine their creativity together with eco-technological insight and know-how, to develop smarter more ecologically sane technological alternatives.

An examination of technology education curriculum documents reveals that on one level most constituencies understand at a basic level at least, that educating young people about the negative consequences of poorly or over/misapplied technologies can have impacts on 'the environment'. Closer examination reveals that relatively few curricula engage students in critical thinking about environmental specifics related to design such as life cycle design or cradle-to-cradle thinking, nor do curricula connect technological systems to concepts such as 'technological metabolism' or ecological and carbon footprints. The word 'environment' and 'environmental impacts' are seldom connected to questions of mainstream economics, and almost never to ideas related to ecological economics or social and ecological justice (Elshof, 2009).

We might ask whether technological education itself is open to the charge of 'greenwashing' its image and the knowledge products that students take away from it. This is a provocative charge of course, but if technological education continues to provide little more than lip service to the serious and encompassing environmental dimensions of its embedded practices and ways of understanding the world, is it not tacitly abetting the continuation of unsustainable technological practices and therefore participating in the ongoing destruction of the natural world?

Today's top-down form of technological capitalism is being reinvented from the ground up, albeit slowly at present with the global financial crisis. New issues like free trade versus fair trade, outsourcing and environmental and humane labour practices in technological production occupy central themes in political, economic and moral discourse.

> As the public's enthusiasm for sustainable ways of life, environmental stewardship, and social equality grows, popular culture is rapidly becoming the predominant arena where the meaning and value of sustainability is contested, produced, and exercised. To state the obvious, this is because sustainability culture is a social practice. It is an instrument of knowledge formation; it is how a local context is narrated; it engages new and emerging social values and the energies driving these in dialogue with more traditional values and conventions, along with the habits and stereotypes underscoring these (Parr, 2009, p.3).

The days of 'don't ask don't tell' in terms of the social and environmental costs of technological products have run their course. Today's consumers are becoming more ecologically savvy, aware and involved in the global chains of production that have for too long escaped scrutiny.Technology education has an opportunity

toplay an important role in bridging the information and knowledge gap that lies between genuine ecological intelligence and mere greenwashing and uninformed consumerism. Understanding a product's adverse consequences involves three interdependent realms:

- The Geosphere which includes air, water, soil and climate;
- The Biosphere which includes our bodies, those of other species, and plant life;
- The Sociosphere which includes human concerns for the conditions of workers involved in the various aspects of a products development

We also need to update our ideas of what most of us consider 'pollution'. When pollution is mentioned we tend to think of visible belching industrial smokestacks, car exhausts, or untreated sewage spilling into water for example, and not the pervasive "marinade" of phthalates, bisphenol A, polybrominateddiphenyl ethers (PBDE's) and other toxic pollutants which we incorporated into tens of thousands of products in everything from personal care items to furniture, clothing and building materials (Smith, & Lourie, 2009). Designed products are awash in chemicals, its estimated that: "by the time an average North American woman grabs her morning coffee, she has applied 126 different chemicals in 12 different products to her face, body and hair" (Smith, & Lourie, 2009, p.4). The precautionary principle should guide us when we know so little about the long-term consequences to human health of exposure to many of the chemicals that flow through the ecologies of our technological products.

The green economy innovation challenge for TE then involves a new dialectic and critique-transformation of economic and technical codes, according to Feenberg:

> Civilizational change can transcend apparent dilemmas through transforming economic and technical codes. Instead of seeking costly trade-offs between

> such goals as participation and efficiency, environmentalism and productivity, innovative redesign of technology must bring these goals into harmony (Feenberg, 2002, p.18).

It is now worth briefly examining how an industrial giant's arrogance and short-sightedness reflected an inability to create new economic and technical codes to guide its own survival.

The GM Syndrome

The gas guzzling sport utility vehicles and trucks that fuelled the profits of North America's 'big three' automakers, Ford, Chrysler and General Motors over the past fifteen years are now a footnote for the history books, they are nowinefficient extravagances, destined scrap heap of technological history. Because General Motors was the industrial epitome of 20th century manufacturing, its downfall is a cautionary tale containing several important cautionary lessons for TE.

In 1953 General Motors president Charles Wilson testified before the U.S. Congress and stated:

> For years, I thought that what was good for the country was good for General Motors and vice versa. The difference did not exist. Our company is too big. It goes with the welfare of the country (Holstein, 2009, p. ix).

Charles F. Kettering, the general director of General Motors Research Laboratories, wrote an article in 1929 in the *Nation's Business*, entitled "Keep the Consumer Dissatisfied" (Holstein, 2009, p. 23). As Kettering explained:

> If automobile owners could not dispose of their cars to a lower buying strata they would have to wear out their cars with a consequent tremendous cutting in the yearly demand for automobiles. If everyone were satisfied no one would want to buy the new thing (Holstein, 2009, p.27).

Coupled with the techniques of mass media public relations manipulation of consumer wants and desires pioneered by Louis Bernays, GM mass produced the concept of planned obsolescence and product dissatisfaction. General Motors was the first corporation to earn a billion dollars a year and a pioneer in creating the system whereby people would purchase automobiles on credit.

A decade after these comments GM held 51 per cent of the U.S. vehicle market, today it's shrunk to less than twenty per cent. As Austen explains:

> The standard-bearer of the old twentieth-century corporate model-unionized GM is in bankruptcy, from which it has proposed to emerge by closing plants at home and importing cheaper cars from abroad (Austen, 2009, p.36).

Since 1986 the Detroit 'big three' automakers lost a quarter of the U.S. market with their combined sales dropping from 72 per cent to 46 per cent by the end of 2008. At its peak in 1970 GM employed 395,000 union employees in 150 U.S. factories, this will shrink to 38,000 union employees in 34 plants (Austen, 2009).

High union wages, corporate mismanagement, greed and poor design have all contributed to the GM fiasco. GM's design of increasingly larger, more powerful and heavier Sport Utility Vehicles (SUV's) and light trucks combined with their paucity of investment in research and design of more environmentally responsible products abetted their problems. When the price of oil hit record levels two years ago, North Americans abandoned their gas guzzling vehicles with a vengeance. SUV's like the Ford 'Explorer', the GM 'Blazer' and the Chrysler 'Jeep Cherokee' are now the clunkers that Americans are returning en masse for a rebate toward the purchase of more fuel efficient Toyota's and Honda's.

The company that developed some of the most iconic brands in the world with advertising campaigns like *"See the USA in your Chevrolet"* with Dinah Shore in the 1950s and rocker Bob Seger's song *"Like A Rock"* to sell Chevy trucks in the 1990's spent $2.1 billion on advertising in 2008 (Shea, 2009; Fredrix, 2009). Today while talking environmental responsibility General Motors is "aggressively marketing" its 'new' Camaro, a retrograde muscle car with a yellow 'bumblebee' version of the vehicle starring in the summer blockbuster movie *Transformers: Revenge of the Fallen* (Stoffel, 2009).In 2008 GM vice president Bob Lutz dismissed global warming as a "total crock of s---t" suggesting that forcing automakers to sell smaller cars would be "like trying to address the obesity problem in this country by forcing clothing manufacturers to sell smaller, tighter sizes" (Krolicki, 2008, p34). Under Lutz's 'leadership' GM reintroduced the Camaro a muscle car throwback to the 1970's with a V8 6.2 litre engine that puts out 427 horsepower, there is a back order waiting list of 19000 and as one reporter states:

> All this adds up to more new horsepower on the market than the Calgary stampede, and puts the neo-muscle car in contention for the hottest segment of the new market cycle (Corcoran, 2009, p.7).

For the last ten years GM has touted and advertised its commitment to hydrogen fuel cell vehicles, running an ongoing TV and magazine advertising campaign, while simultaneously producing some of the most fuel inefficient on the planet. It clearly wasn't living its purported "corporate values". In 2006 Thomas Friedman of the New York Times asked:

> Is there a company more dangerous to America's future than General Motors? Surely, the sooner this company gets taken over by Toyota, the better off our country will be… Why? Like a crack dealer looking to keep his addicts on a tight leash, G.M. announced its "fuel price protection program" on May 23. If you live in Florida or California and buy certain G.M. vehicles by July 5, the company will guarantee you gasoline at a cap price of $1.99 a gallon for one year — with no limit on mileage. Guzzle away (Friedman, 2006, May 31, p.8).

General Motors is also the company whose cost-benefit analysis and subsequent behaviour a U.S. jury found "morally reprehensible" and against applicable laws because it put profits above public safety. GM calculated that it was more cost effective to deal with lawsuits due to fire related injuries and death due to poorly designed fuel tanks that ruptured in rear end collisions, rather than implement a redesign and a fix of existing vehicles (Bakan, 2005). General Motors along with the other automakers have spent millions on lobbying politicians in order to prevent any increase in the North American corporate average fuel economy (CAFÉ) standards, it is ironic that if mandated efficiency increases had occurred over the last twenty five years, these companies would have been better positioned to survive.

A few decades ago General Motors manufactured over half the vehicles on North American roads, now it will be extremely fortunate to capture one fifth of that market. Through a bailout plan to enable GM to have a chance to survive, American taxpayers have invested U.S. $49.5 billion into GM, while Canadian taxpayers have invested $10.6 billion (Niedermayer, 2009). In order to remain solvent, iconic brands like the Hummer, Pontiac, Saturn and SAAB were jettisoned and at least 21,000 workers lost their jobs. Even with these massive changes the desired outcome of a viable manufacturing organization remain highly in doubt. The GM story tells us that effective marketing has the capacity to trump intelligence and technological foresight, and that allusions to power and speed have the ability to short circuit critical thinking and common sense. GM effectively ignored and minimized environmental considerations, preferring to maximize short-term profits at the expense of long-term viability. Instead of investing early in hybrid-electric technology, quality improvements and leading-edge design, GM invested in advertising and lobbying for the status quo. Given the extent of bad decision-making at GM, we might ask whether there are indications that the company has changed course in terms of the environmental performance of their products? Unfortunately no, the 2010 ranking of automakers environmental performance ranks GM second to last of eight major manufacturers (Kliesh, 2010):

> General Motors' next to last place ranking was due to its continued focus on inefficient vehicles with lacklustre smog performance. Surprisingly, average smog emissions of GM's hybrids were worse than the combined average of all eight manufacturers' model year 2008 vehicles—hybrid and non-hybrid. To date, GM has largely squandered its hybrid technology by using it to boost power instead of fuel efficiency and pollution control (Union of Concerned Scientists, 2010, p.1).

Technological education often does little to help enable young people to critically challenge the grand narratives of 'inevitable'progress, consumerism and endless economic growth for its own sake. If technological education was more ecologically responsible and accountable, one might reasonably hope that the design, manufacturing, marketing and consumption of 'dumb' environmentally unsustainable technologies would decline at an even faster rate than they now are. Unfortunately technological education curriculastill have little to say about eco-technological design orprinciples of sustainable production and consumption.

TECHNOLOGY EDUCATION FOR A MORE EQUITABLE WORLD

As Jones points out "the transition to a green-collar economy is not only a matter of economics and entrepreneurship; it is also a matter of policies and politics" (Jones, 2008, p.63). One of the more compelling arguments for promoting green collar technological jobs is the impact they can have on disadvantaged communities. Jones suggests that there are three main pillars of the new green-collar 'social uplift environmentalism':

– Equal protection for all: The poorest suffer first and most extensively in an environmental crisis, hurricane Katrina is a good case in point.
– Equal opportunity for everyone: Access to the opportunities available in the green collar economy should be open to all: How can we make this effort inclusive, ennobling, and empowering to people who were disrespected in the old grey economy? How can this effort be used to increase the work, wealth, health, dignity, and power of our society's disadvantaged?
– Reverence for all creation: Building the green economy should encompass respect for all living communities.

CHALLENGING THE ETHIC OF 'CHEAP'

As mentioned earlier one of the most profound developments over the last twenty years has been the accelerated pace of globalization and an enormous increase in the quantity of throwaway technological products. The massive transformation within many countries from a culture of production to a culture of consumption has only taken a generation or so. The proliferation of 'cheap' goods create supply chains that often stretch for tens of thousands of kilometres wrapping around the globe, all are driven by still relatively inexpensive oil and the propensity of manufacturers to 'externalize' the costs of pollution and waste on 'other' communities.

As Shell points out "cheap objects resist involvement" in fact a 'cheap ethic' has become a point of pride and 'cheap chic' fills in with style whatever quality and endurance is lacking making "craftsmanship beside the point. We have grown to expect and even relish the easy birth and death of objects" (Shell, 2009, p.142). Shell points to the decline of repair shops in the U.S., in two decades three quarters of small appliance repair shops closed, the number of electronics repair shops went from twenty thousand to five thousand:

> Repair people of all stripes have fallen into obscurity. Sesame Street closed its "Fix-it Shop" in 1996, stating as its reason that young viewers were unlikely to encounter one (Shell, 2009, p.143).

While a discussion of the death of craft is beyond the scope of this paper, the point is that rich western nations have grown addicted to cheap technological objects and have paid little or no attention to the environmental and social consequences that follow. An attitude of 'out of sight, out of mind' characterizes many people's awareness and interest in the cheap technological products found in big box stores like Wal-Mart. TE has an enormous opportunity to be at the vanguard of bringing these issues to the consciousness of young people and in doing so engaging them in discussion and the design of alternatives.

WHAT IS A 'GREEN COLLAR' JOB?

> When you think about the emerging green economy, don't think of George Jetson with a jet pack. Think of Joe Six-pack with a hard hat and a lunch bucket, sleeves rolled up, going off to fix America. Think of Rosie the Riveter, manufacturing parts for hybrid buses or wind turbines. Those images will represent the true face of a green collar America (Jones, 2008, p.10).

Jones defines a 'Green-collar' job as:

- Blue collar employment that has been upgraded to better respect the environment
- Family supporting, career track, vocational or trade-level employment in environmentally-friendly fields
- Examples: electricians who install solar panels; plumbers who install solar water heaters; farmers engaged in organic agriculture and some bio-fuel production; and
- Construction workers who build energy-efficient green buildings, wind power farms, solar farms and wave energy farms (Jones, 2008, p.1).

Green jobs' according to the United Nations Environmental Program (UNEP) report *"Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World"*, are jobs in "agriculture, industry, services and administration that contributes to preserving or restoring the quality of the environment" (UNEP, 2008, p. 5). Green jobs hold the promise that humankind will be able to face up to the following two defining challenges of the twenty first century:

- Averting dangerous and potentially unmanageable climate change and protecting the natural environment which supports life on earth
- Providing decent work and thus the prospect of well being and dignity for all in the face of rapid population growth worldwide and the current exclusion of over a billion people from economic and social development (United Nations Environment Programme (UNEP), 2008, p. 1).

As Jones explains:

> Green collar jobs are in the growing industries that are helping us kick the oil habit, curb greenhouse gas emissions, eliminate toxins, and protect natural systems. Today, green-collar workers are installing solar panels, retrofitting buildings to make them more efficient, refining waste oil into biodiesel, erecting wind farms, repairing hybrid cars, building green rooftops, planting trees, constructing transit lines, and so much more (Jones, 2008, p.13).

Moving beyond what Senge terms the 'Industrial Age Bubble' requires that technological education be guided by new insights and precepts rooted in an understanding of the biosphere, toward that end some include:

– Surf the flux: Live within our energy income by relying on renewable forms of energy.
– Zero to landfill: Everything from cars and iPods to office buildings and machine tools is 100% recyclable, remanufacturable, or compostable.
– We are borrowing the future from our children; we have to pay it back.
– We are only one of nature's wonders: we need to begin to understand our interdependence.
– Value the Earth's services, they come free of charge to those who value them: healthy ecosystems must be protected.
– Embrace variety, and build community. Harmony amid diversity is a feature of healthy human cultures and ecosystems.
– In the global village, there is only one boat, and a hole sinks us all: Our mutual security and wellbeing depend on respect and concern for all (Senge, 2008, p.39–40).

The countries that make the most rapid transition to a low carbon way of business will be the economic leaders of tomorrow. China is reportedly investing up to $660 billion over the next decade in clean energy and research (Walsh, 2009). South Korea is planning to invest close to 2% of its GDP each year, or about $85 billion over five years, in clean tech. And Japan is aiming for a twentyfold expansion in installed solar by 2020 (Walsh, 2009). Clean-energy investments generate roughly three times more jobs than an equivalent amount of money spent on carbon-based fuels (Pollin, Heintz, & Garrett-Peltier, 2009). Despite the long-term economic and environmental arguments for a low carbon future, opponents of climate change legislation are many and include not only the oil and coal interests but also major manufacturing business and trade groups in North America (De Souza, 2010). These groups have waged public relations campaigns to stop mandatory limits to carbon dioxide by scaring the public about the sacrifices necessary to slow and stop climate change. This policy is shortsighted and self-interested, as Nobel economics laureate Paul Krugman explains:

> …it's important to understand that just as denials that climate change is happening are junk science, predictions of economic disaster if we try to do anything about climate change are junk economics (Krugman, 2009).

TE needs to immerse young people in learning about leading edge businesses that are redesigning their processes and products for a low carbon, low waste future. Technology education has for too long looked to old industries for direction and 'standards of practice', it is high time to look elsewhere for more diverse ideas and inclusive and sustainable practices. TE classrooms need to become active hubs of innovative thinking to lower the carbon footprint of schools and the local community. TE classrooms can become genuinely progressive as they move toward zero net carbon classrooms incorporating comprehensive new e-tools and strategies to map out the carbon and ecological footprints of technology education classrooms as well as the student designs that are created within them.In this sense TE informs a critical dimension of pro-active citizenship and leadership.

We urgently need to create new transformative stories in the TE classroom, new narratives of how technology might help us create and sustain a new world worth living in and not simply sustain the products of an old wasteful economy driven by a dysfunctional operating system.

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RELATION WITH LITERACY

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LEARNING LANGUAGE, LEARNING TECHNOLOGY

Language proficiency in the technology classroom.

INTRODUCTION

Throughout the world a large group of students is facing considerable academic problems at school due to limited language proficiency. Language learning can, however, not be the sole responsibility of the language teacher, or in case of second language learners, the responsibility of the second language teacher(Vollmer, 2006). We simply do not have enough time in education to wait with subject teaching until the students' language proficiency has reached the standards we would require to start teaching subject matter(Lee & Buxton, 2010). Moreover, there is a fallacy hidden in this idea. It suggests that 'there is language' and then 'there is subject content'. In this chapter we will show that, also for technology, language and subject matter are interwoven and that both domains can be taught simultaneously.We would not wish to imply that separate language teaching does not have a legitimate position in schools, but rather argue that a technology teacher also has a role to play in language teaching. In this chapter we focus on only an aspect of that role: where subject matter and language come together.We will of course draw from work that has been done on other school subjects.

