PATT 18

Pupils Attitudes Towards Technology

International Conference on Design and Technology Educational Research

Teaching and Learning Technological Literacy in the Classroom

Edited by John R. Dakers, Wendy J. Dow and Marc J. de Vries

Faculty of Education
University of Glasgow
Acknowledgements

These conference papers are the result of a great deal of effort by many people, most notably, the authors themselves. There are in the region of fifty papers representing eighteen countries from almost every continent. As with most PATT conferences it is likely that several others will turn up beyond those represented in this conference book. The countries mentioned include:

Canada, The United States of America, Brazil, Australia, New Zealand, India, Israel, Japan, South Africa, Tanzania, Greece, Italy, Finland, Sweden, the Netherlands, England, Ireland and Scotland.

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Introduction

John R Dakers, Wendy J Dow and Marc J de Vries

There is very little literature directly relating to education about the basic technological nature of the world that young people must negotiate nor about the kinds of technological obstacles that they are likely to encounter in that world. Their views of technology influence their ability to both use and relate to it. Many young people have a tendency to perceive technology in terms of its artefacts: computers, cars, televisions, toasters, pesticides, flu shots, solar cells, genetically engineered tomatoes and so on. Often they do not see technology in terms of the knowledge and processes that create these artefacts, nor are they aware of the various implications for society resulting from these technologies.

There is a tendency in the teaching of Technology education at school level, to present information about some pre-existing technologies in an instrumental form. Pupils are then expected to reconstitute this information in the form of concrete artefacts. We do not sufficiently engender in young people an abiding curiosity about how the technologically shaped world in which they live actually affects them.

Within the various rationales for Technology education from across the developed world, an abiding and recurring issue is evident: Technology education must engage with the development of informed attitudes about the impact that existing and emerging technologies will have upon their cultural development, as well as the potential and actual consequences these technologies will have upon the environment, both locally and globally. This is known variously as ‘Technological Literacy’ or ‘Technological Capability’.

This year sees one of the largest PATT conferences ever with almost 100 delegates in attendance. The conference has two elements this year: a research seminar with invited keynote speakers, followed by the normal two and a half day conference.

We are delighted to see old friends of the PATT conference and some new faces. We are delighted with the range of papers. Some reflect the conference theme and others relate to technology education in some other sense. This is the style of PATT conferences. Over the years the scope of topics for discussion have extended to all aspects of technology education. At a certain moment it was decided to set focused themes for the conferences, such as ‘Teaching Technology for Entrepreneurship and Employment’, ‘Teacher Education for School Technology’, and ‘Technology Education and the Environment’. Another new element that was added to the PATT conferences was that not only conferences in the Netherlands were held, but also conferences in other countries, often with a more regional character. Such conferences have been organised in Kenya, Poland, South Africa and Scotland. With the International Technology Education Association (ITEA) in the USA an effort has been made to have PATT-USA conferences as part of the annual ITEA conferences. So far, four of these PATT conferences have been organised (Indianapolis, Indiana, 1999, Salt Lake City, Utah, 2000, Columbus, Ohio, 2002 and San Antonio, Texas, 2007). Traditionally the Proceedings of the PATT conferences were published to make the papers and discussions available to a wider audience. ITEA has put the most recent Proceedings onto their website (www.iteawww.org). In both Scottish conferences we have published a conference book.

In the region of fifty papers will be delivered by over fifty delegates in two parallel sessions. The conference presentations shall take place over two and a half days and we sincerely look forward to meeting everyone and hearing the various presentations.
Inquiry into technological knowledge in an educational context

Willem J. Rauscher  University of Pretoria  South Africa
E-mail: Willem.Rauscher@up.ac.za

Abstract
Teaching and learning technology in South Africa must be aimed at developing technological literacy so that learners are empowered to cope with the challenges of a technological society (Department of Education, 2003:26). To bring this about, an understanding of the nature of technological knowledge is important for the development and delivery of effective technology programmes, which could provide a solid platform for the development of learners’ technological literacy. Technological knowledge should therefore be a specific focus in technology education (Compton, 2004:10,17).

This paper presents a quantitative and qualitative analysis, based chiefly on engineering frameworks, of the categories of technological knowledge used by design and technology education students in designing and making technological artefacts. It finds that the students utilized all the categories of technological knowledge and used knowledge from these categories to a similar extent in two different content areas.

Introduction
The purpose of technology education in South Africa is, according to the Department of Education (DoE, 2002:4), to enhance learners’ technological literacy through integrating the three learning outcomes, viz. technological processes and skills (learning outcome 1), technological knowledge and understanding (learning outcome 2), and technology, society and the environment (learning outcome 3) (DoE, 2002:5). The integration of these learning outcomes entails technological practice in keeping with current sociological understanding of technology and technological developments (Compton, 2004:10).