In subjects like science and mathematics, the effects of limited language proficiency on subject mastery have extensively been researched (Lee & Buxton, 2010; Boer C. van den, 2003; Lemke, 1993). Two aspects of poor language proficiency have become particularly apparent: limited awareness of the problems by both teachers and students and lowering of expectations by teachers.

LIMITED AWARENESS AND LOWERING EXPECTATIONS

Firstly, both the students and the teachers often fail to notice the problems faced by students with low language proficiency. They presume mutual understanding and attribute academic problems to difficulties with subject matter, rather than to language skills or a combination of these (Gibbons, 2002). One of the underlying reasons is that teachers and students do not recognize the gap between basic interpersonal communicative skills (BICS) and cognitive academic language proficiency (CALP)(Cummins, 2010). Students are able to express themselves fluently using every day language and their academic language skills maysubsequently be overestimated. As a result, language is not targeted by the teacher as a source of the problem(Eerde, Hajer, & Prenger, 2008).Another

M.J. de Vries, Positioning Technology Education in the Curriculum, 165–178.

complicating factor that may result in limited awareness by both teachers and students can be found in semantics. A word may have a multitude of meanings, each being reserved for a specific context(Fox-Turnbull, 2008). In many cases, however, there is a deceptive transparency to words. Even an apparently simple technical word such as ‘shaft’ may not be as clear to students as it seems, and for good reasons.

> Beyond the basic qualities of “long and straight” the term “shaft” then, clearly has a range of meanings and these are often context-dependent. From a structural perspective, the term shaft could embrace the long and straight pieces that contribute to a framework. On the other hand, a shaft can describe a long, straight void such as a mine shaft. And then there is the mechanically dedicated meaning. In this instance the long, straight component is further qualified in that it rotates and thus can transmit motion (Parkinson, 1999).

Secondly, teachers often lower cognitive and linguistic expectations when faced withlanguage problems. That, in turn, has a negative effect on learning outcomes for these students (Hajer & Meestringa, 2009). Obviously, language is an important medium to learn *through*. Consequently, technology teachers, like other subject teachers, need to address generallanguage problems in order to get content matter across. Language, however, is not just the medium through which one learns a subject, it is also a target.Technology as well as science or any other subject, is to some extent a language in itself. It has its own vocabulary and ‘ways of expressing things’. Mastery of technical language is, to some degree, mastery of technology itself.

> The term “energy” for example, has a specific, reserved meaning in science [and technology sic]. Yet it has a very unscientific range of applications beyond that discipline when children in class claim they “have no energy today!” Nonetheless, effective teaching and learning should still have enabled the child to gain a grasp of the notion of the principle of the conservation of energy. The word “energy” in the dedicated scientific sense is loaded with meaning and shared across the scientific community(Parkinson, 1999).

An example shows how language, thinking and learning are interrelated and what happens to subject mastery when linguistic demands are lowered.In a chapter on projectors, an experienced and highly respected teacher was explaining how an image can be formed by a beamer.

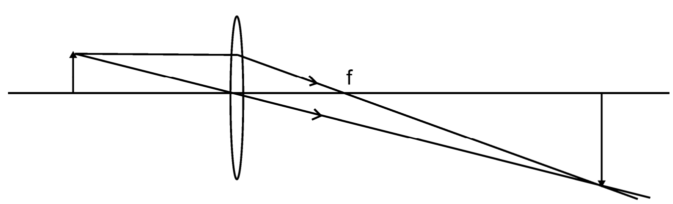

Figure 1. creating an image on a screen.

While the teacher was drawing the diagram on the blackboard, the following utterances were observed:

Speaker	*Utterance*
Teacher	I draw this one through there
Teacher	Now from the focal point, how does it continue, Yasmin?
Yasmin	straight, sir
Teacher	That's correct ....
Teacher	Now, this one goes through there ...

In the experiment that followed after this explanation, the students were observed to say things like:

Speaker	*Utterance*
Student 1	You put it straight
Student 2	Shift it a little
Student 1	There's a good light ray
Student 2	Right! Draw it.

When asked whether they found the explanation or the experiment hard, the students told the researcher that they thought it was quite easy, because the teacher had explained it clearly. And indeed, the students appeared to be drawing lines that resembled correct construction diagrams. During the interview that was held after class the teacher confirmed this, but when asked how he expected the students to perform on the upcoming test, he said that the students would probably disappoint him again. The teacher and the researcher then read the questions and texts in the students' books and comparedthose texts with transcripts such as the ones above.It immediately became clear why the students would indeed fail the test. The books were full of highly specific terms such as 'object', 'construction rays' and 'focal ray'. At no point did the teacher provideanyscaffolding to help the students to master this language. In the discussion with the teacher, one term became of particular interest to get a grasp of what had been going on: 'object'. Students knew this word very well before the lesson had started. They would probably have substituted it with 'thing'. In this lesson however, it should have become clear to them that the word 'object' had a very specific meaning in optics. It is the 'thing' that emits the light rays that are relevant for the problem at hand.Light rays from an 'object' would typically be bent by a lens and come together on a screen, to project an image. The screen could in daily life also be called an 'object', but in this case that would lead to major confusion. When the teacher realized the problematic nature of these words, he went on to explain why he had avoided using these terms in his instructions. He had adapted to a linguistic level thathe thought the students in this ethnically diverse class could handle. He also said that by doing so, he had in fact left the students 'in the dark' when it came to reading textbooks and answering exam questions. On a side note, the reader will recognize an orientation of technology as applied science, as explained by Lebeaume in chapter seven of this volume.

Not only is the interrelatedness of language and subject matter important at the level of technological concepts, but also at the level of more generic skills. Where design and technology is meant to prepare students for a vocation, or even to facilitate a well-informed choice for a vocation, general language as well as specific technological vocabulary and expressions need to be mastered in order to become competent employees. Captains of industry in The Netherlands have, in an effort to describe technology education for the 21st century, stated:

> Competence based learning in the domain of technology must incorporate communicative skills such as writing about work done, working successfully with colleagues, communicating with clients. (Platform VMBO Technische Installaties, 2008)

> Where technology education is used as a means to empower students in a technological world, the same applies. It has for instance become very difficult to buy a new television or computer without the skills to read advertisements, read customer reviews on the internet, or engage in a discussion with salesmen who indulge in technological jargon. A technologically literate person therefore must also be a linguistically literate person.

Another view on technology education is that it should involve learning *about* technology. A technologically literate person has an idea of how technologies have evolved in the past. Moreover, such a person has developed a sensitivity to the impact of new and emerging technologies upon their technologically mediated world and their own life(Dakers, 2006).As Barlex and others explain in this volume, technology is a value laden domain. Values and language constantly shape each other and values are spread across cultures by means of language (Wittgenstein, 1958). We therefore have to conclude that it would be an omission to not target language as a learning objective in a technology class. It would indeed be impossible to teach students to have a discussion about the merits and problems associated with mobile fast internet access, without addressing the way they put their ideas into words and sentences(Browne & Keeley, 2004).

DESIGNING TEACHING MATERIALS

The design-based research project that is described in this section, was meant to provide teachers in five subjects and three levels of secondary education, as well as the wider educational field, with prototypical materials that would help them to make subject teaching more language sensitive. Subject experts were assisted by experts in the pedagogy of language, to write a first version of a booklet and a teacher's guide. For design and technology, the booklet was tested in two classes at different schools. The teacher (Tom) whose trial was most extensively researched, had been a design and technology teacher for many years, with a goodreputation and ample experience as an author of teaching materials. Data collection involved videotaping of lessons and semi-structured interviews with the teachers. Results were discussed among researchers, authors and experts in pedagogy of language acquisition. After the trials and subsequent discussions, student booklets were rewritten. In the next section we will focus on our work with Tom and on the prototypical teaching materials we developed. Subject learning objectives centred around a design method that students would use to design and make a holder for an mp3 player or cell phone.

Language Sensitive Teaching.

Much of the language pedagogy that was used has its roots in second language acquisition (SLA) theoryand content-based learning of second language. In this approach, language acquisition is embedded in learning of subject matter.We will adopt a definition of this pedagogy by Hajer and Meestringa.

> In ‘language sensitive subject teaching’ learning objectives for the subject as well as language objectivesare made explicit. Subject objectives and language objectives are simultaneously developed by means of an education that is rich in context, that promotes interaction and where students receive language support. (Hajer & Meestringa, 2009 p11)

We will now describe how the elements of this definition are recognizable in the booklets that were designed in the course of this study.

Explicit language Objectives.

Even technology teachers who strongly believe in the interwoven nature of language and technology as explained above, have many other objectives on their minds than language pedagogy, when entering class. Most likely they are focused on learning objectives relating to technological skills, conceptual and procedural understanding etc. Therefore explicit language objectives must be functional in the light of the subject objectives at hand.An illustration of this functional nature of language objectives is found in the teacher’s guide accompanying the design booklet:

> A good designer is able to use appropriate technical language when talking to colleagues and different language when talking to customers. He is also able to use verbal and written feedback to improve his design. (Dijk & Bekker, 2009)

Learning objectives are materialized in tasks. When constructing tasks that promote language skills, we also have to keep in mind that, unless such tasks are clearly functional for the subject matter, they will be perceived by both the teacher and the students as an extra burden on top of an already heavy load(Eerde, 2004). Students are often geared towards solving the problem at hand, or making the final product and anything that seems to distract from that, will be skipped or dealt with in a superficial manner. In the example below the student is prompted to engage in functional and educated talk about his design.

> Talk to your customer about his wishes. Your customer will appreciate it if you engage him in a flowing conversation. You are not likely to find out what your customer really wants, if you ask a lot of 'yes/no' questions. In fact, your customer may not even know what he wants at this stage. It is your task as a designer to help him to find out. Here is an example of a sentence that another designer used to keep the conversation flowing.
>
> *"So, you are saying that you would like a modern design for your cell phone holder. Could you tell me a little more about your taste in furniture. Let us start with your favourite colours."*
>
> Afterwards you will write a short report about the conversation, so you can use this information later.

This is only one example where students learn that design involves language. As will be explained by Van deVelde in the next chapter, this is quite a leap for many teachers and students, so we have to repeat this message in different contexts, without becoming boring in the process. At a different point in their work students were prompted to watch a comic video in which a television cook tries to show his audience how he prepares a Christmas dinner. The cook does not use a single word of 'cooking language', but instead says things like: "You put this one in that thing, and add a bit of that stuff, so it will taste a bit like something else". Such non-examples are very suitable to show students that progress in technology, as in any subject, must involve progress in language proficiency.

Rich Contexts

In the pedagogical model we adopted, emphasis is placed on providing rich contexts that make abstract notions comprehensible. Technology is a domainthat is rich in meaningful contexts. It would be a different challenge to embed subject matter in meaningful contexts, if we had to teach students an abstract mathematical notion such as 'hypotenuse'. In case of a design task the main challenge seemed to be, to find a design that would appeal to thirteen year old boys and girls and make all theoretical notions meaningful in the light of the design task. It became apparent during the test lessons that we had succeeded in finding a useful design (the holder for an mp3 player or cell phone), but we had not managed well enough, to motivate the students for the writing and reading tasks at the beginning of the booklet. Students wanted to start working with their hands as soon as possible and no matter how strongly we had contextualized writing and talking tasks, they were still put off by some of the tasks. In other words, students and teachers perceived the language tasks as unnecessary distraction from the core of the assignment. "Students come to this class with the expectation to work with their hands, not to write and read", Tom told us. Wethen decided to build on work by Richard Kimbell, who developed a pedagogy of design. In this pedagogy there is continuous variation in working with hands and mind(Kimbell, 2005).This gave us new possibilities to add context to language tasks at different stages.

> Go and have a look at the inspiration table. You will see different materials you can use later and also a few examples of cell phone holders. Exchange preliminary ideas with a class mate for five minutes. When done, write down the results of that discussion in your design portfolio. This will help you to go back to the earlier stages in the design process whenever you face problems.
>
> You can now start working on a preliminary model using scissors, sticky tape, paper etc. Have a look at what's available on the inspiration table.

New concepts, such as prototype, were embedded in the context of the students' own design task, thereby allowing them to derive meaning from contextual and experiential cues. Explicit attention was given to the different meanings of a word in different contexts.

> (first lesson)
> The word **design** is frequently used in daily life. Write down three sentences with the word *design*.
>
> (last lesson)
> The word design sometimes refers to just the shape (**form**) of an object. At other times it refers to the **function** as well. What does the word design refer to in the next sentences?
>
> - The design of the cell phone I am going to buy is really flashy and cool.
> - The design of this cell phone makes maximum use of new technologies such as high bandwidth internet connection.

Interaction

From some of the examples above, it has already become clear that it is feasible to engage students in academiclanguage production in a technology class. We will now present a few more examples to show how students can be prompted to produce academic language andhow such tasks can be made functional in the light of a design task.

– Give your buddy feedback on his preliminary model. As usual, you start off with a 'top' and then you give your buddy a 'tip'.
– After you have received feedback from your buddy, you write down at least two new ideas.
– Present your proposed design to your customer. You will want to give your customer the confidence that it is a good design, so you may want to use a few designers' words and phrases.It does help the customer to understand that you know what you are doing.

– Look at the picture of a newly designed foldable and lightweight rollator. Use the sentences below to describe the entire design process that resulted in this new model.

> Firstly, the designer investigated problems with existing rollators. For his research he talked to people such as .
>
> He then wrote down a first version of the program of requirements, which he divided into two categories, namely ……………. and …………

The reader will note that in this specific case the task had no direct function within the students' own design task. However, it was included at the end of the booklet in order to help the students to make the transfer of knowledge of design methods, from the context of the cell phone holder to other contexts. The example, however, served to show how written language production was facilitated.

Language Support

Lowering linguistic expectations and demands puts students in a disadvantaged position, as we have seen in the introduction to this chapter. This is why words such as 'prototype' and 'preliminary' were deliberately introduced in the booklet, even though our target group consisted of students in a vocational stream. However, students need support when they are faced with difficult language. A four phase pedagogical model for teaching new words was laid out in the teacher's guide(Nulft & Verhallen, 2009):

– Orientation on the meaning of the word in different contexts.
– Semantisation: giving meaning to the word in the context under study.This can be done by showing pictures, giving and asking examples and non-examples, engaging the students in a discussion about the word and so forth.
– Consolidation: Practicing to use the word or expression in different ways.
– Checking for correct understanding and use of the word.

Not every word can be treated as extensively in a booklet for students, also because as authors we do not know as well as the teacher which words could be difficult for the students. This also uncovers a dilemma in the construction of the booklet. It was made to exemplify a pedagogy that ought to be in the hands of the teacher as much as possible. Teaching materials can only serve to give an already linguistically sensitive teacher the support that he needs. Again, such support can also be perceived as unnecessary. We leave it to the reader to assess whether we have found a balance in this dilemma.

So, rather than avoiding possibly difficult words and expressions, we gave language support (scaffolding) by providing contextual cues as well as explicit translation into everyday language.

> What you will do at this stage is make a **preliminary model**. You will use cheap materials and tools, such as clay, cartboard and glue, to make a first version. This will allow you to 'think with your hands'. You will still be able to change your ideas about your design at a later stage. And of course you will make a much more beautiful model later. Take pictures of your preliminary model and paste them into your design portfolio.
>
> ***Preliminary model:*** *An early model made by a designer to 'play with ideas'.*

Key concepts were also placed in a concept map in order to visualize relations between them.

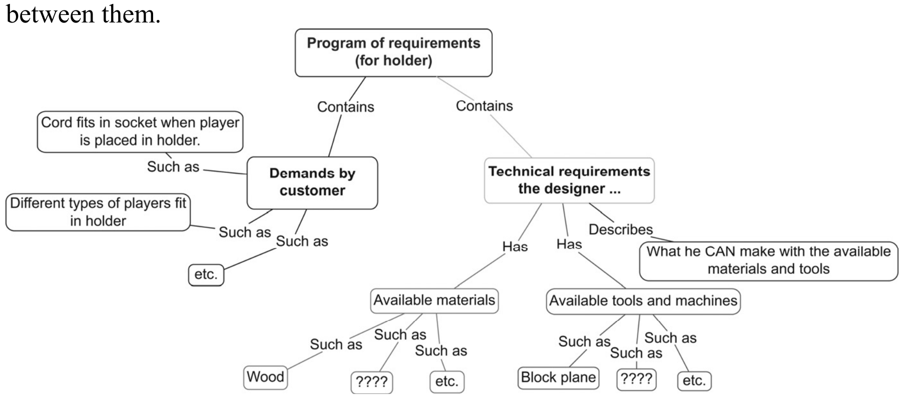

Figure 2. Concept map.

Students also need support in the form of effective feedback on their attempts to produce academic talk and writing. The teacher's guide therefore contains examples of students' phrases that are not accurate enough and suggestions how to provide scaffolding.

> If a student would say "*I wanted to know what my cell phone holder should be able to do*", we would consider that as a first attempt and a starting point for more formal language. Ask the student to go back to the theory and rephrase his sentence to fit the way a designer would say it. Alternatively provide a few cues for formal language, comparable to the prompts in the writing frames .

Teachers' Beliefs and Skills

Technology education is a contested field that is claimed by those who look at it as mostly hand work, rule-driven, serving the needs of industry and those who favour a more academic and philosophical approach (Dakers, 2006). Many teachers and students believe that technology education should be about doing rather than about thinking. Language, particularly in written form, is much more strongly associated with thinking than with doing. In the next chapter Didier van deVelde will elaborate on this. In our research project it wasclear from the onset that the teachers as well as the students had to be helped to understand the symbiosis of language and subject content.

Although the first version of the booklet and the teacher's guide did stress the importance of language pedagogy, we saw during the trial that Tom was hesitant to adopt the suggested teaching strategies. He complained that there was too much thinking before 'the doing', which would put students off. When we reviewed our own work, we could not but agree with his criticism. We had proposed a design pedagogy whereby students had to establish the requirements for the design and engage in a lot of academic work,partly language related, before they could start making their design. Since the booklet needed to be prototypical with regard to language sensitive technology teaching, we decided to adapt the design pedagogy, rather than the language pedagogy. This is what led, among other adaptations, to the introduction of the 'inspiration table', which we have already described.