Since present day schooling is still obsessed with content and the premise of fragmentation as a requirement for the curriculum (Slabbert & Hattingh, 2006:702), content is parcelled in ‘departments’, which causes various problems for technology education. The discomfort of educators in South African schools with the pedagogy of technology because of a general low capacity in terms of the content knowledge, cognitive and manual skills (DoE,2003:31), exacerbates the situation. To build capacity, educators need to begin to understand technology whilst progressing to knowing how to “do” technology (DoE, 2003:31).

As no established subject philosophy exists for technology education, one can draw on the philosophy and history of engineering, as well as design methodology for insights (Broens & De Vries, 2003:459-460). These disciplines provide frameworks and categories of technological knowledge through which technology can be conceptualized, but if they are to be useful they need to be validated by teachers, and data gathered by students in order to begin to develop an idea of the form of technological knowledge (Compton, 2004:17).

1 For the purpose of this study the term “technology” will be used in the broader sense where the term “technology” includes everything the engineer calls technology, along with engineering itself (Mitcham, 1994:143-144). In line with De Vries’s (2005:11-12) approach, the term (technology or engineering) used in this paper will be led by the literature referred to in that particular case.
The following research questions are addressed:

- To what extent do technology education students make use of categories of technological knowledge when they design and make an artefact?
- What is the correlation between the categories of technological knowledge used in two different content areas in technology education?

### Frameworks of technological knowledge

Various authors in the field have presented technological knowledge frameworks. Vincenti (1990:208), in an analysis of historical case studies in aeronautical engineering, identified six categories of technological knowledge: fundamental design concepts, criteria and specifications, theoretical tools, quantitative data, practical considerations, and design instrumentalities. In a philosophical effort to classify technological knowledge, Ropohl (1997:68-71) recognises five categories of technological knowledge applicable to engineering: technological laws, functional rules, structural rules, technical know-how and socio-technological understanding. De Vries’ (2003:13-14) classification of technological knowledge is based on the “main steps” in the development of the LOCaL Oxidation of Silicon (LOCOS) technology, i.e. functional nature knowledge, physical nature knowledge, means-ends knowledge and action knowledge. Bayazit (1993:123) classifies designers’ knowledge into two main groups: procedural and declarative knowledge, and identifies another two forms of knowledge, namely design normative knowledge and collaborative design knowledge (Bayazit, 1993:126-127).

Although it seems that these authors have different approaches to classifying technological knowledge into categories, there are relationships between the categories (see Broens & De Vries, 2003:461; De Vries, 2003:16). The concurrence between the categories of technological knowledge of the various authors presented by Broens and de Vries (2003:461) will be used in the conceptual framework for this study. Vincenti’s categories of technological knowledge will be extended with the addition of Ropohl’s (1997:70) category of socio-technological understanding and Bayazit’s (1993:123) collaborative design knowledge. Table 1 represents the conceptual framework used for this study.

### Table 1: Conceptual framework adapted from Broens and De Vries (2003:464)

<table>
<thead>
<tr>
<th>Category of knowledge</th>
<th>Brief description of the category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental design concepts</td>
<td>Concepts include the “operating principle” and “normal configuration” of the device (Vincenti, 1990:208-211).</td>
</tr>
<tr>
<td>Criteria and specifications</td>
<td>The qualitative goals for the device must be translated to quantitative goals in concrete technical terms. This requires knowledge of technical criteria regarding the device and its use, and the ability to assign numerical values or limits to the criteria (Vincenti, 1990:211-213).</td>
</tr>
<tr>
<td>Theoretical tools</td>
<td>Tools include intellectual concepts for thinking about design, and mathematical methods and theories for design calculations (Vincenti, 1990:213-216).</td>
</tr>
<tr>
<td>Quantitative data</td>
<td>Two types of knowledge are distinguished: descriptive (how things are) and prescriptive (how things should be) (Vincenti, 1990:216-217).</td>
</tr>
<tr>
<td>Practical considerations</td>
<td>Derived from experience in practice and include not only design but production and operation as well (Vincenti, 1990:217-219).</td>
</tr>
<tr>
<td>Design instrumentalities</td>
<td>Instrumentalities include procedures, ways of thinking and judgmental skills applied (Vincenti, 1990:219-220).</td>
</tr>
</tbody>
</table>

2 Vincenti (1993:208) acknowledged that his categories are probably not exhaustive.
Socio-technological understanding
Technical objects have to be optimized while considering the ecological and psychosocial context of the artefact (Ropohl, 1997:70).

Collaborative design knowledge
The knowledge development of individuals working in groups (Bayazit, 1993:126-127).

The framework above is complex and it should be noted that Vincenti (1990) did not intend his categories of knowledge to be used for the purpose of this study. Since he (Vincenti, 1990:7,207) derived the categories from historical cases which focused on knowledge for normal, everyday design, and as all the categories refer to knowledge as related phases in the design process (Broens & De Vries, 2003:469), it seems appropriate, however, to use Vincenti’s (1990) framework, because the students had to follow the prescribed design process to design and make their simple artefacts.

**Target and contextual background of study**
The target comprised third year undergraduate (elective) technology students at the University of Pretoria in the Bachelor of Education (BEd) course. This study focuses on two capability tasks from two different technology content areas taken by these students, JOT 353 and JOT 354.

In JOT 353 (a seven-week, six-credit third term module that deals with the content area of systems and control) students had to design and make an educational toy comprising at least two different mechanical components, e.g. gears, pulleys, levers, etc., and an electrical circuit. At the end of the module, students had to present the educational toy as well as a comprehensive project portfolio, documenting the design and manufacturing process. Figure 1 and 2 depict some of the toys.

![Figure 1: Educational toy 1](image1)

![Figure 2: Educational toy 2](image2)

JOT 354 (a seven-week, six-credit fourth term module) covers the content area of structures. During this module the capability task required the students to design and make a structural artefact based on and selected from their individual learning programmes created in JMC 300: Methodology in Technology. As part of their JMC 300 module, all students had to create a complete learning programme for a phase of their choice. Learning programmes had to include all three content areas in each grade, viz. systems and control, structures, and processing. Since technology’s teaching strategy

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3 Capability task – designing and making a product that works (Barlex, 2000). Projects are done over a longer period of time using the design process (investigate, design, make, evaluate and communicate) as prescribed by the Department of Education (2003:6).

4 Six credits entail 60 hours (contact and non-contact time) to be spent on the module.
is project based, students had to specify a contextualised project as a capability task for each content area for each grade. Students acted as curriculum developers since they were not required merely to select a capability task from a pre-existing set. Students were free to choose any project from any grade specified in their learning programme that related to the content area of structures and had to design and make the artefact. An outcome of the module was that they had to present the structural artefact and a comprehensive project portfolio documenting the process followed to design and make it. Figure 3 and 4 show examples of some of these structural artefacts.

![Figure 3: Structure 1](image)

![Figure 4: Structure 2](image)

All the capability tasks were performed during non-contact time in a constructivist manner. Since a problem-based approach was followed, it meant that students identified need and artefact differed and therefore the solution to their problems was unique. Each student required different knowledge at different phases of the design process, which due to time constraints, be realised only if the students worked in a constructivist manner during non-contact time. Contact time was reserved for activities such as resource tasks, case studies, etc., activities, which could have had an influence on, the technological knowledge used by the students in the capability task. The students however could have constructed their own knowledge based on knowledge acquired elsewhere. The focus of this paper is therefore not on the origin of the knowledge, but on whether the students indeed employed technological knowledge.

**Research design**

This study engaged a sequential explanatory mixed method design. For the purpose of this paper, priority was given to the quantitative (QUAN) analysis, which will be presented first and followed by a small qualitative (qual) component which will reveal, by means of examples from the student portfolios, whether the students did in fact made use of the categories of knowledge.

Limitations of this study include the:

- contextual scope, i.e. students from only one University participated;

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5 It is assumed that all the third year design and technology students, although they had no previous engagement in the content of systems and control, and structures, were competent in following the design process independently as it was part of their formal first and second year training.

6 Resource tasks – are short practical activities to encourage pupils to think and help them acquire the knowledge and skill they need to design and make competently (Barlex, 2000).

7 Case studies – are true stories about design and technology in the world outside the classroom (Barlex, 2000).
• focus of this study is limited to technological knowledge in a South African educational context; and
• a limited number of cases (projects) were used in the research.

Quantitative analysis

Sampling
The sample was a non-random, or non-probability convenience sample (Creswell, 2005:146-149; Neuendorf, 2002:87-88). The whole target was selected due to the small number of students available in the target population. The sample consisted of mostly the same students from two different modules, i.e. JOT 353 (systems and control): 22 students and JOT 354 (structures): 21 students.

Both groups were heterogeneous in terms of language, gender and culture, and they ranged in age from 20-23.

Instrument and data collection
A rating scaled questionnaire was used to collect data at the end of each module. In completing the questionnaire, students had to indicate the extent to which they made use of the various categories of technological knowledge (e.g. “Not at all”, “To a limited extent”, “To a fairly large extent”, “Extensively”). The student responses were then counted to determine the extent to which each category of technological knowledge was used to design and make an educational toy and structural artefact.

The questionnaire was piloted before it was administered to establish the students’ understanding of concepts used in the questionnaire. During the pilot the concepts were explained with the aid of relevant examples which did not pertain to the content of the modules mentioned above. Through the student answers to probing questions (which were not in the questionnaire) asked by the administrator, it was established that the students did indeed understand the concepts in the questionnaire. While administering the questionnaire at the end of the two relevant modules, the same explanations and examples were used to refresh students’ memory.

Results
The tallied results of the students’ responses to the rating scaled questions, indicating the extent to which each category of technological knowledge was used to design and make an educational toy and structural artefact, are shown in graph 1 and graph 2 respectively.

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8 Students who were repeating the module or who had already passed it and were therefore not present, account for the slight difference in student numbers between the two modules.
Graph 1: Number of student responses to the categories of technological knowledge applicable to the educational toy

N = 22

Graph 2: Number of student responses to the categories of technological knowledge applicable to the structures artefact

N = 21
From graph 1 and graph 2 it can be seen that the students made use of all the categories of technological knowledge in the design and making of both artefacts. Most of the responses fall in the “To a fairly large extent” range.