During a number of discussions with the researcher, Tom said that he began to understand the importance of language pedagogy. Whether this shift in attitude would have been achieved without such in-depth discussions remains unclear. We nevertheless decided to enhance our work with more explicit attention to the importance of subject-based used of language, not only for a designer but for anyone who engages with technology. This was done in an attempt to facilitate transfer of knowledge and beliefs about the interwoven nature of technology and language beyond the context of design. A suggestion in the teacher's guide reads:

> At the end of the project, students should understand the interconnection of design skills and language skills. However, they will not automatically make the transfer other technological contexts. The teacher can promote this transfer. Possible starting points are:
>
> A gardener is asked to design a garden for a family who have always lived in an inner city. He first visits the customers to have a look at the old garden, to talk about their wishes and to try to get the job. What could happen if the gardener uses excessive technical language such as 'perennial herbs'? What could happen if he uses no technological language at all?
>
> Did you ever come across some professional who used a lot of difficult technological words and sentences? Think about a dentist's assistant or a computer salesman, for instance. Did that person speak to you, or to a colleague? Describe what you felt when you overheard the conversation.

When we studied the video footage of Tom's lessons, it became clear that Tom had tried hard to help the students with words such as 'prototype', but we also saw that we had not achieved our goal to let him use content-based pedagogy as described in the teacher's guide. Rather than to negotiate meaning, Tomdefined the meaning of the word unilaterally and he would typically repeat his definition a few times.

Speaker	*Utterance*
Teacher	What does prototype mean, Isabel?
Isabel	Uhm ....
Teacher	Who can help Isabel?
Youssef	A first series you make to
Teacher	no, not a first series ... It is a test model. The first model to show and to find out if your ideas really work...'test model'.. So? (*looks around at class*, *points at Karen)*
Karen	.... *(silence)*... Your thing?
Teacher	No, not 'your thing' ... 'test model' .. Youssef?
Youssef	Test model.
Teacher	Yes! Test model

We then realized that it would take more than a booklet, a teacher's guide and a few discussions to achieve our goals. Our findings are consistent with research in mathematics and science classrooms, where teachers were observed to merely tell the students what a word means. Contextualization and promoting interaction, or more precise, prompting students to produce academic language, are very often mostly absent. Prenger has found this in mathematics classes and we have now seen the same in a technology class (Prenger, 2005). In science classes Lemke and Osborne would relate these findings to implicit theories about language that science teachers have adopted.

> In contrast to the recognized role of language in science, the common conception amongst many science teachers is that the discourse of science is essentially transparent and that language offers some unique ability to represent the physical world in an unambiguous manner (Lemke, 1990).

And

> Implicit in such a view is a correspondence theory of language often coupled with a naive realism, both of which are positions that have long been philosophically questioned. For the thread that runs from the work of Saussure to Wittgenstein to the latter day social constructivists is that language can only be understood in the context of its use.(Osborne, 2002)

It is this implicit theory about the nature of language that may have prompted Tom to say something like "*no, not first series … test model..*" Clearly we have to be modest about our attempts to influence teachers' such beliefs about the nature of language by merely presenting some new teaching materials.

DISCUSSION

As authors of teaching materials we have discovered that it is possible to incorporate pedagogy of language acquisition into a pedagogy of technology. Technology education has its own challenges and opportunities in this respect. On the one hand there is a challenge because of people's beliefs about the nature of technology and the nature of words, but on the other hand we have found it relatively easy to use the design task as a vehicle for the ambitions we had. Design is about human needs and such needs can only be met when designers manage to engage in effective communication. It is precisely this communication that can be used as a vehicle to teach language, as we hope to have demonstrated.

We have not yet investigated how teachers and students engage with the revised version of the booklets. Since the revision was drastic, we would expect changes in this engagement. We cannot be conclusive about the effectiveness of our approach, either. We don't know whether students' and teachers' attitudes, skills and knowledge changed, as a result of working with the materials we produced. Nonetheless, we are confident that our work can be used by technology teachers, as an example of language sensitive technology teaching materials and practice in class.

In the Netherlands we did take our work forward, for instance by using the booklet and the teacher's guide as prototypical material in a course on content-based language learning in initial teacher training. Of course, teachers will have to adapt these ideas to their own circumstances, but we hope to have given them a little jumpstart. Again, we need to be modest about our achievements, since people's beliefs about the nature of technology and the best way to teach it, are not likely to change as a result of the above mentioned interventions.

Taking it Further

From the perspective of the pedagogy we adopted, there is no fundamental difference between a secondary school student learning about 'prototype', or a university student learning about 'design methods'. We therefore also hope to see progress in our own work as university lecturers at the department where technology teachers are trained. It is there, where we ought to demonstrateto teachers in training that pedagogy of technology and language pedagogy can complement each other effectively. In a next round of research we will continue to collaborate with experts in the field of language pedagogy, in order to learn how to practise in our own teaching, what we have preached in this article. Not only will we try to serve as models, but we will also have to be rigorously explicit about the pedagogy we employ. Only by doing so, can we expect future technology teachers to question their own beliefs about the nature of technology and language and ultimately improve their own practice.

We also need to be on the lookout for new developments in language pedagogy. A promising pedagogy, that has already been used for decades in Australia and for some years in Sweden, is called genre pedagogy, which builds on 'systemic functional linguistics'(Rose, 2008). In genre pedagogy, language is seen as ways of being, doing and saying. We will use two examples from this chapter to illustrate how different genres are produced in different situations.

> The design of the cell phone I am going to buy is really flashy and cool.
>
> The design of this cell phone makes maximum use of new technologies such as high bandwidth internet connection

Appropriate genres for technology education can for instance be found in apparatus manuals, in essays on how technology is value laden, in shop floor talk about the use of tools, or in commercials for newly designed artifacts. In each of these cases there is specialized communication about specific subject matter (*field*), there is a specific relationship between the speaker/writer and the listener/reader (*tenor*) and finally there is a certain *mode*of communication, which refers to the channel of communication such as informal talk or highly formal writing.

Genre pedagogy isas explicit in its approach as what we have shown in this chapter, but it takes such pedagogies a step further. First of all the teacher needs a basic (functional) linguistic understandingof prototypical subject texts, at the levels of the entire text, sentences and words. Through elaborate and systematic modelling and scaffolding students are consequently taught to read, speak and write such subject-specific genres. Workhas been done to apply genre pedagogy to the sciences, history and other subjects, with promising results (Gibbons, 2002). We hope to tap into similar developments in technology education andperhaps to even promote such developments.

Another option that we have not yet explored at the intersection of language pedagogy and the pedagogy of technology,is the use of concept cartoons. In the next chapter Van deVeldewill demonstrate how such cartoons can aid an education for technological literacy.

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DIDIER VAN DE VELDE

CO-DEVELOPMENT OF LANGUAGE AND TECHNOLOGICAL LITERACY

INTRODUCTION

Attention for ‘equal opportunities’ is very important in the education policy of the Flemish community in Belgium. A crucial element is the knowledge of languages, certainly for minorities in the population. Every student should benefit from the cultural and economic advantages of a good knowledge of language for communication and instruction.

The ‘technological literacy-view’ emphasizes the emancipating role of the subject: we educate children to become conscious civilians in a technological world. Values become more important in the context of sustainable technology, and the use of narratives in this matter seems obvious. Besides this, we want children to develop rich and meaningful concepts of technology.

It becomes clear that the alliance between language, narratives and technology education opens up promising frontiers to be explored.

By means of the research project ‘gewetech’ (Van de Velde, De Lange and Van Den Broeck, 2009), we have explored pupils’ and teachers’ perception of their learning process using a textbook for technology education (context food technology) and concept cartoons. By means of this textbook, we have explored also the possibilities for ‘co-development’ of language and technological literacy. The methodology of ‘design research’ is used to improve pragmatically the educational quality of the textbook.

This chapter describes how a textbook can be screened on language thresholds and how it can be enriched with strategies for developing language as well as technological knowledge.

An interesting qualitative learning strategy for technology education is the use of ‘concept cartoons’. Their effects on the learning process have already been studied in science education and as I will illustrate further on in this chapter, they seem to be a promising strategy for discussing technological concepts in the classroom.

The article explains how technology education as a subject can use linguistic strategies to improve the learning of technology.

M.J. de Vries, Positioning Technology Education in the Curriculum, 179–188.

DIDIER VAN DE VELDE

LANGUAGE AND TECHNOLOGY EDUCATION

Alliances between language, narratives and technology education

Although C.P. Snow has discussed the problem of ‘two cultures’ in his famous lecture in 1959, it was George Sarton who in 1931 spoke already about the division of the intellectual elite into two hostile groups which can be called for short the literary and the scientific (Meinhardt, W. and Theunissen, B. 1988). French philosopher Gilbert Simondon (Hottois, 1993) has argued that the dichotomy culture-technology is a source of a certain technophobia that characterizes our occidental culture. It is affected by huge tensions generated by the difference in speed in the development of technology and other domains of our culture. Anyhow, a lot of technology teachers have no idea on how technology education can be linked to language education.

On the one hand, there can be argued that technology education should emphasize its perceived quantitative nature. So techno-scientific-gifted pupils should not be brought at a disadvantage by imposing a literary approach in technology education. On the other hand, some arguments are pointing in another direction. Firstly, educators in math, natural science and technology nowadays advocate active and problem-based learning in simulated real-life and meaningful contexts.

Secondly, an emphasis on the emancipating role of the subject leads to a more value-driven content. The importance of sustainable technology is an example of that. Philosopher Richard Rorty (Groot, G. ,1998) advocates a narrative approach for dealing with moral issues, not because they reveal certain moral ‘principles’, but because “they make us familiar with an expanding horizon of experiences and views”. So, in this perspective, technological literacy can open up a qualitative horizon of meaning to help learners in becoming conscious technology-users. In this perspective, technology acts, just like language, as a semiotic sign system, filling our life with meaning. In chapter 12 and 13 of this book, Aki Rasinen and Leo Elshof explore the relations with ethics and sustainability education in a more profound way.

Thirdly, as the diversity of the population in West-European countries rises, the number of non-native speakers increases. It is estimated that at the start of secondary education, a large number of learners have difficulties to comprehend school textbooks. Children with low language abilities experience problems in many subjects. The presence of so called ‘school words’ and ‘low-frequent daily words’ play an important role in that. Van Berkel (1995) found that language abilities can influence 25% of the school performance in Flemish primary schools. Some other indicators that are related to basic literacy-problems: in 2007, about 18% of the boys and 11% of the girls left secondary school without a degree (Van Landeghem et al., 2010) . A large number of unemployed adults have low reading and writing capabilities.

Finaly, a broad background knowledge is a strong indicator for good school performance. And an important part of this background knowledge has a linguistic representation. Indeed, the so called 'cristallized intelligence' is closely related to verbal intelligence and exposure to education.

Comparable problems with basic language abilities occur in developing countries as discussed in chapter 16 of this book by Frank Banks.

Overview . perspectives in the need for language sensitive technology education.

The perspective of equal opportunities
– Offering sufficient language abilities for more efficient learning
– Assuring opportunities for disadvantaged groups
– Preventing unqualified high school dropout
The technological literacy perspective
– Vocabulary for a better use of products and systems
– Vocabulary for understanding concepts of technology
– Thinking about relations between society and technology
Social-constructive learning pedagogy
– Context descriptions and analysis
– Language for cooperative learning
– Problem analysis in assignments
The professional perspective
– Identifying needs for technology
– Communication with customers and clients: planning, quality...
Cultural integration of immigrants

TEACHING LANGUAGE AND TECHNOLOGY EDUCATION

Becoming a language developing technology teacher

A 'language-conscious approach' in education can be applied in many ways. Four consecutive phases in the process of becoming a language-conscious teacher can be observed in practice (Riteco and Meestringa, 2009):

- Phase 1: a budding consciousness: teachers are willing to see their role in pupils' language development.
- Phase 2: making the language input more comprehensible for pupils: using reading-strategies, varying learning settings and language input, offering visuals and diagrams to support comprehension, explaining the meaning of words.
- Phase 3: stimulating the language production: teachers acknowledge the importance of reading and writing for the learning of subject-specific content: stimulating interaction and cooperative work, scaffolding the learning process.
- Phase 4: aiming for language goals in the learning content: designing tasks mixing language and content goals, giving language feedback, using speech- and writing frames to support language production.

A 'language-conscious' approach leans on the triad 'context-interaction and linguistic support'. Teachers must have the ability to approach content by using rich contexts. Secondly, they need to stimulate interaction and thirdly, they can use supporting 'linguistic-tools' such as speaking and writing frames.

When textbooks are enriched with these strategies, they can become 'sign systems' of good practice in communicating language-conscious education.

Educating subject-content in language-conscious ways

Verhallen and Walst (2007) recommend following interventions to raise the linguistic awareness in education:

1) increase the linguistic input by:
- initiating, maintaining and fixing the pupils' motivation for learning;
- paying attention to a good comprehension of the used language in context;
- stimulating the zone of nearest language development from above: add new words and structures and decontextualize them;

2) increase the occasion for language production:
- giving time to produce language,
- giving freedom and support in subject-specific content-choices;

3) increase language feedback:
- correcting content and form of linguistic representations;
- supporting comprehension: clarifying meaning, helping interpretation;
- giving constructive feedback.

Enhancing student achievement and crystallized intelligence using direct vocabulary instruction

Marzano (2003) advocates attention for vocabulary terms and phrases as an important factor that influences student achievement. He indicates following generalizations from Research (Marzano, 2006).

- Students must encounter words in context more than once to learn them.
- Instruction in new words enhances learning those words in context.
- Provide direct vocabulary instruction for words in the text passage that is being read.
- Direct instruction on words that are critical to new content produces the most powerful learning.
- A text density of 1new/150 word results in a chance of 30% for learning the word. A higher density of new words leads to a lower learning chance.

He advocates following six-step process for learning new terms.

- Step 1: Provide a description, explanation, or example of thenew term.
- Step 2: Ask students to restate the description, explanation, or example in their own words.

– Step 3: Ask students to construct a picture, symbol, or graphic representing the term or phrase.
– Step 4: Engage students periodically in activities that help them add to their knowledge of the terms in their notebooks.
– Step 5: Periodically ask students to discuss the terms with one another..
– Step 6: Involve students periodically in games that allow them to play with terms.

SCREENING AND OPTIMIZING EDUCATIONAL TECHNOLOGY

Methodology to Analyse the Linguistic Characteristics of a Textbook for Technology Education

Firstly, in the 'Gewetech'-project, we have tested the word comprehension of learners (K7 and 8; n=52): 'school words' , low-frequent daily words and subject-specific words in the text-book 'Alimento' for food technology. This textbook can be retrieved from www.alimento.be.

Secondly, a teacher trainer in language has performed a document analysis of the textbook by using the a Dutch translation of the 'Common European framework of reference for language: Learning, teaching, assessment' (Council of Europe, 2001) as a point of reference. This framework is a guideline used to describe achievements of learners of foreign languages across Europe. Its main aim is to provide a method of assessing and teaching which applies to all languages in Europe. The defined six reference levels are becoming widely accepted as the European standard for grading an individual's language proficiency. We have screened the textbook meant for grade 7 and 8 using the A2-level (=basic user-waystage) as a reference. This document analysis consists of a screening of text- and sentence-length, text-coherence, information-density, word-use and vocabulary, grammar, lay-out, visuals and graphics.

Some conclusions of the analysis: the most difficult word for learners in the textbook is 'technology'. The book offers many possibilities for learners to read and write. Filling in tables, formulating conclusions and questions for inquiry, expressing opinions…. The book consists of several kinds of texts such as instructions, tables, questions, news-paper articles, pictures with explanatory texts... There is also attention for role-play in cooperative learning assignments.

Teachers' and Learners' Perception of the Textbook 'Alimento'

Five schools have used the Alimento-textbook for about 6 to 8 lessens of food-technology addressing 52 learners. In-depth interviews confirm also in Flanders a weak understanding of concepts such as 'creativity' and 'technology' in learners. Instead of explaining these words in the beginning of a course, it is better to build up the understanding gradually, while learners are experiencing these concepts in their lessons.

Redesigning the Textbook 'Alimento': Using a Text-Books as Semiotic Carrier of Good Practice

As an outcome of the 'gewetech' project (Van de Velde, De Lange and Vandenbroeck, 2009) we have translated the recommendations of Verhallen and Walst (2007) into requirements for text books:

Language developing support tools	*Implementation in textbooks, educational technology and teaching methods*
Language input	– Increase pupils' involvement by using challenging contexts – Increase the comprehensibility through a well-considered language input and a good pronunciation of important information – Increase linguistic understandings by linking content to visuals and experiences – Challenge language abilities by bringing in new words and sentences.
Opportunity for language production	– Use active and cooperative learning strategies offering all pupils' enough time to speak. – Education technology offers supplementary opportunities for language production: task-sheets, digital interactions, …. – Encourage pupils' self-esteem by alluding to their interests so they can communicate with self-assurance about their assignments. – Support language output by using speech- and writing frames.
Feedback on language output	– Give feedback about the meaning of school words and low-frequent daily words using wordlists supported by visuals. – Verify interpretations through the use of linguistic exercises. – Use language oriented content exercises with structured feedback features.

Another result of the 'Gewetech-project' is the optimization of the language-content of the textbook 'Alimento'. More specific, we have made following adjustments:

– Making passive sentences active.
– Adding explanatory word-lists.
– Addition of speaking and writing frames for writing a report, formulating an opinion, describing a concept, describing differences or correspondences, giving an explanation.
– Addition of (self-) assessment tables for language-driven tasks such as giving a presentation, understanding subject-specific words, making arrangements for assignments.
– Addition of digital interactive exercises to train difficult words and meanings.

– The use of wordtables, flow-diagrams, mindmaps…. to make language-based associations in the process of a broad understanding of words and concepts.
– Applying observation lists consisting of questions for the pupils to support listening abilities when watching the accompanying educational film.
– Using 'concept cartoons' to enrich pupils' concepts about subject-specific words such as 'creativity' and 'technology, to support discussion and reflection on abilities for making technological choices in user-situations.
– Transforming some long texts in a more appealing narrative style.

Some examples of speak- and writing frames:
– Discribing differences:
"However ….and…are both…., there are a lot of differences. The…..is….,
while…….. They are also different because of …..
An other point of distinction is…..
Finaly….
– Self-assessment:
I can select difficult words in a text that I want to remember
I can build op a presentation with a opening, middle section and a conclusion
In chapter 13 of this book, Gerald Van Dijk gives examples for scaffolding a design assignment by the use of speaking frames and concept maps.

THE USE OF CONCEPT CARTOONS IN DEVELOPING LANGUAGE AND CONTENT

Concept cartoons are developed and described by Naylor & Keogh (2002) as an innovative pedagogy for science education. They focus on the development of naïve concepts in pupils. Posner (1982); and Driver (2000) have described their influence on conceptual change.

> Concept Cartoons are drawings with a number of characters making predictions about an experiment. Their predictions are based on naïve concepts typically found amongst pupils.
> These cartoons trigger interaction by stimulating debate about concepts in physics.
> Research shows positive results on the pupils' and teachers' perception of concept cartoons (Keogh and Naylor, 1999). The most important conclusions are:

– High motivation and involvement.
– Revelation of (naïve) concepts about scientific phenomena in pupils.
– Pupils train their abilities in communicating and adapting their concepts.
– The cartoons are a stimulus for further experimental learning.
– Concept cartoons support differentiation in the learning process.