Relation regarding the extent to which students made use of the categories of technological knowledge between the two content areas

The Pearson product moment correlation coefficient \( r \) was used to establish whether a relationship existed regarding the extent to which students made use of the categories of technological knowledge between the two content areas. Table 2 indicates the Pearson’s \( r \) for each category of technological knowledge.

<table>
<thead>
<tr>
<th>Category of technological knowledge</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental design concepts</td>
<td>+ .88</td>
</tr>
<tr>
<td>Criteria and specifications</td>
<td>+ .76</td>
</tr>
<tr>
<td>Theoretical tools</td>
<td>+ .90</td>
</tr>
<tr>
<td>Quantitative data: Descriptive knowledge (how things are)</td>
<td>+ .96</td>
</tr>
<tr>
<td>Quantitative data: Prescriptive knowledge (how things should be)</td>
<td>+ .35</td>
</tr>
<tr>
<td>Practical considerations</td>
<td>+ .98</td>
</tr>
<tr>
<td>Design instrumentalities</td>
<td>+ .72</td>
</tr>
<tr>
<td>Socio-technological understanding</td>
<td>+ .90</td>
</tr>
<tr>
<td>Collaborative design knowledge</td>
<td>+ .83</td>
</tr>
</tbody>
</table>

Jackson’s (2006:124) estimates were used to interpret the above-mentioned correlation coefficients as listed in Table 3.

<table>
<thead>
<tr>
<th>Correlation coefficient</th>
<th>Strength of relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>± .70 – 1.00</td>
<td>Strong</td>
</tr>
<tr>
<td>± .30 - .69</td>
<td>Moderate</td>
</tr>
<tr>
<td>± .00 - .29</td>
<td>None (.00) to weak</td>
</tr>
</tbody>
</table>

Table 3 shows that eight of the nine categories of knowledge listed in table 2 show a strong positive relationship between the two content areas, while the category of quantitative data that relates to prescriptive knowledge shows a moderate positive relationship between the two content areas. Students have thus used knowledge from these categories of technological knowledge to nearly the same extent in both content areas, which suggests that the knowledge contained in one content area (e.g. systems and control) does not significantly favour the categories of knowledge above the knowledge contained in the other content area (e.g. structures).

Qualitative analysis

Instrument and data collection

The categories of technological knowledge listed in the conceptual framework were used to guide the content analysis of the project portfolios – an attempt to find evidence for each category of technological knowledge to substantiate students’ answers to the questionnaire.
**Sampling**

The sample was a non-probability, purposive sample, beginning with the best project portfolios\(^9\) and building up the sample based on the principle of saturation of data. Three project portfolios were used to provide the examples listed in Table 4.

**Results**

The students’ project portfolios were scrutinised for evidence of the categories of knowledge listed in the conceptual framework. For the purpose of this paper only a limited number of examples from these portfolios as they relate to some of the categories of knowledge are included as shown in Table 4.

**Table 4:** Examples from students’ portfolios pertaining to each of the categories of knowledge

<table>
<thead>
<tr>
<th>Category of knowledge(^*)</th>
<th>Examples from the students’ portfolios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental design concepts (Operational principle)</td>
<td>A pulley allows … a change in the direction of movement … Mechanical advantage is achieved when more than one pulley is used … By using more pulleys, the distance the cord must be pulled is increased. Two pulleys will halve the force required, but the cord will have to be pulled twice the distance (s23080532:9).</td>
</tr>
<tr>
<td>Fundamental design concepts (Normal configuration)</td>
<td>A resistor must be connected in series with a light emitting diode (LED) to prevent it from burning out.</td>
</tr>
<tr>
<td>Criteria and specifications (Assignment of values and limits based on norms and standards for the LED)</td>
<td>$V_S = 9$-volt battery $V_L =$ voltage across LED $= 2V$ $I =$ current through the LED $= 20$ mA The resistor’s (R) value can be determined by: $R = \frac{V_S - V_L}{I}$ $V_S =$ Supply voltage $V_L =$ Voltage across the LED $I =$ Current in circuit The theoretical value of the resistor was calculated to be $350 , \Omega$. (s23080532:12-14)</td>
</tr>
<tr>
<td>Theoretical tools (Mathematical methods and theories - simple formula for direct calculation)</td>
<td>$V_S = 9$-volt battery $V_L =$ voltage across LED $= 2V$ $I =$ current through the LED $= 20$ mA The resistor’s (R) value can be determined by: $R = \frac{V_S - V_L}{I}$ $V_S =$ Supply voltage $V_L =$ Voltage across the LED $I =$ Current in circuit The theoretical value of the resistor was calculated to be $350 , \Omega$. (s23080532:12-14)</td>
</tr>
<tr>
<td>Practical considerations (Consideration coming from operation)</td>
<td>Design three… is in actual fact a box within a bigger box… The inner box sits slightly lower than the outer, and the CD’s, to make removing CD’s easier (s23230879:10).</td>
</tr>
</tbody>
</table>