The Gewetech project (Van de Velde, De Lange and Vandenbroeck, 2009) included also a registration of the perception of 133 high school students using concept cartoons in science lessons. We can confirm that the approach is appealing to students: 90% of them find it 'interesting' to 'very interesting'. We found no differences between boys and girls. 42% of them experience the lessons as being difficult. It is the same group that finds the lessons interesting. 66% report 4 or 5 on a scale from 1 to 5 indicating that concept cartoons are useful to become aware about their opinions and conceptions.

It is clear that the use of educational concept-cartoons is very supportive for student-interaction in lessons. Therefore, it is a promising approach for combining the learning of content and language.

- We recommend to explore the use of concept cartoons in technology education to clarify students conceptions about ‘technology’, ‘creativity’, ‘design’, ‘industry’…. An important requirement is the presence of some experience based cognitiveunderstanding in students. Otherwise, discussions will rapidly become sterile.
- Another possibility is the use of cartoons (or pictures with text-balloons) in discussing safety situations in technology-use. Here, the discussions are more oriented towards norms, rules and facts.
- Finally these educational tools are very useful to discuss the decision-making of technology users. Typical every-day situations can be enacted using three to five ‘actors’ to express opinions that are relevant in the process of decision making. For instance in buying, using or maintaining systems. The pupils must express factual understanding that is related to the context as well as the underlying values and ethical choices.
- The pedagogical use of concept photo’s or cartoons is demanding for teachers. There is a task-shift in the teaching towards more attention for coaching and scaffolding. The teachers’ speak time must be limited and it must be clear that the process of constructing answers by the pupilsis essential for their learning.

Providing a manual for teachers in their use of this educational tool is therefore necessarily.

Figure. concept photo discussing values in food-technology use.

CONCLUSION

Nowadays, modern technology education tends to become more language-driven. So it is important to be aware of possible obstacles in order to guarantee equal opportunities for non-native pupils and learners with low language abilities.

Social-constructive learning strategies can support powerful content-learning as well as developing language abilities.

A lot of strategies for language and content learning offer possibilities for the design of tasks in text-books enriching a toolbox for an active learning pedagogy.

The use of concept cartoons should be explored to help learners in developing conceptions about technology and in the process of technological decision-making.

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PROGRESSION IN THE CURRICULUM

VICKI COMPTON AND ANGELA COMPTON

PROGRESSION IN THE KNOWLEDGE AND PHILOSOPHY OF TECHNOLOGY

INTRODUCTION

Technology in New Zealand is and has been an essential learning in the New Zealand curriculum since the early 1990s. Successive New Zealand governments have supported national curriculum and classroom based research projects and professional development related to the development and implementation of technology as a learning area in its own right across compulsory and post-compulsory schooling (Compton, 2001; Ferguson, 2009). As introduced by Marc de Vries, and discussed by Gene Martin and others in this book, this position and research support is unlike many other countries. In 2007 the latest *New Zealand Curriculum* (*NZC*) (Ministry of Education, 2007) was published and a significantly revised technology curriculum was contained within this document. These revisions were based on an evaluation of the impact of the previous technology curriculum *Technology in the New Zealand Curriculum (TiNZC)* (Ministry of Education, 1995), and informed by additional policy-directed research (as discussed by Compton and France, 2007; 2008). The 2007 technology curriculum is structured around three strands and eight components[1] that together support the aim of technology education. This aim is to provide students with the opportunity to develop their technological literacy. As with the previous technology curriculum, the 2007 technology curriculum emphasises the importance of students undertaking their own technological practice and this is captured in the Technological Practice strand. However it also recognises the importance of generic technological concepts and philosophical understandings for student learning in technology and this was captured in the two additional strands of Technological Knowledge and the Nature of Technology. These strands were developed[2] to increase the depth, breadth and criticality of the technological literacy students had been developing when supported by programmes based on the previous curriculum. Underpinning this ‘expanded’ literacy is an exploration of the issues discussed by others in this book – see for example Jonas Halstrom, John Dakers, Lars Adiels, Aki Rasinen, and Leo Elshof.

Since 1993, all New Zealand national curricula have been ‘outcomes based’ with the proviso that all outcomes be described as achievement objectives that span eight progressive levels[3]. The achievement objectives are written to guide school programmes and classroom units of work and therefore provide coherent learning pathways for students from new entrant to year 10 (end of compulsory curriculum), and on to year 13 (final year of schooling) for those who choose to continue study in the learning areas. Technology, along with all other learning areas (science,

M.J. de Vries, Positioning Technology Education in the Curriculum, 191–216.

mathematics and statistics, the arts, English, health and physical education, learning languages, and social sciences), has therefore developed eight levelled achievement objectives for each of the identified components across the three strands. Previous research, (Compton & Harwood, 2003; 2005) and more than ten years of classroom implementation experience based on the 1995 technology curriculum, had resulted in detailed understanding of how student learning progresses within the components of the Technological Practice strand. The components within this strand are brief development, planning for practice, and outcome development and evaluation. However, when the 2007 curriculum was released research informed understanding of how student learning might progress had yet to be established for the components within the two new strands. The components within this strand are technological modelling, technological products, technological systems, characteristics of technology and characteristics of technological outcomes. Establishing the nature of progression for each of these components was therefore one of key aims of the Ministry of Education funded Technological Knowledge and Nature of Technology: Implications for teaching and learning (TKNoT: Imps) research project.

In this chapter we begin with an overview of the ‘outcomes based’ nature of national curricula in New Zealand and discuss progression in terms of constructivist and sociocultural learning theories. We also introduce what is meant by Indicators of Progression in the learning area of technology in New Zealand. We then provide an outline of the TKNoT: Imps research project and present findings from Stage One. Extracts from student interview data collected during this stage are used to illustrate student understanding reflective of levels 1–3. We conclude the chapter with a description of the overarching nature of progression underpinning each component of the Technological Knowledge and Nature of Technology strands in the *NZC* (Ministry of Education, 2007).

OUTCOMES BASED CURRICULA AND PROGRESSION

National curriculum development in New Zealand, and therefore technology curriculum development as part of this, has undergone a significant shift since 1993. This shift can be described as a move away from largely behaviourist theories of learning that led to curricula as prescriptive ‘bodies of knowledge’ to be taught, towards constructivist theories of learning leading to curricula as ‘outcomes based’. In both the *NZCF* (Ministry of Education, 1993) and the *NZC* (Ministry of Education, 2007), knowledge is presented as a social construct and viewed as developed by and inseparable from the ‘knower’. This resulted in a strong focus on ‘*knowing’* as well as ‘*doing’* in national curriculum development work and resulted in less specific and more process oriented outcome based documents. Much was also written in these documents and supporting material about the importance of prior knowledge to student future learning and the impacts of social, cultural and physical location on the learning environment.

During the same time frame sociocultural theories of learning were informing much of the research related to technology education in New Zealand. Packer discusses sociocultural views of learning as arising from a non-dualistic ontology whereby "…coming to know is a part of a larger process of coming to be a particular kind of person." (2001, pg 504). Learning theories and models, such as situated cognition (Brown, Collins and Duguid, 1989), apprenticeship models (Rogoff, 1991) and learning through participation in communities of practice (Lave and Wenger, 1991; Lave 1993), have provided foundational work for researchers in technology education in New Zealand to date.

Sociocultural views, like constructivist views, perceive knowledge as evolving and intimately connected with the knower. However, unlike sociocultural views, Packer and Goicoechea (2000) argue that all constructivist stances are underpinned by dualist ontology, albeit often unacknowledged, due to their Kantian and Descartian philosophical roots. Therefore, while recognising the importance of the social, knowledge can still be identified and described as separate to the context of its construction. As such, constructivism has no problems with the notion of identifying broad outcomes that should provide a focus for student learning prior to the learning experience. Identifying and addressing ideas or practices that students may already hold, particularly those that differ from those currently validated by the discipline, is seen as crucial to inform teaching. This contrasts with a sociocultural point of view, where learning is described as a transformation of being. Therefore to pre-determine the 'outcomes' of future learning experiences is somewhat problematic.

These two theoretical positions lead to differences in how progression is conceptualised. Progression from a constructivist perspective is described as students constructing "qualitatively different" and "progressively more adequate" (Packer and Goicoechea, 2000) knowledge and/or practices as a result of their learning experiences. Within the framework provided by the *NZC* (Ministry of Education, 2007), this progressively more adequate knowledge and/or practice is focused around the agreed to 'big ideas' of each learning area and give rise to the levelled achievement objectives. From a sociocultural perspective however, progression rests on the concept of student transformation due to the development of a holistic competence or 'literacy' in a learning area.

The differences inherent in the constructivist technology curriculum and the more sociocultural technology research tradition can work effectively together to enhance learning opportunities for students. This stance is supported by other authors who support a synthesis of constructivist/cognitive and sociocultural/ situative approaches. For example, Cobb (1994) suggests each "tells half a good story" (cited in Packer and Goicoechea, 2000, pg 227), and Greeno suggests working in both cognitive and situative perspectives may both "inform and challenge" and thus lead to "more comprehensive and coherent theories of learning and contribute more productively to discussions of educational practice." (Greeno, 1997, pg 15).

Based on this, we argue a constructivist outcomes based curriculum provides a strong direction for the development of technology programmes that can be supported by sociocultural learning models. Such models serve to embed the outcomes in technology programmes that support students to know and act in ways informed, but not constrained, by them. That is, to borrow from Capra's description of social networks (2002, pg 79), the described outcomes embodied in material structures such as curriculum documents provide important 'semantic social structures' (ideas, values, beliefs and other forms of knowledge). These are then available to work alongside the more socioculturally located 'emergent structures' that arise from the educational network as it exists with bounded communities of practice (Capra, pgs 105–106). Thus, in keeping with Capra's assertion that both 'designed social structures' and 'emergent structures' are critical to the health of a creative and successful social network, we can draw from understandings provided from both these structures when supporting the educational networks teachers and students are involved in.

The achievement objectives can therefore be understood and valued as constructivist-based progression tools for technology education that also allow opportunity for students' emerging technological literacy. That is, descriptions of progression in terms of student transformation into more 'technologically literate' beings.

INDICATORS OF PROGRESSION – EVIDENCE-BASED MEDIATION TOOLS TO SUPPORT ACHIEVEMENT OBJECTIVES

As clearly outlined in the *NZC,* teachers are given the task of interpreting the national curriculum into an appropriate school curriculum that meet the needs and desires of the school community and the social, cultural and geographical locations of the students within it (Ministry of Education, 2007, pgs 37–45). Similar to 'Attainment Targets' in other international curricula, the *NZC* achievement objectives are somewhat vague statements that attempt to capture a number of 'big ideas and/or practices' for each of the learning areas. These statements have been developed from an analysis of what is deemed of value within the wider discipline in which the learning area resides. The vagueness of the achievement objectives requires extensive professional understandings on behalf of teachers if they are to interpret them as intended. This requirement has in the past proven problematic for teachers in the relatively young learning area of technology. Earlier work undertaken to support teacher understandings of technological practice, as intended by *TiNZC* (Ministry of Education, 1995), resulted in the development of a mediating tool that served to make the achievement objectives more useful for teachers (Compton and Harwood, 2005). This tool is known within the technology education community of New Zealand as the technology Indicators of Progression.

Unlike the levelled achievement objectives for each 'big idea' located in the three strands of technology (referred to earlier as components of technology), the Indicators of Progression have arisen from an analysis of *student data* and are therefore more useful for teachers than the achievement objectives which have been derived from an analysis of the discipline. They are more useful as they reflect how students learn and what students can articulate and do and then capture these as student indicators. These indicators have been shown to be powerful tools for teachers as they attempt to develop programmes of learning and focused units of work, support formative interactions in their classrooms, and identify 'next steps' for student learning. Teacher guidance is also provided in the Indicators of Progression in terms of the sorts of learning experiences that could provide opportunities for students to progress from one level to the next. Because the indicators sit under each of the achievement objectives they also provide tools for teachers to help gather assessment data to make summative judgments against the achievement objectives. In so doing they enable teachers to report on student achievement in terms of the national curriculum at the end of a learning programme.

TECHNOLOGICAL KNOWLEDGE AND NATURE OF TECHNOLOGY: IMPLICATIONS FOR TEACHING AND LEARNING (TKNOT: IMPS) RESEARCH PROJECT

Research Aims

The key aim of the TKNoT: Imps research was to explore the components of the two new strands of the reviewed 2007 technology curriculum to validate and further describe how these components might progress from level 1–8 as outlined in the levelled achievement objectives of the *NZC* (Ministry of Education, 2007) and described in an initial set of draft Indicators of Progression for each component of the TK and NoT strands. This draft had been published in 2007 as an interim measure only. They had been derived directly from the achievement objectives rather than from student data and were in need of significant work. This aim was therefore the main focus for Stage One. An additional aim was to gain understanding of the pedagogical requirements for the implementation of the components within the Technological Knowledge and Nature of Technology strands in New Zealand classrooms. This second aim was the main focus of Stage Two of the research.

Methodology

The TKNoT: Imps project employed a critical social science research approach. Critical social science upholds an ontological view of the world as 'real' but 'knowable' only as mediated by people within the sociocultural setting they inhabit. It supports an epistemological stance that recognises that different disciplines will validate knowledge on their own agreed criteria, and thereby lends support to both sociocultural and constructivist learning theories. Such a methodological framework therefore, is well suited in terms of purpose and theoretical underpinnings for explorations in the field of technology education in New Zealand as described above. This approach allowed for a "critical process of inquiry that goes beyond surface illusions to uncover the real structures in the material world in order to help people change conditions and build a better world for themselves" (Neuman, 2003, pg 81). As such, it allowed opportunity to explore and understand the complexities of the technology education world in order to empower teachers to make changes for themselves and their students. Not only did the research seek to make changes for the teacher and student participants involved, it also provided insight into how similar changes could be mediated outside of the research site through the research informed revision of the Indicators of Progression for the five TK and NoT components. Three research stages were developed to address the research aims.

Stage One

Stage One of the research began in November 2007 and ended in February 2009. This stage was non-interventionist in nature in that we did not require teachers to change their current technology programmes, but rather embed one or more of the new components into a current unit of work. Most teachers were teaching units focused on technological practice and therefore found it relatively easy to select a particular component and add this as an additional focus in their teaching. Each teacher was supported by the researchers to do this. Originally we had planned to collect relevant student data from portfolios/workbooks at the completion of each teacher's unit of work. However, it became apparent that much of this data was not focused enough on the new components to provide substantive material for analysis. At this point, we decided to select students from each class and interview them to supplement the data. In many cases, the interview data became our sole data source. The interviews used semi-structured interview schedules developed for each component. An 'instance' of some sort (scenario, pictures, technological products, systems) provided the focus for student discussion and therefore the generation of relevant data. All selected students from years 1–13 were interviewed using the same schedules in order to increase the likelihood of gaining data that would be useful in rewriting the Indicators of Progression for each component.

The 2007 draft Indicators of Progression provided a focus for the teacher's planning during this stage and were also used in the analysis of student data. Using the Indicators of Progression in this way allowed for substantial critique of the initial draft and resulted in them being significantly rewritten as the key outcome of Stage One. Findings from this stage of the research are presented in detail below.

Stage Two and Three

Stage Two began in March 2009 and was completed in February 2010. This stage of the research used the rewritten Indicators of Progression from Stage One to support teachers as they developed and trialed pedagogical strategies to enhance learning in terms of the TK and NoT achievement objectives. Stage Three of the research trialed two component-related tools (one focused on Characteristics of Technology and one on Technological Modelling) developed to attempt to push student achievement above level 4. Findings from Stages Two and Three will be provided in subsequent research papers.

Participants

A total of 36 teachers and 22 schools were involved in Stage One, geographically spread across New Zealand. Eight (22.2%) of the teachers were in Northland schools, seven (19.5%) in Auckland, four (11.1%) in Waikato, thirteen (36.1%) in

Wellington, and four (11.1%) in Canterbury. Eighteen teachers (50%) were from the primary sector (year 1– 8), with the remaining 18 teachers (50%) being from the secondary sector (year 9–13). Twenty five (69.5%) of the participant teachers were female with the remaining 11 being male (30.5%). Ten of the 18 secondary teachers (55.5%) were male, showing a relatively even gender split in this sector. However, 17 of the eighteen primary teachers (94.4%) were female. This is in keeping with New Zealand primary sector demographics. Twenty two of the teachers (61%) had some form of specialist technology teacher education, with the remaining 14 (39%) coming through generalist primary initial teacher education programmes. Twelve of the teachers (33.3%) were currently employed as generalist teachers (teaching across all curriculum areas), with the remaining 24 teachers (66.7%) teaching with some element of specialisation, loosely related to the technological areas[4] in the *TiNZC* (Ministry of Education, 1995).

FINDINGS FROM STAGE ONE

As mentioned above, the key outcome from Stage One of the research was the rewriting of the draft Indicators of Progression for the components of the TK and NoT strands. The revisions were based on the analysis of student data (as described below) and on teacher feedback from working with the earlier draft. The 'student indicators' were revised to better reflect student learning and significant changes made to clarify how learning progressed across levels 1 to 4 in particular. The original 'learning environment' section was also reviewed in an attempt to more clearly communicate the support required for key shift/s between levels. This was now named 'teacher guidance'. A complete set of revised Indicators of Progression were published in April 2009 on the techlink website[5]. The April 2009 student indicators for level 1–3 are provided in Tables 2b-6b below.

Data Collection and Analysis Focus

A total of 359 interviews were completed and used as a basis for reviewing the draft Indicators of Progression for TK and NoT. While some additional data was collected from student portfolios/workbooks, the interviews provided the richest data source. The data was coded as reflective of a particular level and then sub-coded within levels as a, b or c. For example, if a student was coded as 1a this referred to student understanding as being at beginning level 1 with more learning experiences at this level being required. 1b referred to student understanding reflective of working comfortably at level 1 but still requiring further consolidation learning experiences at this level. Level 1c referred to student understanding reflective of a comprehensive understanding of level 1 concepts and showing a readiness for future learning experiences at level 2. The revised 'student indicators' made these within-level judgments relatively easy to make. If students didn't show evidence of any level 1 ideas, the student was coded as 0 in the Tables 2a–6a.

The number of interviews undertaken for each component is provided in Table 1 below.

Table 1. Summary of Component Coverage in Interviews

Components of NoT and TK					*Total*
CoT	CoTO	TM	TP	TS	
81	55	78	92	53	359

A summary of the questions asked in the interview is provided for each component below. Tables 2a–6a provide an overview of the findings. Tables 2b–6b present the Level 1–3 achievement objectives and 'student indicators' and extracts that illustrate the type of explanations students provided.

Data for Characteristics of Technology (CoT)

In the CoT interview students were asked a range of questions about a scene from the past and then showed two pictures of the same man – one in a suit and the other in running shorts with his prosthetic legs clearly visible. The students were asked questions focused around such things as: what they identified as technology, how they would describe technology, how they think technology has changed, why they think technological change occurs, how technologists work, and the ethics involved in extending human capability.

Table 2a. Level Distribution of Students for Characteristics of Technology (n=81)

Level	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
#	19	43	16	3	0	0	0	0	0
%	23.4%	53.1%	19.8%	3.7%	0	0	0	0	0

Table 2b. Characteristics of Technology Indicators and Illustrative Data

Level 1 Achievement Objective - Students will: Understand that technology is purposeful intervention through design. **Student Indicators** - Students can: • identify that technology involves people designing and creating technological outcomes for an identified purpose • identify that technological practice involves knowing what you are making and why, planning what to do and what resources are needed, and making and evaluating an outcome.
I = Interviewer **S** = 7/6/2/2[6] **I**: Can you identify anything in this picture as having to do with technology? **S**: The TV, the light… the clock and the phone… and is that a vacuum cleaner? Yep that would be… **I**: Why do you think those things have something to do with technology? **S**: 'Cos they've all been invented… and before you didn't have them. **I**: How do you think technologists develop new things? **S**: They look at old designs and try and improve them… they imagine it in their heads and then they build it…. They have got to have drive – and they need to know what they are doing. If you plan something and don't write it down… you might forget it. ***This student was coded as 1b as he showed an appreciation of technology involving people creating things for a purpose – to improve them. He also described some aspects of technological practice, namely knowing what they want to make and why, some level of planning and the actual making of the outcome.***

Table 2b. Characteristics of Technology Indicators and Illustrative Data (cont.)

Level 2 Achievement Objective - Students will: Understand that technology both reflects and changes society and the environment and increases people's capability. **Student Indicators -** Students can: • identify influences on particular technological developments • identify how particular technological outcomes have changed how people do things • describe examples to illustrate how a technological development has had a positive impact on society and/or the environment • describe examples to illustrate how a technological development has had a negative impact on society and/or the environment.
I = Interviewer **S =** 4/9/2/1 **S:** Technology is anything manmade (sic) that we can use to help us in our everyday lives… so it's not just computers… or electrical things… but lots of other things as well. Like things to help us cook… anything that is advanced – that we have developed. **I:** What do you think influences what is developed? **S:** Probably what people like… their choices… if we don't really like something we don't want to develop it further. But if people come up with ideas that are good and practical and people like it then it can be developed further. **I:** Are all technologies good do you think? **S:** Ummm – no… like nuclear advancements… they were good to get nuclear power but now people are using it to get nuclear weapons and threatening to use these weapons to kill people. But other things… like houses – the way we develop houses, through architecture and that, that is good for people… it doesn't really hurt people. ***This student was coded as 2a as he identified one of the drivers of technological development as human desire and acceptance of a development. He also outlines examples of technological developments that have had negative and positive impacts on the people.***
Level 3 Achievement Objective - Students will: Understand how society and environments impact on and are influenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function. **Student Indicators -** Students can: • describe examples to illustrate how social and/or environmental issues have influenced the technological practice undertaken. • explain why particular technological outcomes have changed over time • describe examples to illustrate how technological developments have changed society over time • describe examples to illustrate how technological developments have changed physical environments over time • explain that technological knowledge is evaluated in terms of how effective it is in supporting an outcome to function successfully

Table 2b. Characteristics of Technology Indicators and Illustrative Data (cont.)

I = Interviewer **S =** 2/6/1/4 **S:** The clock… because clocks used to be like a grandfather clock and take up lots of space and had to be hand wound and now clocks are really modern, like digital clocks. And the TV – they used to be like that (points to TV in picture) and take up a lot of space but now you can get portable TVs… lights – they used to be quite plain but now you can get all sorts of shapes – like an egg, and lots of colours. The rug – it is technology as well and now you get things like anti-allergenic rugs. Often things change because different people take over things – like the newspaper, and they might change the format…and what is in it changes… the news changes. **I:** Why do you think these changes happen? **S:** Because humans have different needs. Sometimes humans can be too lazy to do stuff so they want technology to do it for them. Or they want special things that suit their needs. Space is a big thing… they needs things now that don't take up too much space – like the clock and TV… and the mat being anti-allergenic. If you have a child with asthma or hay fever then you need a mat or carpet that suits their needs… also new materials can mean you can do different things. **I:** How do you think technologists develop new stuff **S:** They probably have people going around and surveying people about what they don't like about what they have, or what they might like to see in the future, and they can go from there. Or what suits them… or just stuff to make things better. Then technologists need skills to successfully plan things out, probably have to be quite good with ideas and they need to be critical thinkers. If you can't think critically about something you can't think what needs to change. ***This student was coded as 3a as she described a number of whys in which technological outcomes have changed over time and explained some of these in terms of key drivers – mostly human needs, but mentions also how different materials change what it possible to develop. She begins to discuss the way in which technological outcomes can change the physical environment for people in terms of the anti-allergenic rug explanation.***

Characteristics of Technological Outcomes (CoTO)

During the CoTO interview the students were given a pen used to advertise a business. The students were asked questions focused around such things as: is a pen technology, how they would describe the pen (prompting for physical and function nature), how they think it works, why they think it was designed, who might it be designed for, could it be used for other things, and what would a pen they designed be like.

Table 3a. Level Distribution of Students for Characteristics of Technological Outcomes (n=55)

Level	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
#	8	24	21	2	0	0	0	0	0
%	14.6%	43.6%	38.2%	3.6%	0	0	0	0	0

Table 3b. Characteristics of Technological Outcomes Indicators and Illustrative Data

Level 1 Achievement Objective - Students will: Understand that technological outcomes are products or systems developed by people and have a physical nature and a functional nature. **Student Indicators -** Students can: • explain that technological outcomes are made by people • describe selected technological outcomes in terms of their physical nature • describe selected technological outcomes in terms of their functional nature
I = Interviewer **S =** 16/5/1/1 **I:** Can you describe this pen for me? **S:** It's got a little clip so you can clip it on to your shirt… and it's got a little grippy part down here… and it has got a button up here so it can go in and out. And its blue – that's all I can think of. ***This student was coded as 1a as she described one aspects of the pen's physical nature – its colour, and identified the functional nature of some of the pen's parts, that is, the clip, grip and button.***
Level 2 Achievement Objective - Students will: Understand that technological outcomes are developed through technological practice and have related physical and functional natures. **Student Indicators -** Students can: • explain how a technological outcome can be distinguished from other things created by people • identify a technological outcome as a product and describe its physical nature in terms of the materials it is made from • identify a technological outcome as a system and describe its physical nature in terms of the components within it and how they are connected • identify links between the physical and functional attributes of particular technological outcomes
I = Interviewer **S =** 16/6/2/4 **I:** Can you describe this pen for me? **S:** It is meant for writing something… so you can get ink on to a paper so you can write something. It has also got a grip so you don't slide off and make a mistake. It has a button on the end with a spring so it pushes the end in and out. It has got a clip so you can put it on your shirt. It is blue… and has got ink inside it. It is made of plastic with some metal inside it. ***This student was coded as 2a as he related components of the pen and suggested how they might be linked in order to allow the pen to function as it does. He also identified the overall function of the pen and named materials. However he made few links between how the materials related to the functional nature of the pen.***

Table 3b. Characteristics of Technological Outcomes Indicators and Illustrative Data (cont.)

Level 3 Achievement Objective - Students will: Understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures. **Student Indicators -** Students can: • describe possible physical and functional nature options for a technological outcome when provided with a need or opportunity • describe examples of technological outcomes with different physical natures that have similar functional natures • describe examples of technological outcomes with different functional natures that have similar physical natures • explain the relationship between the physical and functional nature of selected technological outcomes.
I = Interviewer **S** = 14/8/2/2 **I:** Can you describe this pen for me? **S:** There is a pointy end with a hole in it for the ink to come out of. Clip to clip on to your pocket. It's round… and at the other end is a knob you can press down to get out the ink… but then push again to stop the ink getting in your pocket when you are not using it. It's got a rubber grip for comfort and it's got an advert on it. So…it's used for writing and advertising. It's good to use a pen to advertise because everybody uses pens and when you write you are thinking and you might look at your pen and go ahhh I might use that business or whatever. **I:** Can you think of any ways this pen could be improved? **S:** One thing is I would change is that… I can put my hand in my bag and accidently click it and I find that annoying so I would probably make it so it is more hidden – so you have to turn it on more intentionally. And I would have the grip a bit lower so you have more control and I don't really mind but lots of people when they use this they would get a bump on there finger 'cos the rubber is very thin… its more like for show. So you could get pens with like air in there so it is more comfortable and your finger fits in more… tightly I guess… more to the shape of your finger. ***This student was coded as 3a as he discussed that something with the same physical nature could have more than one functional nature. In this case, he discussed the fact this pen could function as a writing device as well as an advertising tool. Later in the interview he gave a detailed explanation as to how the physical nature of the pen (the clicking component, and the grip) could be changed to enhance the functional nature.***

Technological Modelling (TM)

During the TM interview the students were initially asked about modelling in technology and then provided with the scenario that they were to design a playground. The students were asked questions focused around such things as: describing a model, describing a prototype, different types of modelling, modelling in technology and what modelling might help them design a playground.

Table 4a. Level Distribution of Students for Technological Modelling (n=78)

Level	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
#	9	39	22	8	0	0	0	0	0
%	11.5%	50%	28.2%	10.3%	0	0	0	0	0

Table 4b. Characteristics of Technological Modelling Indicators and Illustrative Data

Level 1 Achievement Objective - Students will:
Understand that functional models are used to represent reality and test design concepts and that prototypes are used to test technological outcomes.
Student Indicators - Students can:

- explain that technological outcomes are made by people
- describe selected technological outcomes in terms of their physical nature
- describe selected technological outcomes in terms of their functional nature

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I = Interviewer **S =** 9/5/1/3
I: What do you think a model is?
S: Something that's not real…
I: What do mean by not real? Think about what you did in you made your Matariki[7] biscuits… did you make any models?
S: We had to make it out of paper first to see how it looked… to see if it looked good. We used black crayon to show the night and the stars to show Matariki

This student was coded as 1a as she showed a beginning understanding of modelling as representing something 'real' for the purpose of testing out the design idea prior to making the biscuits.

Level 2 Achievement Objective - Students will:
Understand that functional models are used to explore, test, and evaluate design concepts for potential outcomes and that prototyping is used to test a technological outcome for fitness of purpose.
Student Indicators - Students can:

- explain that the purpose of functional modelling of design ideas allows for the gathering of specific information about the possible nature of a potential technological outcome
- describe examples to illustrate how functional modelling has been used to test design ideas and develop conceptual designs
- describe examples to illustrate how prototyping has been used to test technological outcomes
- discuss the importance of functional modelling and prototype testing in the development of technological outcomes.

Table 4b. Characteristics of Technological Modelling Indicators and Illustrative Data (cont.)

I = Interviewer **S** = 4/9/2/1 **I:** What do you think technological modelling is? **S:** Anything that you can use to help you visualize the outcome that you want to get… for example like storyboards, maybe trials… for example, in Jurassic Park they made short animated sequences to show the director… 'cos they were developing the equipment… the tools… like CGI they were using… so they needed something else to show and test what it had to do. We are using PowerPoint to do the same sort of thing before we make our film with movie maker. **I:** So why do you want to do that? Why not just go ahead and make it? **S:** Well in the case of Jurassic Park… the director wanted to get realistic looking dinosaurs… so by trialing more advanced animation techniques they could show that it would be better than using models and stop/go techniques. ***This student was coded as 2b as he showed an understanding of the impact that modelling can have on the way an outcome is developed as well as the nature of the outcome itself.***
Level 3 Achievement Objective - Students will: Understand that different forms of functional modelling are used to inform decision making in the development of technological possibilities and that prototypes can be used to evaluate the fitness of technological outcomes for further development. **Student Indicators -** Students can: • explain that different forms of modelling provide different types of evidence • discuss examples to illustrate how particular models were developed to gather specific data to inform decision making • identify the benefits and limitations of functional modelling undertaken in particular examples • describe examples to illustrate how prototypes were tested to evaluate a technological outcome's fitness for purpose and to identify any need for further development.
I = Interviewer **S** =23/12/2/6 and 23/12/2/7 **I:** Tell me about the technological modelling have you undertaken? **S6:** We had four of these ones and we developed them a bit better and then we did pros and cons and conclusions…After we choose one we developed it more and came up with more ideas of what we could do with them and went into depth with how they were made and what the frames were like and so we did little mock ups. **I:** What was the purpose of the mock-ups? **S6** and **7:** Part of the brief was that they had to be movable… portable and easily taken down and put up… **S6:** so our stairs were going to be made of individual pieces… so this is just a little mock up of the frame locking in to each other. And this mock up here is my handrail… it has Perspex in it so we could put a sand blasted logo on it that would light up. So we did a mock-up of that and went out to the cupboards and tried it out. After we came up with our final designs and made models of them we met with the stakeholders… and went through the pros and cons… they liked parts of both of our ideas….so we combined ideas… and came up with another model.

Table 4b. Characteristics of Technological Modelling Indicators and Illustrative Data (cont.)

S7: So we did a bigger model then to see how it came together more - to show what it looked like… **I:** Why was the bigger one was better? **S7:** well this one we went a little bit further and put in the handrail as well… **S6:** …and it was easier to work with because this was to scale… we could actually use it (for the actual build). In the real build (prototype development) we could work out than when we walked on it…it actually gave way… so we had to go back (to our design) and fix that… ***These students were coded as 3c as they confidently discussed how different forms of models provided different information that informed their decision making and talked about limitations of their models. The 'real build' was crucial to test the actual function and for further refinement.***

Technological Products (TP)

During the TP interview the students were given an unknown technological product. The students were asked questions focused around such things as: identifying the materials it was made from, why those materials were selected, what other materials could be used, how the materials allow it to work, and what happened to the materials in making the product.

Table 5a. Level Distribution of Students for Technological Products (n=92)

Level	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
#	6	48	38	0	0	0	0	0	0
%	6.5%	52.2%	41.3%	0	0	0	0	0	0

Table 5b. Characteristics of Technological Products Indicators and Illustrative Data

Level 1 Achievement Objective - Students will: Understand that technological products are made from materials that have performance properties. **Student Indicators -** Students can: • identify materials that technological products are made from • suggest why the materials used in particular technological products were selected • identify that materials have been shaped, joined and/or finished to make a technological product

Table 5b. Characteristics of Technological Products Indicators and Illustrative Data (cont.)

I = Interviewer **S** = 6/6/2/5
I: Can you tell me about the materials this is made from?
S: Its got metal and its got wood on it.
I: What do you think has happened to the materials to make that object?
S: They would probably have to bend the metal and probably shaved the wood.
I: Why do you think these materials were selected?
S: Maybe to cut stuff on the side… 'cos it looks a wee bit sharp.
I: So why do you think they've used wood for the handle?
S: Maybe because they didn't want to make it in plastic 'cos it might break…and they wouldn't use metal because it wouldn't be good and your hand would slip off…
I: So what is it about the wood that stops your hand slipping off?
S: Maybe because it has got better grip and these wee lines (referring to grain) and it has got this (referring to the shape) 'cos they had to shave it off.

This student was coded as 1c as he could identify the materials used in the object and how they may have been manipulated to make the product. He suggested why wood was chosen and linked this to the properties (grain and ability to be shaped), however he could not do the same for the metal.

Level 2 Achievement Objective - Students will:
Understand that there is a relationship between a material used and its performance properties in a technological product.
Student Indicators - Students can:

- describe the performance properties of particular materials
- identify the performance properties of materials used in particular technological products

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I = Interviewer **S** = 14/8/2/2
I: Can you tell me about the materials this is made from?
S: Its got a wooden handle and its got steel coming out of the handle…I don't what type of steel it is… it is metal… its chrome… steel is a very hard object and most steel's rust but only in conditions… wood doesn't conduct electricity and keeps heat off… so if this part (pointing to metal) gets hot it doesn't matter.

This student was coded as 2b as he described some properties of materials generally and also identified the properties of wood that made it suitable for use in this object.

Technological Systems (TS)

During the TS interview the students were initially asked about systems in technology and then given lighting device as an example of a technological system. The students were asked questions focused around: what a technological system is, how the light might work, what it was made of, how parts might be connected and how the way it worked could be described in symbols.

Table 6a. Level Distribution of Students for Technological Systems (n=53)

Level	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
#	17	23	11	2	0	0	0	0	0
%	32%	43%	21%	4%	0	0	0	0	0

Table 6b. Characteristics of Technological Systems Indicators and Illustrative Data

Level 1 Achievement Objective - Students will: Understand that technological systems have inputs, controlled transformations, and outputs. **Student Indicators -** Students can: • identify the components of a technological system and how they are connected. • identify the input/s and output/s of particular technological systems. • Identify that a system transforms an input to an output.
I = Interviewer **S =** 7/6/1/12 **I:** What do you think a system is? **S:** A system is lots of little things built together to make one big thing… it has an input that makes an output… **I:** What would make a system a technological system? **S:** It would probably have a lot more pieces – like a lot more steps to make the thing…it will be technical. **I:** Look at this (light) do you think this is a technological system? **S:** It would be… pretty much putting everything together… that is technical… 'cos you have a lot of little things in there. **I:** Can you name the parts that might be in there? **S:** There's got to be some sort of battery and little wires…and a microchippy thing in there to make things do as they do. **I:** Can you explain what might be happening in terms of inputs and outputs? **S:** The inputs are the things like the battery and the wires and the output is the torch… ***This student was coded as 1a as although she had a reasonably good understanding about what a system was she found it difficult to determine what a technological system was. She identified components of the light, however goes on to describe these as being the inputs of the system with the lighting device itself being the output.***
Level 2 Achievement Objective - Students will: Understand that there are relationships between the inputs, controlled transformations, and outputs occurring within simple technological systems. **Student Indicators -** Students can: • describe the change that has occurred to the input to produce the output in simple technological systems • identify the role each component has in allowing the inputs to be transformed into outputs within simple technological systems.

Table 6b. Characteristics of Technological Systems Indicators and Illustrative Data (cont.)