\(^9\) The best portfolios were those that scored the highest marks when assessed at the end of each term. It is assumed that these portfolios provide the most comprehensive documentation, and as a result, richness in data.
Design instrumentalities (Ways of thinking – visual thinking)

Vincenti (1990:208) acknowledges from the outset that the divisions between the categories are not entirely exclusive, as seen in Table 4, where the example presented for the category of criteria and specifications can also be classified in the category of quantitative data: the LED specifications can be seen as quantitative prescriptive data. The purpose of this qualitative phase, however, is not to determine the extent to which this kind of overlapping takes place, but to search for evidence of the categories of knowledge used to validate students’ responses to the questionnaire.

**Conclusion**

The findings show that students:

- made use of all the categories of technological knowledge “To a fairly large extent” in the design and making of both artefacts, and
- used knowledge from the categories of knowledge to almost the same extent in both the content areas, suggesting that the knowledge contained in one content area examined does not significantly favour the categories of knowledge above the knowledge contained in the other content area.

It is clear that the categories of technological knowledge derived from practice also apply to technology education. By considering these categories of technological knowledge, educators can deepen their understanding of the nature of technological knowledge. In addition, such a framework can be considered as an alternative approach to cross-curriculum development in technology education to avoid problems arising from a fragmented approach. This in turn, can empower educators to develop a learning programme that can fully integrate the learning outcomes in a problem- and project-based approach in line with technological practice (Compton, 2004:10).

**Bibliography**


It is said to be a fact – at any rate it is generally believed – that the Swedish people distinguishes itself by a strong natural ability for mechanics and technology.¹

Svensk Läraretidning 1902

School technology education is a phenomenon common to most Western countries, which have introduced a general or comprehensive technology subject in the curriculum of primary and/or secondary education in the past 30 years or so. Examples of such are Design and Technology in Great Britain, Technology Education in the USA, Technology in New Zealand, Teknologi og design in Norway and Teknik in Sweden.² The introduction of a basic technology subject has generally been rather troublesome in that the identity and content have been difficult to pin down. This, in turn, is partly due to the patchwork of historical knowledge traditions that make up technology as a school subject.³

It is therefore imperative that historical research be carried out concerning the origins of technology education in schools. This has been missing to a great extent in the field of technology education as well as educational history, particularly for countries other than the United States.⁴ Historians of technology have shown interest in education, but this has mainly been higher engineering education or museums, and the teaching itself has played only a minor role.⁵

Aim and Source Material
The aim of this paper is to identify a comprehensive technical domain of knowledge – teknisk allmänbildning – in the curriculum of the Swedish elementary school (folkskola) as well as views on elementary school technology of central interest groups, in order to shed light on the intricate pre-history of the Swedish technology subject. The source material is the Swedish elementary school curricula of 1900 and 1919 as well as school- and technology-oriented journals in connection with these curricular changes. Svensk Läraretidning, journal of Swedish elementary school teachers, has been studied for the years 1900-1903 and 1919-1924. Furthermore, Teknisk tidskrift – journal of

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¹ Vår praktiska bildningslinje. Folkskolan som bottenskola 1902 p. 492. All translations from Swedish to English are my own. The research on which this paper is based was financed by the Swedish Research Council (Vetenskapsrådet), to which I am grateful for support.
² Ginner and Hallström 2006.
⁴ For example, Waetjen 1992 and Pannabecker 1994 have indicated the absence of historical research on technology in schools. However, something seems to have happened since the early 1990s. A few articles and reports have been written on the history of American technology education, such as Herschbach 1997a, Herschbach 1997b, Zaga 1997 and Lewis and Zuga 2005. Chafy 1997 and Pannabecker 2004 explore the older roots of technology education in Europe and America. De Vries and Mottier 2006 is a review of the past twenty years of technology education in many parts of the world.
⁵ Petrina 2004 p. 305-307; Sundin 1999. A recent example of the focus on higher education – more specifically whether engineering colleges were practice oriented or science oriented in the 19th and early 20th centuries – is Harwood 2006.
Svenska Teknologföreningen, an association representing Swedish engineers – has been studied for the years 1900-1903 and 1919-1924.6

Theory and Method
Theoretically, this paper is inspired by a view of the study of technology education put forward by David Layton, who sees the evolution of technology education as a negotiation between different interest groups. School technology is subject to “a range of competing influences” and it is possible to pinpoint the “principal actors in this curriculum drama”.7 Ivor F. Goodson argues similarly that “subjects are not monolithic entities but shifting amalgamations of subgroups and traditions which through contestation and compromise influence the direction of change. . . . the debate over curriculum can be interpreted in terms of conflict between subjects over status, resources and territory.”8 It is the roots of Swedish technology education that is focussed in this paper, and Layton’s and Goodson’s respective approaches will be used as a loose framework for analysis. The method employed in this study is a hermeneutic method, that is, a method of interpretation.9

Bildung, bildning and teknisk allmänbildning
To describe the kind of technical knowledge or competence a Swede might need, a specific term has been used throughout the 20th century: teknik bildning or allmänbildning,10 derived from the German word Bildung. It can be said to be an early Swedish counterpart to the present-day concept of technological literacy.11 The closest English translation of allmänbildning would be general education or liberal education, but these terms do not really catch the essence of either the Swedish or the German term. In this context Bildung is often connected with the German philosopher and pedagogue Wilhelm von Humboldt, who was Minister of Education in Prussia and co-founder of the Humboldt-Universität of Berlin in 1810. Humboldt’s romanticist and neo-humanist idea of Bildung was that knowledge fundamentally transforms and develops human beings into becoming something which is not given. Bildung was thought to give the basic, all-round skills necessary to become human. At the same time von Humboldt emphasized central, stable areas of knowledge, particularly classical languages, history and mathematics for secondary education (so-called formal Bildung; university courses were to be freer).12

The idea of bildning in the natural sciences was expressed as early as 1828 by the Swedish botanist Carl Adolph Agardh. From the mid-19th century, however, the Swedish word bildning came to be associated primarily with the humanities as opposed to the new, “practical” natural sciences and technology.13 Bildning was therefore most often talked about as a humanistic trait until the 20th century, when natural sciences and technology were also included in such discussions. The term allmänbildning was also in use, meaning all-round, comprehensive knowledge, which in public

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6 The journal Teknisk tidskrift was divided into a general section, Allmänna avdelningen (periodically also called Veckoupplagan), and several specialized sections, the latter of which represented different areas of the engineering sciences. I have limited my research to the general section, since this was where educational matters were mostly discussed.
8 Goodson 1994 p. 42.
9 The stance put forward here is historicist, that is, meaning is determined by the context in which the source material was written as well as the historian’s own context (MacLean 1986 p. 122-124, 136-138).
10 See, for example, Ginner and Mattsson 1996.
11 Technological literacy is “the ability to use, manage, assess, and understand technology,” according to the American Standards for Technological Literacy (Standards for Technological Literacy: Content for the Study of Technology 2000 p. 1-10). Cf. Dakers 2006.
13 The subject natural science (Naturkunskaper) in elementary school was an exception in that it was created as a basic, comprehensive (bildande) subject, although its introduction was very controversial (Hultén 2006). A similar subject – general science – was introduced in American secondary schools in the 1910s (Rudolph 2005).
debates often meant the same as \textit{bildning}.\textsuperscript{14} \textit{Teknisk allmänbildning} thereby came to mean all-round, comprehensive technical knowledge and skills.

\textbf{What is Technology and Technical Knowledge? Swedish Technology Education in the 19th Century}

An opposition appeared between handicraft, with a long historical tradition, and a more recent polytechnic ideal in the new technical schools that were established in Sweden in the early 19th century. The early Swedish engineering schools had their roots in military engineering, sloyd and handicraft: The Artillery School (\textit{Artilleriläroverket}) at Marieberg, Stockholm (1818), the School of Mines (\textit{Bergsskolan}) in Falun (1822), the Technological Institute of Stockholm (1827) and Chalmers’ Sloyd School in Göteborg (1829).\textsuperscript{15} The first principal of the Technological Institute, Gustaf Magnus Schwartz, defended the practical tradition on which the Institute had been founded:

\begin{quote}
The world of art which man himself has created through his own thoughtfulness, inventiveness and assiduity, forms . . . an organic whole of a completely different kind than nature, the archetype of the sciences. The characteristic and arrangement of art as \textit{problems} are something completely different than the formation of laws of nature as \textit{theorems} within the sciences. . . . Experience has therefore . . . made an own practical theory, created through induction and after analogy, and this is \textit{technology} or systematized experience.\textsuperscript{16}
\end{quote}

This passage illuminates the conflict between the natural sciences and technology that existed in mid-19\textsuperscript{th} century technology education. A more modern definition of what technology is would seek to bridge such differences, although, by and large, the above definition still holds good: science and technology as knowledge domains have very different historical roots. The definition of technology that will be used in the current paper is adapted from Ginner (1996): 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.\textsuperscript{17} Technical knowledge is by tradition practical, although it could also be theorized and theoretical influences from the natural sciences increasingly pervaded it in the early 20\textsuperscript{th} century.\textsuperscript{18}

In the 1840s education at the Technological Institute was scrutinized by a committee, which promoted a polytechnic ideal. Higher technical education should not, according to this committee, primarily devote itself to practical technology in a handicraft tradition but to the teaching of natural science and mathematics. This investigation laid the foundation for the subsequent transformation of the institute into the Royal Institute of Technology (\textit{Kungliga tekniska högskolan}, KTH) in 1877. It was founded on the polytechnic tradition. All the higher technical education in eastern Sweden was thereby gathered under the same umbrella – architecture, chemical technology, mechanical engineering, science of mining and civil engineering became five sections within the KTH.\textsuperscript{19}