I = Interviewer **S =** 18/13/2/8 **S:** A system is a series of related processes… it has inputs and outputs plus feedback. A torch is a technological system – you have the battery that provides the input…and the switch which is there for the user to turn it on and off. You have your process making sure the current is running to the LEDs and things like that… making sure its doing what the user wants it to do. And the output is the light… ***This student was coded as 2a because he described the role of components in allowing input to be transformed into outputs within the system.***
Level 3 Achievement Objective - Students will: Understand that technological systems are represented by symbolic language tools and understand the role played by the "black box" in technological systems. **Student Indicators -** Students can: • describe what a 'black box' is within a technological system • identify possible advantages and disadvantages of having black boxed transformations within particular technological systems • describe technological systems using specialised language and symbol conventions.
I = Interviewer **S =** 3/12/2/1 **I:** What do you think a technological system is? **S:** They all have inputs, control, storage, processing and then finally an output… they all must have these things to do what they do…For example the door closing mechanism… its going to take the position of the door where it is and a spring that's going to change… it has got the input of the force of the door needing to close, its going to change based on that…so the output is the door slowly closing … **I:** Have you heard of the term black box? **S:** Yes a black box can be all kinds things. The whole idea of them is that it works and it's a finalised component within a product. So… an example is this heater here is like a black box to me… I don't need to know worry about how it works – it just heats. As long as I don't need to change it in any way, I'm simply happy with the output it gives me… I just need to plug it in. **I:** Have you got black boxes in the work you are developing? **S:** As the programmer it is less of a black box than it is to the stakeholder… the students who don't have to understand how the coding works. But we still have black boxes… the basis behind C sharp at the moment we've been told to stay away from it… because its just too complex… it could easily change everything we've built so far… we don't need to adapt it because it can still suit our purpose. ***This student was coded as 3b as he was able to explain what a black box is and the role it can play with regards to technological systems. He also recognised that components that may be black boxes for users are generally not for developers, however in some instances, even developers may black box components in their development.***

As can be seen from the 'a' tables above, the majority of students across all components were categorised as showing understandings at level 1 or 2. For CoT however, there was a more even split between students coded as 0 and levels 1 and 2. Very few students showed understanding above level 2 particularly related to TP (no students), CoTO (two students) and TS (two students) and CoT (three students). A slightly higher number of students showed level 3 understandings related to TM - although this was still only eight students or 10.3%.

Possible Trending by Year Group

A further analysis of the data by student year group was undertaken. Tables 7–11 provide an overview of the relationship between each component, level and year group.

Table 7. Relationship between Year Group and Level Distribution for Characteristics of Technology

	Level					
Year Group	**0**	**1**	**2**	**3**	**4**	**Total # in Year Group**
4	3	0	0	0	0	**3**
5	2	4	0	0	0	**6**
6	7	11	1	1	0	**20**
8	0	5	0	0	0	**5**
9	1	3	6	0	0	**10**
10	3	5	2	0	0	**10**
11	3	5	6	0	0	**14**
12	0	4	1	1	1	**7**
13	0	6	0	0	0	**6**
Total # at Level	**19**	**43**	**16**	**2**	**1**	**81**

There was a slight positive trending in level with increased year group although there was some disruption of this at year 6 and 13.

Table 8. Relationship between Year Group and Level Distribution for Characteristics of Technological Outcomes

	Level					
Year Group	**0**	**1**	**2**	**3**	**4**	**Total # in Year Group**
5	1	3	0	0	0	**4**
6	2	7	3	0	0	**12**
7	2	2	1	0	0	**5**
8	1	4	4	1	0	**10**
9	0	1	2	0	0	**3**
10	2	1	1	0	0	**4**
11	0	2	3	0	0	**5**
12	0	4	7	1	0	**12**
Total # at Level	**8**	**24**	**21**	**2**	**0**	**55**

Table 9. Relationship between Year Group and Level Distribution for Technological Modelling

	Level					
Year Group	**0**	**1**	**2**	**3**	**4**	**Total # in Year Group**
5	5	3	0	0	0	**8**
6	3	7	1	0	0	**11**
7	0	2	0	0	0	**2**
8	1	11	3	0	0	**15**
9	0	6	3	0	0	**9**
10	0	1	1	0	0	**2**
11	0	6	3	4	0	**13**
12	0	2	7	3	0	**12**
13	0	1	4	1	0	**6**
Total # at Level	**9**	**39**	**22**	**8**	**0**	**78**

A positive trending with increased year group was also apparent for both these components.

Table 10. Relationship between Year Group and Level Distribution for Technological Products

					Level	
Year Group	**0**	**1**	**2**	**3**	**4**	**Total # in ear Group**
5	3	2	0	0	0	**5**
6	1	12	3	0	0	**16**
7	1	7	2	0	0	**10**
8	0	11	5	0	0	**16**
9	0	2	5	0	0	**7**
10	0	3	2	0	0	**5**
11	0	4	8	0	0	**12**
12	0	2	8	0	0	**10**
13	1	5	5	0	0	**11**
Total # at Level	**6**	**48**	**38**	**0**	**0**	**92**

There was a slight positive trending with increased year group although there was some disruption of this at year 13.

Table 11. Relationship between Year Group and Level Distribution for Technological Systems

	Level					
Year Group	**0**	**1**	**2**	**3**	**4**	**Total # in ear Group**
5	0	2	0	0	0	**2**
6	7	10	3	0	0	**20**
7	0	2	3	0	0	**5**
11	6	2	1	0	0	**9**
12	3	5	3	2	0	**13**
13	1	2	1	0	0	**4**
Total # at Level	**17**	**23**	**11**	**2**	**0**	**53**

There is no discernable trending by year group shown for this component.

Possible Difference by Gender

A further analysis of the data was also undertaken to determine any difference by gender. Tables 12–16 provide an overview of the relationship between each component, level and gender.

Table 12. Relationship between Gender and Level Distribution for Characteristics of Technology

Level	*0*	*1*	*2*	*3*	*4*
Girls	9	22	2	1	0
(n=34)	26%	65%	6%	3%	0%
Boys	10	21	14	2	0
(n=47)	21%	45%	30%	4%	0%

While these results suggest that a greater percentage of boys in this cohort showed level 2 or above understandings, 70% of the girls in this cohort were from year groups 4–8, whereas only 34% of the boys were from these lower year groups. Taking this into account, no gender difference was apparent.

Table 13. Relationship between Gender and Level Distribution for Characteristics of Technological Outcomes

Level	*0*	*1*	*2*	*3*	*4*
Girls	2	10	7	1	0
(n=20)	10%	50%	35%	5%	0%
Boys	6	14	14	1	0
(n=35)	17%	40%	40%	3%	0%

No gender difference was apparent.

Table 14. Relationship between Gender and Level Distribution for Technological Modelling

Level	*0*	*1*	*2*	*3*	*4*
Girls	5	20	9	1	0
(n=35)	14%	57%	26%	3%	0%
Boys	4	19	13	7	0
(n=43)	9.3%	44.2%	30.2%	16.3%	0%

There appeared to be a difference within this component with more boys than girls (46.5% compared to 29%) showing understandings at level 2 or above.

Table 15. Relationship between Gender and Level Distribution for Technological Products

Level	*0*	*1*	*2*	*3*	*4*
Girls	3	25	11	1	0
(n=40)	7.5%	62.5%	27.5%	2.5%	0%
Boys	3	23	26	0	0
(n=52)	5.8%	44.2%	50%	0%	0%

There appeared to be a difference within this component with more boys than girls (50% compared to 30%) showing understandings at level 2 or above.

No gender difference is apparent.

Table 16. Relationship between Gender and Level Distribution for Technological Systems

Level	*0*	*1*	*2*	*3*	*4*
Girls	6	9	3	1	0
(n=19)	31.6%	47.3%	15.8%	5.3%	0%
Boys	11	14	8	1	0
(n=34)	32.3%	44.1%	20.6%	3%	0%

DISCUSSION OF FINDINGS AND IMPLICATIONS

Stage One of the TKNoT: Imps research allowed us to begin to build up a picture of what progression in Technological Knowledge and the Nature of Technology ‘looks like’ by way of student data and this was communicated in the April 2009 Indicators of Progression. However, as seen above, our student data was very partial for levels 1 to 3 and non-existent for levels 4 to 8. One implication of this was that the revised 2009 Indicators of Progression were still somewhat tentative and, as mentioned above, were revised again after Stage Two.

While the student data related to most components showed some positive trending by year group, the trend was not particularly strong. The low number of students at each year group however, made these trends somewhat inconclusive. Given the ‘newness’ of the ideas captured in the components it was not unexpected to find many older students exhibiting understanding reflective of lower levels than would be expected in other learning areas or indeed in the three components related to technological practice. As students are provided with more opportunity year by year to develop these ideas, trending by year group should begin to become clearer. A clear implication of these findings is that teachers of higher year groups must clearly identify where their students' current understanding lie, and not be tempted to assume them to be at higher levels.

These findings provide little evidence to suggest any gender difference in level of understanding of the TK and NoT components, with the possible exception of TM and TP. It is important that students are provided with ample opportunity to explore and 'play' with a range of different materials. This may be particularly important for girls who, at least in the past, may have had less explorative play opportunities than boys. However, as students in New Zealand, along with much of the Western world, spend an increasing number of hours 'playing' in a more virtual world, the opportunity to 'pull things apart' and experiment with a range of common materials would be of benefit for *all* to increase understanding related to the TP component. It is also important to ensure explicit reference is made to what *technological* modelling is in order to address barriers that may exist through alternative concepts of models. These concepts include such things as fashion models, replica models and/or role models. It was noted in the interviews that more girls than boys referred to fashion models, and more boys than girls referred to replica models. Of these two concepts, replica models provide an 'easier' basis to begin discussing technological modelling, than fashion models do, which may explain the difference in girls and boys understanding of ideas related to the TM component.

Nature of Progression

At the completion of Stage One we felt confident to begin to address the first aim of the TKNoT: Imps research. That is, to establish and describe how student learning progressed in each of the five components within the TK and NoT strands. This was captured in the 2009 revised Indicators of Progression. We could also outline the overarching nature of these progressions and these were described as follows:

Progression in the Characteristics of Technology:
A shift from developing a simple understanding of technology as a form of human activity towards an ability to critically evaluate complex technological issues associated with social and environmental drivers and impacts.

Progression in the Characteristics of Technological Outcomes:
A shift from identifying key features of a technological outcome towards the ability to critically analyse technological outcomes as socially, geographically and historically situated artefacts.

Progression in Technological Modelling
A shift from identifying and describing types of and purposes for technological modelling towards the development of a comprehensive understanding of how technological modelling allows for informed and defensible decision making and risk mitigation.

Progression in Technological Products
A shift from understanding the overt properties of materials towards a more detailed understanding of material composition and the implications of this composition for material performance and manipulation and product development, maintenance and disposal that is supported by in-depth understanding of specific examples.

Progression in Technological Systems
A shift from understanding the components and connections of a technological system to more detailed understanding of the operational parameters of a range of technological systems and the implications of this for system design, development and maintenance that is supported by in-depth understandings of specific examples.

Being able to describe the nature of progression of technology as it relates to the 2007 technology curriculum as a whole, amounts to being able to describe the progressive development of student technological literacy. We believe that gaining a sense of the progressions inherent in each of the components of each strand, provides a good starting point for future work to look at how these strands may come together to support emerging student technological literacy and how that literacy may develop and progress to be deep, broad and critical in nature. Before moving to focus on technological literacy however, more work was required to explore what effective teaching of the TK and NoT components involved. This was the main focus of Stage Two and Three of the TKNoT: Imps research and the findings from these stages will be discussed in detail elsewhere.[8]

IN CONCLUSION

Technology education in New Zealand has now entered its second exciting and demanding implementation phase. The opportunity provided by the time between the release of the *NZC* (Ministry of Education, 2007) and its mandated implementation in 2010 has been very welcome. Lessons learned from the implementation of the *TiNZC* (Ministry of Education, 1995) have provided considerable incentive to the New Zealand technology education community to ensure adequate support is made available to teachers by way of professional development and resources. As mentioned above, research based advice and resource provision has been a key feature of technology education in New Zealand since the early policy days and this continues to be the case. The TKNoT: Imps research discussed in this paper is an example of this ongoing research commitment and has resulted in better understanding of how student learning progresses in the knowledge and philosophy of technology. In addition this research has provided the revised Indicators of Progression as professional development resources to help teachers enact these components of the latest technology curriculum (Ministry of Education, 2007).

NOTES

1 For explanations of the eight components please see http://www.techlink.org.nz/curriculum-support/papers/index.htm

2 For details of the development of these strands please see Compton and France, 2008.

3 The NZCF (Ministry of Education, 1993) differentiates 8 levels of learning across years 0-13. These are loosely aligned to two years of learning from levels 1-5 and then single years from levels 6-8. However, it is acknowledged that students' progress at different rates. Therefore any age-level relationships are indicative only.

4 The technological areas in the *TiNZC* were: Biotechnology, Electronics and Control, Food Technology, Information and Communication Technology, Materials Technology, Production and Process Technology and structures and Mechanisms (Minstry of Education, 1995).

5 Please note, the April 2009 Indicators of Progression have since been replaced by the 2010 version as a result of Stage Two and are no longer available. The 2010 versions are available at http://www.techlink.org.nz/curriculum-support/indicators/index.htm.

6 7/6/2/2 Student code where 7 is the teacher code/6 is the year group/2 is male/2 second student interviewed from this class.

7 Matariki is the Maori name for the Pleiades star cluster or The Seven Sisters. The Maori New Year is celebrated when Matariki rises and the new moon is sighted.

8 Papers are currently being written to report on findings associated with the effective teaching of technology as found from Stage Two and Three of the TKNoT: Imps research.

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DEVELOPING COUNTRIES

FRANK BANKS

TECHNOLOGICAL LITERACY IN A DEVELOPING WORLD CONTEXT: THE CASE OF BANGLADESH

INTRODUCTION

Bangladesh, a semi-tropical country which lies in the north-eastern part of South Asia bordered by India and Myanmar (Burma), is one of the largest deltas in the world. Its land is consequently very low-lying and crossed by three great rivers. The Ganges, the Brahmaputra, and the Meghna all flow south into the Bay of Bengal and their many tributaries make travel within Bangladesh difficult. Bangladesh is one of the most densely populated countries of the world with a population of 138.6 million, crowded into an area of only 147,570 square kilometres, giving a population density of 926 persons per square kilometre. The Netherlands, in contrast, is approximately 400 persons per square kilometre. Over three quarters of people live in the rural areas. Nearly half the population is under 19 years of age (MoPME, 2008).

Primary education is provided to children of 6 to 10 years, in Classes 1 to 5, with an examination at the end of each academic year. In 2005, the Department of Primary Education in Bangladesh conducted a survey, which revealed that the percentage of students not completing primary school is 47.1% with a range in different areas of 72% to 30% not completing their primary education (MoPME, 2008). Secondary education is Grades 6 to 10, divided into two groups: Lower Secondary is Grades 6 to 8, with a terminal examination, and Upper Secondary is Grades 9 and10 with the public Secondary School Certificate examination (SSC) conducted at the end of Grade 10. Higher Secondary Education comprises Grades 11 and 12 with the public Higher School Certificate (HSC) examination taken at the end of Grade 12. Surprisingly although almost all primary schools are government controlled, of the 18,500 secondary level institutions in Bangladesh (excluding Madrasas), less than 2% (317) are government secondary schools. Nearly all secondary schools are private, although the government through the examination system specifies the syllabus and also pays the teachers' stipend. Class sizes are large with 60– 90 students not uncommon in primary classrooms in urban areas.

In addition to government schools, there are a number of Non-Government Organizations (NGOs) that contribute significantly to education. The Underprivileged Children Education Programme (UCEP), for example, provides general education and vocational training for over 30 thousand poor working children who have generally missed out on their primary education. The children continue to work and earn while they attend school. UCEP schools operate 3 shifts

M.J. de Vries, Positioning Technology Education in the Curriculum, 219–225.

per day, each of 3 hours duration. This allows a child to choose a shift of his/her convenience, in consultation with their parents (guardians), to minimise the economic loss to the family for the children attending school. The schools offer the standard national curriculum but taught over a shorter period; each year's syllabus being completed over a six month period using the curriculum and textbooks prescribed by the National Curriculum and Textbook Board (NCTB) but incorporating basic elements of technical education too. In contrast to the national picture, the attendance rate at UCEP schools is almost 94% and the drop-out rate is very low (UCEP 2009).

Similarly, schools run by Bangladesh Rural Advancement Committee (BRAC) for the rural and urban poor offer informal education to many children:

> Most BRAC nonformal schools are one-room schools with limited floor space. The classroom is very neat and clean and students sit on mats on the floor. There are commonly about 30 students, two thirds of whom are usually girls. The teacher, generally a female with at least 10 years of schooling, is chosen from the community where the school is situated. […] The informality of the nonformal school environment has flexibility for teaching and learning in a community context where interactions between school and community are very influential and fruitful for students' development. (Shohel and Howes, 2008. pp293–294)

When considering technological literacy for the general population, therefore, one needs to take note of a number of factors. Why do so few students move on to secondary education? What is known about the curriculum, the teaching strategies used by the teachers and the economic context in which teaching and learning takes place?

THE SPECIFIED CURRICULUM

The specified curriculum relates to the formal intended learning outcomes that are either explicitly or implicitly set out for teachers by the government or their employer if an Non-Government Organisation (NGO) or community school. The government prescribed primary curriculum has the core subjects of mathematice, English, Bangla (Bengali), science and social studies. The curriculum in all subjects is dominated by the specified government text book and an examination system that largely tests simple recall. The school text books for different grades have often been written by different people at different times and progression in subjects is poor (Smith, B. 2009). The relevance of the curriculum to the lives of the majority of students is also to be questioned. BRAC schools link the curriculum to basic hygiene and health education, but little is done in government schools to consider the usefulness of science to agriculture or the need for clean food and water. For example, Shohel tells of a school Home Economics lesson on the need for cleanliness in the home to prevent disease, taking place in a very dirty classroom (Shohel and Howes, 2008. p 305).

In contrast to the formal education in large primary schools, BRAC informal education encourages creativity with such materials as cloth and clay to make decorative items, and to link the products to a possible client.

Technical streams are available at both Secondary and Higher Secondary levels, administered by the Technical Education Board. The Bangladesh Technical Education Board (BTEB) specifies the curriculum, and in secondary and upper secondary schools, technical streams are available from Grades 9 and 11. Although the National Curriculum in Bangladesh is specified through textbooks and examination syllabuses, the technical areas available are wide. Through the BTEB, students in Grade 9 in a technical stream, for example, could be offered Automotive, Wood Working, Dress Making and Tailoring / Garments Manufacturing, Fish Culture and Breeding, Fruit and Vegetable Cultivation, Plumbing and Pipe Fitting, and Industrial Electronics (BTEB, 2009). However, it is highly unlikely that a secondary school has the resources to offer these subjects in a practical way. The Campaign for Popular Education, Bangladesh notes:

> A high degree of inequity exists in the secondary education sub-sector in Bangladesh. Inequity starts with unequal distribution of basic school facilities. All types of secondary educational institutions lack basic minimum requirements for quality education. […] As learning performance in secondary education has direct implications for future life, the above inequities persist throughout the life of the secondary graduates, afflicting adversely their further education and employment opportunities. (CAMPE, 2008, pxxxiii)

In stark contrast, UCEP schools offer an integrated general and vocational curriculum. Students basically follow the NCTB curriculum both at primary and lower secondary level (grades 1 to 8). However, the curriculum has been abridged in a careful manner so that it remains comparable with that of national mainstream curriculum. The curriculum consists of Bangla (mother tongue), English, mathematics, vocational, social environment and hygiene. The focus is to educate poor working children in urban environments, and so they are accepted into the programme no younger than age 10 for girls and 11 for boys. Each 3 hour shift is focused on general education, but where possible examples are drawn from a technical context. For example, the English alphabet is taught through naming of craft tools – D for dividers, H for hammer and so on. Stories in Bangla are linked to the discovery of inventions and the use of agricultural and other devices. After grade 8 UCEP continues Technical Education training on 16 trades:

- Auto Mechanics
- Welding & Fabrication
- Machinist
- Plumbing & Pipe Fitting
- Electronic Technology
- Industrial Electrical and Electronic Control
- Refrigeration & Air Conditioning

- Offset Printing Technology
- Industrial Woodworking
- Tailoring and Industrial Sewing Operation
- Industrial Wool Knitting Operation
- Garments Finishing & Quality Control
- Industrial Garments Machine Mechanics
- Textile Weaving Mechanics
- Textile Spinning Mechanics
- Textile Knitting Mechanics

Here the students learn in a highly vocational and practical way using English where necessary as technical vocabulary (EIA, 2009). At the end of their training they are guaranteed a job. In contrast to the formal government system, these poor working children attend school regularly and complete their education. The attendance rate is over 94%.

THE ENACTED CURRICULUM

The enacted curriculum relates to the teaching strategies enacted by the teacher and so is linked to their professional knowledge (See Banks et al., 2004, Banks, 2008).

In 2009, the author initiated a large-scale study of pedagogical practices in Bangladeshi classrooms (EIA, 2009). Using a team of eight Bangladeshi colleagues and four Open University researchers, a total of 252 classroom observations were undertaken in both Primary and Secondary schools. Care was taken, using videoed classrooms and live observations in pilot schools, to try to achieve reliability of observations from all observers before the fieldwork took place, and in the field some joint observations were undertaken to see if reliability had been maintained. Information was recorded about the classroom environment and the professional background and experience of the teacher being observed. During the lesson a 'time sampling' technique was used to record what type of activity (from a pre-determined list) the teacher and students were doing at selected points. The observers could also annotate the instrument with any details that would complete the account of the lesson. The observation data collected provides an indication of the types of activity that happen in classes at the start, during and at the end of lessons.

Throughout the lessons, teaching from the blackboard or front of the class was the predominant pedagogic approach. As the lesson progressed, teachers tended to read from the textbook, ask closed questions or move around the classroom monitoring and facilitating students as they worked individually. The use of teaching aids (other than the text book) was infrequently observed: between 2% to 6% of classes at any of the times sampled. More frequently, teachers gave instructions for student activities (from 5% to 8% at any of the times sampled) or listened to students as they read aloud from the textbook (from 2% to 8% at any of the times sampled). At the end of a lesson teachers usually assign homework (53% of classes) and/or recap what the lesson has just covered (49% of classes). In many cases teachers provide feedback on the students' performance throughout the lesson (43%) and assess students' understanding by asking summary questions (34%). In almost 10% of the lessons observed, the teacher simply stopped teaching and left the room. The majority of teachers appeared to be fully or partially confident with the subject matter of the lesson. Teachers with a general training in education appeared to be more confident than others. However, there was little evidence of a lesson plan being used for guidance by most teachers – only 14% did so either 'regularly' or 'occasionally'.

Most teachers interacted positively with their students and maintained good discipline. Few teachers focused their attention only on those students at the front of the classroom (only 8% overall) while the majority focused on students throughout the class. However, most teachers did not adopt a stimulating and task-based approach to their lessons. Overall, 58% did not ask any thoughtful questions to stimulate students' interest and 48% did not set any challenging tasks for the students to make them think.

Although not seen in this observation study, Shohel and Howes make reference to the use of excessive corporal punishment in secondary schools, particularly in contrast to the pedagogy of nonformal education in BRAC schools.

> You know, in high school, teachers don't bother whether you've learnt anything or not. Don't care whether you come to school or not. You see, she was […] like our mum [teacher in BRAC school] she hardly hit us. But in this school if you fail to answer the teacher's question, you definitely will be slapped or beaten [either with hand or stick]. I hate punishment in high school (Grade 6 student reported in Shohel and Howes, 2008. p 300).

THE EXPERIENCED CURRICULUM

The experienced curriculum relates to student learning. Clearly students can only experience the curriculum if they attend school and, as is indicated above, many students in Bangladesh drop out of school before the end of primary education. A key reason often given is poverty and the need for students to help support the family by working. There is evidence for this. Poor children are most likely to drop out of primary school, and the government realizes the need for targeting poor locations of the country to add enhanced stipend (proportionately greater for poor boys), school feeding, and school health programs, from pre-primary to primary school levels (MoPME, 2008).

Such inducements would no doubt help in encouraging school attendance, but students want to also enjoy coming to school. Our observations of the classrooms showed that in most classes, students were not interactive at all; rather they were very passive learners. They were only participating by answering the questions asked by the teacher. Generally the students were well behaved in class and in the majority of classes there were few students who had problems concentrating and/or displaying inappropriate behaviour. They were generally passive, and generally bored.

Consequently, the predominance of memorisation for a knowledge recall examination and the rationale for covering so much content, is itself not proving highly successful. Pass rates of the Secondary School Certificate (SSC) are about 60% (MoPME, 2008).

Moreover the environment was uninspiring. Although classrooms are generally clean and tidy, have good natural light and basic teaching equipment like a blackboard and chalk, with sufficient furniture for the students present in class however, there is little evidence of students' work on display and different learning and teaching materials are not often used.

In contrast the UCEP experience shows that imaginative teaching in a stimulating environment through a relevant curriculum linked to real-life technological literacy, even at the primary stage, can encourage very poor underprivileged students to attend school. Further, the students are rewarded for the vocational work that they do. For example, when they service a car as part of their work on automotive maintenance, they receive a small fee for the work done.

CONCLUSION

The UCEP model illustrates the over simplification of the view that school drop-out in Bangladesh is solely due to poverty. It is certainly a factor, but possibly more significant is the need for a relevant curriculum. Technological Literacy at the primary level, particularly prominent in UCEP but also in BRAC schools shows the need for easily perceived links between education and real life. Education needs to be seen as more than an exercise in simple memorisation for an examination by both teachers and parents. There is also the need for a stimulating environment with an increase in the use of student-centred learning techniques. Even in low-resourced primary schools BRAC have shown that students can engage in designing and making for a specified client.

The rhetoric of Technology Education for All in the global north has been to distinguish it from vocational education. In the UK, for example, technology as a school subject has tried, sometimes unsuccessfully, to move away from its roots in Craft. In the USA, care has been taken to show Technology Education is not the same as Industrial Arts or 'shop'. In Bangladesh and in other emergent economies, however, the relevance of education to everyday life is paramount. As England and a number of other western countries struggle to find an appropriate curriculum and context for general technical education for all, much could be learnt from the success of UCEP and BRAC schools.

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EXPLORING THE POSITION OF TECHNOLOGY EDUCATION IN CHINA

INTRODUCTION

China's post-1978 reforms, such as the opening up policy, have had far-reaching economic and social impacts. Over the past several decades, China has been introducing more and more flexibility into its governance. The establishment of special administrative and economic regions such as Hong Kong, Macao, Shenzhen and Zhuhai is a good example of this effective and flexible governance. However, as government leaders have indicated, maintaining rapid and stable economic development and social transformation in a country with a population as big as 1.4 billion requires a comprehensive and sound education system. Accordingly, the government has been implementing a series of educational policy and management reforms to match the changing social and economic environment.

Education in China is administrated by the Ministry of Education. The current nine-year system of compulsory education from the primary to the junior secondary level was first introduced in 1986. Since 1996, the Ministry has been servicing the largest population in the world, with all races and national minorities, women and the disabled expected to have an equal right to education. This aim of education for all has been almost reached.

Although several special administrative and economic regions in China have achieved significant economic growth in recent years, mainland China considers itself and is widely recognised to be a developing country. A number of areas need to be improved before China will reach the standard of other foreign developed countries (Hewett, 2008; Yeh, 2006; Yuen, 2010). Thus, the government has focused its attention on the modernisation of industry, agriculture, science, technology and defence. In this regard, all of these areas will benefit from the development of new technologies. Therefore, understanding, mastering and applying technology have become important issues in China. In fact, there were no formal educational curricula relating to technological concepts before the foundation of the People's Republic of China. Although some technical subjects were introduced in the following years, the subjects focused on basic artisanal production skills and mostly served political needs. In addition, the general education system paid little attention to all-round development. To a large extent, education was exam-oriented and aimed to train students to achieve high scores. As a consequence students ended up with limited abilities in other areas. Moreover, many students pursued academic subjects, rather than seeking knowledge applicable to the problems of the real word. Accordingly, more modern educators in China are calling for "additional values" to be introduced

M.J. de Vries, Positioning Technology Education in the Curriculum, 227–242.

into education, while others are stressing the need for "quality education" (Borthwick, 1983; Hall & Lewis, 2008; Hewitt, 2008; Price, 1979; Siu, 2009). Although technology should not be thought of as the panacea for all educational problems, technology education does have the potential to provide a new direction for further educational reforms (Feng & Siu, 2010). The integration of technology education into the general education system is an irreversible trend. Therefore, it is necessary to consider how technology should be integrated into the current curricula and what kinds of implementation models are suitable for a country such as China. It is also necessary to consider whether the current technology education is positioned correctly. In light of these practical problems, the direction of development must be continually rectified, especially given the size of the population and the correspondingly large number of students in China.

Increasingly more countries, including China, are including technology education in the general education system as the key learning area. Different countries use different terms to describe technology education, including technology, technical education, design and technology, and technological education (Rasinen, 2003; Siu, 2002, 2009). Instead of arguing over the meaning of the terms, this chapter focuses more on the nature and objectives of technology education itself and, thus, considers these expressions to be synonymous. In addition to reviewing and discussing the development and situation of technology education in mainland China, the situation in Hong Kong (as part of China) is also discussed in later sections as a case study of technology education. This case study is designed to supplement the discussion on technology education development in mainland China.

THE PROGRESSION OF TECHNOLOGY EDUCATION IN MAINLAND CHINA

Technology education has a rather short history in mainland China when viewed from the perspective of the history of education. From informal apprenticeships to formal school education, technology education has gone through almost 60 years of development (Siu, Wong & Feng, 2010a). The following section reviews and discusses this transition in relation to the structure and characteristics of the curriculum, educational facilities, teacher education and assessment.

The Transition Process of Curriculum

In the 1950s, technology education in the People's Republic of China was influenced by the Soviet model of polytechnic education (Jiang, 1996). This conception of the polytechnic, which grew out of Marxism-Leninism, made a tremendous impact on education in China. Politically, polytechnic education was designed to serve the political needs of the proletarian class. Economically, from the 1950s to the 1970s, teachers and students were also considered to be members of the class of productive labourers: that is, workers who satisfied basic life needs (Fouts & Chan, 1997). On the basis of these two major historical precedents, labour-technical education began to emerge in the early of 1980s.

Labour-technical education is different from other traditional school subjects, as its teaching content is much wider and less clear. The subject mainly consists of the two parts of labour education and technical education. Labour education is intended to instil in students an appropriate attitude towards labour; while technical education teaches the technological skills related to agriculture and industrial manufacturing. Although labour-technical education serves political and economic needs, its development has reached an end-point for three main reasons: assessment, a shortage of labour-technical teachers and few formal or official textbooks. Thus, labour-technical education has little attraction for students, their parents and teachers (Bao, 1997; Siu, Wong & Feng, 2010a). Despite these existing problems, labour-technical education has undergone significant changes over the past two decades (Xu, 2002; 2004). Importantly, more emphasis has been placed on the technological dimensions of labour-technical education, especially in Shanghai, which is the largest modern metropolitan city in China. In this respect, the curricular goals focus on "hands-on activities" and developing the "technological skills" for manufacturing products used in daily life (Shanghai Municipal Education Commission, 2004).

In the late 1990s, a wave of educational reforms (8th reform) was introduced national wide. One result of these reforms was that technology was made one of the eight key learning fields in general education, especially at senior secondary level (Ministry of Education, 2003). In April 2003, the Ministry of Education issued "The Standards of Technology Curriculum in Senior Secondary Schools (Experimental)", which reveals that technology has become an independent subject at the senior secondary level (Gu, 2004). This national curriculum document is the first indication of how the discipline is emerging through the implementation of curriculum standards. At primary and junior secondary levels, however, technology education is still integrated into comprehensive practical activities, rather than existing as an independent subject. Furthermore, technology education co-exists with other technically related programs at the primary, secondary and higher education levels.

The core content of the new curriculum is design (not fine art), which provides opportunities to cultivate students' initiative, creativity, problem-solving skills and practical design competence (Siu, Wong & Feng, 2010a; 2010b). Another objective is to strengthen information technology learning. This approach encourages students to use information technology in their learning and to solve any problems they may encounter. It is hoped that each student will strive to obtain a wealth of practical experience through observation, investigation, design, production, experimentation and other similar activities. As a result, students are expected to develop emotional and social skills, as well as technical ability (Ministry of Education, 2003).

Curriculum Structure

The technological education curriculum is divided into two parts: Information Technology and General Technology. Information Technology consists of six modules, one compulsory and five elective, while General Technology comprises nine modules, two compulsory and seven elective. Each module is worth two academic credits (Table 1).

Table 1. Structure of technology education in senior secondary schools in mainland China

Subject	*Module*	*Remark*
Information Technology	Information Technology Foundation	Compulsory
	Algorithms and Programming	Elective
	The Application of Multimedia Technology	
	The Application of Network Technology	
	Data Management Technology	
	Introduction to Artificial Intelligence	
General Technology	Technology & Design 1	Compulsory
	Technology & Design 2	
	Electronic Control Technology	Elective
	Architecture and Architectural Design	
	The Construction of Simple Robots	
	Modern Agricultural Technology	
	Home Economics & Life Technology	
	Garments and Garment Design	
	Automobile Driving and Maintenance	

The inclusion of elective and compulsory courses is designed to cater for the different needs of students. The compulsory content, which covers the basic requirements to develop students' technological literacy, reflects the progressive nature of technology education in China and provides necessary foundation for students' future work and life. Alternatively, the electives provide individual topics which extend the compulsory modules into specific technology fields. Students are required to take one elective module in addition to the compulsory course to obtain the four credits necessary to complete the Information Technology component. As students also need to obtain at least four credits in General Technology, they are free to choose any elective module, or none, after finishing the two compulsory modules. As they are offered a variety of opportunities for technological practice, the students are able to enrich their technological proficiency and improve their ability to put theory into practice. Overall, this approach to technology education is extensively applicable, widely suitable and flexible to implement.

Curriculum Characteristics

From an educational perspective, the aim of the curriculum is to deepen "quality education" to foster the life-long development of secondary school students. The major goal is to improve students' technology literacy. On the one hand, efforts are directed toward helping students understand technological concepts, theories and methods, as well as operating procedures and techniques, and to promote their analytical and decision-making skills. On the other hand, emphasis is also placed on enhancing students' understanding of the humanistic value of technology and leading students to develop positive attitudes and values when they probe, test and create during their technological learning to break through the biased assumption that technology only relates to skill. Furthermore, technical design is regarded as pivotal to organising students' technological learning content. Fully exploring the educational function of technical design can help students learn how to make thorough investigations, how to think effectively, how to create and how to make sound judgments. In this regard, design represents an important vehicle for improving student's technology literacy.

The technology curriculum is also intended to help students learn about methods of experimenting with and probing technology, thereby enabling students to convert their knowledge into practical skills in finding and solving problems. In addition, fully aware of the interdependence between science and technology, theory and practice, and designing and producing, the current curriculum tries to unify these aspects into an organic whole.

The contents of the technology curriculum are designed to follow students' social development and to closely match students' real life needs. For instance, "Modern Agricultural Technology", which is one of the seven general technology electives, includes several optional special topics that reflect the fact that the needs of students from rural areas are different from those from urban centres. This curriculum can be easily adapted and applied to different regions. Accordingly, this structure effectively resolves the problem of unifying the core and targeted needs of the technology curriculum.

In light of the imbalanced distribution of resources in China, schools in different areas can select their own content to include in the technology curriculum. Meanwhile, schools are encouraged to share curriculum resources. For example, senior schools, local vocational schools and technical schools can share teachers, equipment, apparatus and laboratories. Students can gain the same credits at vocational schools, technical schools, technological educational bases or scientific and technological venues.

At present, officials are exploring a technological certificate system for senior school students. The idea is that after completing the compulsory modules, students in rural areas will receive "green certificate" and other technical training to gain "double certificates" in technology education. Alternatively, students in urban areas gain corresponding course certificates after taking occupational technical courses or other technical trainings. This structure can help to balance the differences between urban and rural schools, and to strengthen the ties between general technology education and vocational technology education.

Facilities

Over the past twenty years, the development of the facilities for labour-technical education has gone through three stages:

1. The 1980s – a lack of well-established standards

At this stage, there were no educational standards or related requirements for facilities. Neither the educational departments nor the schools had any definite schemes for what should be provided or how to map it out. Moreover, there were no professional manufacturers (or well-monitored or recognised manufacturers) to supply facilities. The teaching aids and learning kits were mainly made or bought by teachers themselves. This scattered and disorderly situation had the added effect of hindering regular teaching.

2. The 1990s – the toolbox standard

In 1989, the Ministry of Education issued the standards for teaching equipment for secondary labour-technical education. The equipment was classified into categories according to the type of activity. In each category, the corresponding equipment was divided into three levels adaptable to different regions. In accordance with the standards, some manufacturers produced several different sets of toolbox equipment, for example, manual kits, wood-work kits, metal-work kits and bench-work kits. However, these diverse types and specifications made management inconvenient.