As early as the mid-19\textsuperscript{th} century, there were ideas of how to divide Swedish technology education into different levels. According to Rolf Torstendahl, up to 1870 three levels had crystallized. The Technological Institute and Chalmers’ Sloyd School constituted the highest level; higher education which was also science oriented. In the rising Swedish industry there was a need for theoretically trained engineers and designers in leading positions, but also more practical engineers with qualities of

\begin{footnotesize}
\textsuperscript{15} Sundin 1991 p. 246-248; www.chalmers.se.
\textsuperscript{16} Quoted in Torstendahl 1975b p. 72.
\textsuperscript{18} Cf. Liedman 2001 p. 169-179.
\textsuperscript{19} Torstendahl 1975a p. 40-41; Sundin 1991 p. 246-248.
\end{footnotesize}
leadership such as master mechanics and foreman. Just below this level was the so-called *teknisk elementarskola* – a technical school on upper secondary level, established in the 1850s – as well as certain Sunday and evening schools. These schools educated fairly advanced engineers, for example, with future positions as foremen or assistants to university-trained engineers. On the third and lowest level were the majority of Sunday and evening schools, whose educational content varied a great deal and was not mainly technical. They educated young people for manual labour in trade and industry. The state guaranteed the quality on the two highest levels of technical education, which would yet serve both public and private, industrial interests.20

The subject-matter of this paper – basic, comprehensive technology education, *teknisk allmänbildning* – would be just below the third of Torstendahl’s levels. It thus constituted a fourth level of technology education, which was comprehensive and to a certain extent vocational and belonged in elementary school (see Figure 2). This level has not really been the object of any Swedish studies so far, maybe because elementary school has not been considered a technical school or a school with any manifest technical content at all.21

Up until the 1840s, the development of technical education can be said to have been common to sloyd education, at least, no one separated clearly between the two. When a more distinct structure of technology education began to appear in the mid-19th century, symbolized by the three levels, it became clear that it was more occupationally oriented than sloyd. From the mid-19th century more and more sloyd schools were established parallel to the already existing elementary schools. The first comprehensive technical education for the Swedish people can be said to have emerged around 1880, when educational sloyd was introduced as an optional subject in elementary school.22 There pupils had the opportunity to encounter and use technical tools such as saws and carpenter’s benches and later on also sewing machines.23

A close-up of the curriculum for elementary school of 187824 shows that it was not only in the sloyd subject that elements of a technical domain of knowledge appeared, but also in several other subjects. In educational sloyd (*Slöjd*) one focussed the work of the hand, practical-technical skills as well as associated tools such as carpenter’s tools and turning equipment for boys and knitting-needles for girls. The pupils were to produce primarily “objects that are necessary and useful for the peasantry [allmoge] . . .”25 In the obligatory natural science (*Naturkunnighet*), which was a subject with contributions from both physics, chemistry, botany and zoology, teaching about technical artefacts such as the lever and the thermometer should be included.26 The subjects drawing (*Teckning*) and

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21 Magnus Hultén, pedagogue and historian, is currently finishing a thesis on natural science in the Swedish elementary school since its inception in the 1840s. He addresses some of the technical content, although this is not his main purpose (Hultén 2006).
22 This meant that it was optional for individual schools whether they wanted to offer teaching in this subject or not. The same can be said about the subjects gardening (*Trädgårdsskötsel*) and domestic science (*Huslig ekonomi*).
24 The Swedish *normalplan*, *undervisningsplan* and *läroplan* constituted official documents that prescribed the content and goals for the Swedish school and the different subjects, much as the German *Lehrplan*. Although the English word *curriculum* does not quite match the Swedish word it will be used for want of a better term. Cf. Linde 2006 p. 5. The curriculum of 1878 was for elementary school (*folkskola*, including *småskola*, the first two years) as well as *fortsättningsskola*.
25 *Normalplan för undervisningen i folkskolor och småskolor* (Stockholm 1878), p. 32.
26 *Normalplan för undervisningen i folkskolor och småskolor* (Stockholm 1878), p. 27-32.
geometry (Geometri) can also be said to have been part of a technical domain, since they prepared for various technical schools. Both subjects should aim at “the needs of practical life.”

Swedish School Technology Education 1900-1920

In the period from 1900 to the 1920s Sweden was transformed from an agricultural country to an industrial one. Technology played a central part in this major economic development, partly because exploitation of natural resources such as iron ore deposits and waterfalls required technology, partly as a few central engineering firms became prime exporters of Swedish innovations. Due to this great industrial momentum class struggle and the forming of labour unions and employers’ associations intensified in the beginning of the period, but in 1918 to 1921 universal suffrage was introduced and a more harmonious period ensued.

In 1900 to 1920 there was also an intense extension of technological systems such as railroads, tramways, water supply and sewerage, telephone lines and electric wires, as well as incipient motoring and aviation.

The beginning technicalization of Swedish society was mirrored in the school curriculum. Compared to the elementary school curriculum of 1878, certain items of natural science were extended in the curriculum of 1900 to include more “applications” of scientific phenomena, for instance, the pump, the steam engine, the telegraph and the telephone.