3. From the late of 1990s to the present – the workshop style

After being equipped with the toolboxes mentioned above, schools found that they needed to provide special work spaces for students to complete their projects. This led to the birth of "special workshops" in each school for students to carry out projects related to all the compulsory modules. Although the workshops solved many problems, after three to five years of implementation new shortages and limitations began to emerge. For example, the work spaces are used for different kinds of projects. After home economics teaching, students also use the spaces for metal-working projects, which may damage the instruments. Moreover, as too many students used the work spaces at the same time this tended to reduce the hands-on opportunities for each student.

Reviewing these three stages of development, it is obvious that there are no definite standards for facilities. Teachers are left to purchase or design their own equipment. Moreover, with the rapid developments in information technology, education department official and a number of secondary school principals have begun to transform the conventional technology curriculum to information technology subjects. One of the major reasons for this is that information technology enables students to master basic programming and to make simple robots. Often these learning outputs bring opportunities for students to participate in various international competitions. A student can gain a great sense of achievement by wining a prize. The schools, the school head and teachers can also gain a good reputation. In fact, over the past decade, the mass media have also reported on the achievements of schools and individual teachers. In view of this added value, secondary schools, as well as a number of primary schools have invested a lot of money in purchasing high power computers and other related teaching aids. Furthermore, many schools have even allotted additional special classrooms or converted conventional classrooms specifically for the teaching of information technology. This overemphasis on information technology has led to the subject appearing in the teaching timetables of nearly all of the senior secondary schools in mainland China. By the end of 2001, 12,000, or 92% of all senior secondary schools offered information technology courses (Liu, Gu, & Yu, 2005). This extreme focus on information technology has caused the design and development of facilities for traditional hands-on technology activities to stagnate. Similarly, the curriculum goals of the new senior secondary technology curriculum have changed to "promoting technological literacy for each student" (Ministry of Education, 2003). Therefore, the existing facilities for the original "Integrated Curriculum of Practical Activities" may not be suitable for the new technology curriculum, especially for the "general technology" component.

Furthermore, although a number of best practices for facility layout have been developed in Western countries, these practices cannot be applied in the mainland Chinese context without modification, due to the different economic and cultural environment and the different curriculum contents. In addition, there is a slight overlap between labour-technical education and general technology education. Thus, it is necessary and appropriate to have facility standards for technology education that are specific to the social, cultural and educational characteristics of mainland China (Feng & Siu, 2010). Officials and educators have begun to devote time to designing the necessary facility standards, and several local facility standards have been issued. New facilities for secondary technology education in mainland China have been developed from scratch in a workshop style and based on an industrial centre model. This development is a big step in the history of technology education in China, especially in regard to the birth of regional facility standards. Due to the varying levels of economic development and stages of curriculum implementation, a final universal standard needs to have different grades that can be adapted to different regions. In sum, considering the wide scope of technology education and the rapidly changing curriculum content, the workshops must be designed in different styles conforming to the different modules. In addition, industrial centres should be established to facilitate the sharing of facilities, especially for sharing expensive facilities in more deprived regions. In view of the current overemphasis on information technology, cooperation between enterprises and the design of projects that combine information technology and general technology are the ultimate solution for mainland China.

Teacher Education

The curricula for technology education at the senior secondary level are highly comprehensive and stress synthesising knowledge from other disciplines. Accordingly, technology teachers are required to have a comprehensive grounding in the scientific fields of mathematics, physics and chemistry, as well as in the arts and humanities. This is a basic requirement for normal teaching and self-learning (Ministry of Education, 2003). Because the most recent technology education curriculum is completely new, there is not yet any formal education programmes at the tertiary level to nurture technology teachers. At present, the majority of teachers are from other disciplines, such as science, physics, chemistry and labour and technology education, and have not received systematic pre-service training. However, most have gained experience in technology education through in-service retraining or, in some case, even without it. As a result, they tend to retain the thinking associated with their original subject areas. In their minds, the current technology subjects are the same as before, but are just packaged differently: modules are used instead of unit shops and computers and robots replace metalworking and woodworking. Furthermore, the teachers usually do not have much more than the basic knowledge necessary to teach. As De Vries (2002) mentioned, most teachers of technology education lack the wherewithal necessary to create a new approach to these subjects in their schools.

To implement the new curriculum smoothly, the Ministry of Education has invested large amounts of human and financial resources in in-service teacher education. Presently, some regional- and provincial-scale face-to-face training of core teachers has been carried out. The technology teachers are trained in dialogue, collaboration, technical exploration and technical practice. Some technology teachers have also made individual bulletins which they have stuck on the back wall of the classroom to share their experiences and training notes with other teachers. After training, technology teachers are required to submit a self-summary and a teaching project for assessment. Experts from the national curriculum standard group and scholars from each technology field give lectures to enhance the teachers' knowledge and background information, and to raise their awareness of the importance of technology education.

On-line learning for technology teachers started in the summer of 2007 after the Ministry of Education set up a special website for long-distance training. Several areas are represented on the site, including curriculum arrangement, video source downloads, curriculum bulletins and on-line discussion. Unlike face-to-face training, on-line training enables technology teachers, not just core teachers, to start self-learning. They use their own username to logon to the website and the system keeps a record of their learning. After the teachers' submit a learning report of their on-line training, the Ministry of Education assesses whether they should be awarded the teaching certificate. Moreover, on-line discussions (live chat) are popular among teachers, as they can share their opinions and experiences with others all over the nation, even with curriculum experts. Curriculum experts and education department officials are able to give feedback directly and instantly.

The Ministry of Education has also invested vast amounts of financial, material and human resources into technology teacher training to advance the curriculum implementation. Unfortunately, many problems and challenges still exit (Feng & Siu, 2010). On the one hand, although technology is part of the government-driven curriculum, the relevant subjects have not been made part of the college entrance examination in some provinces. Some schools only open these subjects for a short period solely for government inspection. In reaction to official pressure, some schools dispatch teachers from other disciplines to participate in face-to-face training. However, once trained, these teachers have no opportunity to teach technology subjects. This is ultimately a waste of training resources. On the other hand, the extent of technology curriculum implementation varies widely in different provinces as a result of numerous factors, including school support, family attitude and financial support. Therefore, it is impossible to design one style of training scheme capable of meeting these different needs. The technology curriculum has been implemented very well in some provinces and teachers in these schools urgently need new information and more training. However, quickly updating the training contents and designing new projects is difficult to achieve.

Assessment

Assessing students' performance in the field of technology education requires appropriate methods and tools (Assessment and Performance Unit, 1994; Eggleston, 2001; Feng & Siu, 2010; Kimbell, 2002; Kimbell et al., 1991; Leung, 1998; Nicholson, 1989; Scott, 1990; Stables, 2002; Tufnell, 2000). The contents of the technology and design related activities are open to technical issues to provide opportunities for students to investigate and find solutions to problems in daily life. This requires a series of complex cognitive processes including thinking, gaining feedback and experimenting. Therefore, the assessment of students' work involves not only what students know, but also how they employ their knowledge in solving problems (Assessment and Performance Unit, 1994; Eggleston, 2001; Siu, 1997; 2002). This is also the case with emotional attitude, values and modes of thinking. In the past decade, a great deal of research on assessment has sprung up (e.g., Atkinson, 1999; Eggleston, 2000). Nonetheless, how to assess students' technological literacy, including design literacy, and how to use assessment to promote technology and design related subjects are issues that are of continual concern to educators and educational researchers.

To date, assessment in mainland China has mainly been based on written tests. Some provinces are still at the wait-and-see stage with regard to introducing new assessment methods. It is notable that, especially in relation to the social environment in China, college entrance examinations currently have their own special status and social significance. There needs to be a just, fair and open way of assessing students' technological literacy. Whether the most authoritative entrance examination is bound to be the best needs further study and experimentation. However, what is certain is that the final method chosen should control and guide teaching and learning activities towards predetermined goals (Gu, 2005).

HONG KONG — TECHNOLOGY EDUCATION IN A SPECIAL ADMINISTRATIVE REGION

The teaching of formal technical subjects in educational institutions and schools in Hong Kong can be traced back to the 1920s (Siu, 2009). Technology education is formally offered only at the secondary and tertiary, or post-primary levels in Hong Kong (Fung, 1997; Siu, 2002, 2009). As implied by the names of the technical subjects offered, students (sometimes called apprentices) were mainly required to acquire skills and practical experience in preparation for earning a living (Leung, 1998; Siu, 1997; 2009). As a former British colony, Hong Kong had been influenced by the UK education system. With respect to curricula, most of the craft and technical subjects were adopted directly from the early curricula for British schools, and were not revised for many years.

In the mid 1970s, a Design & Technology (D&T) course was introduced in an attempt to move beyond the traditional craft-based and skill-oriented subjects, such as woodwork and metalwork (Fung, 1997). At that time, many of the workshop facilities, including machines, hand tools and furniture, were imported from the United Kingdom and, accordingly, were designed to fit the British curricula (Fung, 1997; Siu, 1997, 2009). Alternatively, D&T is expected to enable students to achieve design and technological literacy through the development of:

– Design and technological knowledge and understanding,
– Communication and problem-solving capabilities,
– Design and technological capability, and
– An understanding and awareness of the relationship between design/technology and society. (Curriculum Development Council, 2000)

D&T offers a new direction in learning, and an environment in which students can have more opportunities to practice their problem-solving skills (Leung, 1998). The programme focuses on the processes of thinking and design more than in the past and is implemented concurrently with conventional technical subjects (Table 2). Today, about half of the secondary schools in Hong Kong offer D&T in Secondary One to Three, though fewer than 40 schools offer the subject at senior level (Siu, 2009).

Table 2. Technology education at secondary level in Hong Kong (Curriculum Development Committee, 2002; 2007)

Junior Secondary	Automobile Technology Catering services Design & Technology Design fundamentals Electronics & Electricity Graphical Communication Retail Merchandising Textiles Business Fundamentals Computer Literacy Design & Technology (Alternate Syllabus) Desktop Publishing Fashion Design Home Economics Technology Fundamentals
Senior Secondary (Implemented in September 2009)	Design and Applied Technology Technology and Living Information and Communication Technology Health Management and Social Care Business, Accounting and Financial Studies

Unfortunately, until September 2000 these technical subjects continued to adopt an outdated syllabus, teaching approach and facilities. However, the situation changed after the Education Commission (EC) submitted the "Reform Proposal for the Education System in Hong Kong" to the government. The Commission proposed that all subjects be re-organised and categorised into Key Learning Areas (KLAs), with Technology Education being one such KLA (Curriculum Development Committee, 2002a). However, D&T (or Design and Applied Technology (DAT) at the senior secondary level) and other technical subjects are not compulsory (or "recommended") subjects in Hong Kong. Teacher experience and the facilities in the labs ("workshops") also influence the teaching of technical subjects. Teachers have relative freedom to follow either the older 1983 syllabus or the new syllabus introduced in 2000. At present, the general system is being restructured in that the senior secondary level is being adjusted to a 3-year schooling period. Furthermore, the syllabi for technology-related subjects are still under review and further modifications are planned.

The latest junior secondary school syllabus for technology education was established in 2000 to "develop the technological awareness, literacy, capability and lifelong learning patterns" of students (Curriculum Development Committee, 2007; Siu, 2009). Students have to study four areas of learning: "the nature and impact of technology for yesterday, today and tomorrow", "design and communication", "the tools and machines of technology" and "resources of technology". The latest senior secondary school technology education curriculum was established in 2007 and implemented in 2009. The senior levels cover more advanced areas of technology, such as electronics and automation. Students are required to study three core subjects (technological principles, design and innovation, and value and impact) and another two of five elective modules (electronics, automation, creative digital media, visualisation and CAD modelling, and design implementation and material process) (Curriculum Development Committee, 2000b). The two core concepts underlying the curriculum are innovation and entrepreneurship.

Secondary schooling in Hong Kong is currently being restructured to a three-year schooling model and the changes are to be implemented in 2010. However, until now, D&T (or DAT) and other technical subjects have not been compulsory subjects in Hong Kong. Today, around half of the secondary schools in Hong Kong offer D&T in Secondary One to Three, and fewer than 40 schools offer the DAT at the senior level. Technology programs in some secondary schools have been cut back or closed, which has led to declining enrolments in technology-related teaching majors.

Over the past thirty years, technology education in Hong Kong has been gone through unprecedented changes. A few decades ago, technical schools were very popular among primary school graduates (Fung, 1997; Siu, 2009) and the craft-based technology education was attractive to students and parents. This was largely due to the fact that from the 1950s to the 1980s, a formal educational system was established to cultivate technology teachers. Students at the Hong Kong Institute of Education received four years education before becoming technology teachers.

However, due to the rapid decline of students enrolled in technology courses, technology teacher training programmes have faded out since 2004. The two full-time technology education teacher training programmes (the 4-year full-time BEd(Sec) and the three-year mixed-mode BEd(Sec)) at the Hong Kong Institute of Education (the only formal technology education programme in Hong Kong) ceased in 2003/2004 and 2005/2006, respectively. Furthermore, the Institute officially phased out the Postgraduate Diploma in Education (PGDE) programmes for technology teachers in 2007/2008, though in reality no students were admitted to either the one-year full-time PGDE(Sec) in 2005/2006 or two-year part-time PGDE(Sec) programme in 2004/2005.

Nevertheless, the syllabi for technology-related subjects in Hong Kong are still under review and further modifications are planned. As pointed out in interviews with officers from the Curriculum Development Council and the Hong Kong Examinations and Assessment Authority there is still a long way for technology education to go (Siu, 2009). Opportunities for achieving a better situation for teacher education remain and the realisation of these opportunities depends on the direction of the new DAT curriculum and further curriculum development in the coming years.

SUMMARY AND DISCUSSION

Although special administrative regions have their own particular policy considerations and backgrounds in educational development, developing and implementing a better organised technology curriculum, with a clear vision, mission and objectives, over all of the country's regions is an important and urgent task (Gu, 2004). Secondary technology education has undergone approximately ten years of development since the new technology curriculum was implemented in mainland China. Technology education has developed at a high speed during those ten years and the new technology curriculum is currently being experimented in almost all provinces, with some encouraging feedback. Students are also reported to enjoy learning technology compared to other subjects (Siu, Wong & Feng, 2010b). While these developments imply some success with the curriculum, many problems and challenges remain. For example, although technology is still a new curriculum in mainland China, there is still no formal education system at tertiary level to nurture technology teachers. Furthermore, even though technology is part of the government-driven curriculum, subjects have not been included in the college entrance examination in some provinces. Some schools open these subjects only for short periods solely for government inspection. Under official pressure, some schools dispatch teachers from other disciplines to participate in face-to-face training. However, after finishing their training, these teachers have no opportunity to teach technology subjects. This situation ultimately results in a waste of training resources.

From the late 1970s when the subject of D&T was introduced in Hong Kong (a special administrative region of China) schools, technology education achieved high levels of enrolment (Fung, 1997). This established a good foundation, with the necessary facilities and experience, to train technology teachers and to benefit their professional development. However, due to changes in the schooling system and in educational policy, technology education has sunk to its current "tortuous" situation. D&T (or DAT at senior secondary level) and other technical subjects are not "compulsory" or "recommended" subjects in Hong Kong. This has produced a knock-on effect on the enrolment of technology teachers. Consequently, technology teacher education programmes have been discontinued and the workshop and laboratory facilities are left unused, which is a waste of resources.

The curricular objectives for technology education in both mainland China and Hong Kong aim to develop students' technological literacy. It is obvious that technology is becoming one of the key learning areas in these two regions. However, the difference is that technology education is not a compulsory subject in secondary schools in Hong Kong. Technology education, which could be formally offered as an independent curriculum at secondary level, is not yet a complete system capable of progressively cultivating students' technological literacy (Volk, Yip, & Lo, 2003). Another typical characteristic of technology education is that it has changed from the traditional craft and technical subjects to the current design and technology-related subjects. Design has become the core content, which provides opportunities to cultivate students' initiative, creativity, problem-solving skills and practical design competence.

There are many reasons behind the current situation in Hong Kong. In recent years, curriculum planners and teachers have tried to develop technology education specific to the needs of Hong Kong students, as industry does not need large amounts of technologically well-skilled people and has shifted to a knowledge-based and management-based economy. However, from a different point of view, the current crisis presents an opportunity for curriculum planners, teachers and other educational researchers to review the development of technology education in Hong Kong. The reasons for the decline in technology education in Hong Kong might not only be associated with the industrial decline during the 1990s. Other internal factors relating to current technology education and beliefs held by Hong Kong people may also have contributed. For example, some school administrators may not understand the educational value of technology education, while others may still perceive it to be a skills-based discipline. Although Hong Kong is only a small part of China and the world, the success and failure of technology education experienced in Hong Kong can provide some hints for technology educators in other places who wish to optimise technology education. More important in this regard is how educators and researchers should intervene in the process and re-launch, redevelop, or rekindle technology courses in secondary schools. Action must be taken to develop a better system of technology education, so that students can enjoy the true benefits of the curriculum.

As discussed earlier, the development of, and problems with, technology education coexist in mainland China and Hong Kong. Technology education is currently in a period of transition within the implementation of the new curriculum structure for general senior secondary schools in mainland China. Hong Kong is currently confronted with greater challenges in technology education than ever before. Although technology education is classified as a key learning area in mainland China and Hong Kong, the actual implementation situation is not as expected (Siu, 2009). We must now ask whether the present position of technology education in the school curriculum system is suitable or not? Do we need to define a new identity for technology education to meet educational and societal needs? Taking Hong Kong as an example, if the position of technology education is currently suitable, why are these subjects now closed in most secondary schools? Are the issues of successes and problems in Hong Kong similar to those experienced on the Chinese mainland or in other countries? Can the situations in mainland China and in Hong Kong serve as references or mirrors for each other? All of these questions need to be continually asked during the implementation process to correct or revise policies and curricula.

The current situation indicates that the development of technology education needs the support of policy and that the instruments and equipment required depend on making full use of local resources. The evaluation system needs to be based on the specific needs of Chinese culture to promote the steady development of the curriculum. Changing people's ideas about education is an arduous task, as is overcoming their ignorance of technology education. Overall, the reform of the technology curriculum in China has had a great impact in improving students' innovative spirit, practical competence and adaptability in a technology-based society, and more importantly their overall well-being and lifelong development. The reforms also have a profound historical significance in that are enhancing technology literacy all over China. It is necessary to establish a strong leadership position to ensure that technology education remains a significant part of the mainstream public education curriculum. Technology education is still a new area, particularly in Asian regions such as China. It is thus necessary for curriculum planners and teachers to realise that the reform of technology education does not require a perfect final solution in curriculum development. Instead, reform should be considered as a series of continuous cycles of research, implementation, evaluation and further research. It is only through such a continuous cycle of action and reflection that technology education can be made to fit the ongoing social and educational changes within society.

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