Even in this curriculum educational sloyd was an optional subject in which technical knowledge and skills should be communicated. Gardening (Trädgårdskötsel och trädplantering) included practical-technical elements such as digging, sowing and planting. The new, optional female subject domestic science (Huslig ekonomi, för flickor) contained domestic technology and skills like the operation of a stove and the cleaning and management of household utensils.

Drawing and geometry had about the same content as in the curriculum of 1878.

The curriculum of 1900 did not primarily prescribe a vocational-technical form of education, but rather elementary schooling designed to give very basic knowledge in fundamental subjects. However, it can be said that elements of a comprehensive technical knowledge domain was scattered in several different subjects. Especially representatives of farmers and the working-class also saw elementary school as an institution instilling comprehensive knowledge, which was necessary for the coming working life, as well as a springboard to higher levels of education.

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27 Normalplan för undervisningen i folkskolor och småskolor (Stockholm 1878), p. 23, 30-34, 45, 47 (quote).
31 This was for elementary school (folkskola, including småskola, the first two years), högre folkskola as well as fortsättningsskola.
32 Normalplan för undervisningen i folkskolor och småskolor (Stockholm 1900), p. 41-45. It is clear from the text that these technical artefacts were seen as applications of scientific phenomena, which explains why they are part of the natural science subject. Furthermore, these artefacts and associated phenomena (for example, the characteristics of liquids and gases) had been picked out as particularly important – and maybe especially down-to-earth examples – for schools that did not have so much teaching and therefore had to compress the course (Ibid., p. 41-45, 68). It is interesting that the steam engine was seen as an application when it is such a good example of a technical artefact that preceded its scientific understanding (thermodynamics) by at least 150 years.
33 Normalplan för undervisningen i folkskolor och småskolor (Stockholm 1900), s. 49-51.
34 Normalplan för undervisningen i folkskolor och småskolor (Stockholm 1900), p. 33-34, 45-47, 68-69.
35 See, for instance, Realskolexamen och folkskolan 1903. Drawing (Teckning) is an example of a subject that representatives of (technical) universities and secondary schools thought had a generally educative (allmänbildande) significance and was important for practical as well as scientific work. (Teckningsundervisningens betydelse för den allmänna bildningen 1901 p. 334). Various forms of drawing (Ritning) were also important in the timetables of the technical upper secondary schools (see, for example, Redogörelse för Tekniska Elementarskolan i Norrköping under läsåret 1903-1904, Norrköping 1904).
In late 1901 there was a discussion in Svensk Läraretidning about the need for a clearer organization of vocational education. The topic of discussion was really the schools immediately following elementary school and as such it anticipated political debate and reform of vocational education during the 1910s. A representative of artisans and craftsmen argued for a new kind of vocational school for pupils between 13 and 16 years old. He thought that courses extended from elementary level sloyd could do for the practical parts – “to handle tools and work up materials” – and as theoretical subjects he proposed various kinds of drawing, perspective as well as writing and bookkeeping.

Representatives of elementary school teachers were overall positive to the proposal, especially the fact that the new school could partly be built upon the sloyd subject. They suggested the existing superstructure, higher elementary school (högre folkskola), as the solution. In Teknisk tidskrift C. Billberg also addressed the proposed vocational school, but argued from the point of view of the crafts and industries. He was of the opinion that the crafts and industries should arrange these “schools” through their own organizations (yrkesföreningar) for them to be relevant, not the public domain, which the elementary school teachers proposed.

In a 1902 article in Svensk Läraretidning an anonymous author emphasized the importance of Sweden’s industrial development and the pivotal role of technical education. It was therefore imperative that technology education was made available for the greatest possible number of people, particularly manual workers: “Technology is nothing but the science of manual labour, its methods and means, and common sense as well as experience show . . . that no sound industrial development is conceivable without manual labour and technology in close collaboration with each other.”

The writer went on to praise efforts made in America, England and Switzerland to promote and diffuse general, comprehensive technical knowledge (teknisk bildning). In Sweden, on the other hand, it seemed that the school system was bent on obstructing technical education and the obtaining of comprehensive technical knowledge for those who belonged to the working class. Both technology education at university level and upper secondary level required pupils to do all or parts of the Swedish secondary school (allmänt läroverk), which was education designed for the middle and upper classes (see Figure 2). The author instead wanted to promote elementary schools – and the continuation known as högre folkskola – as the basic education for further studies in technology on higher levels. This would give workers the opportunity to attend secondary or university technology education, but it would also show that elementary school in itself was a competent provider of practical-technical, comprehensive education (praktisk bildningslinje).

In the curriculum of 1919 the subjects domestic science (Hushållsgöromål), gardening and sloyd were still not mandatory subjects in the sense that they were an unequivocal part of the timetable. Domestic science was not considered appropriate for separate lessons, but should exist as one-day

37 Om yrkesuppostran 1901 p. 712.
38 Om yrkesuppostran 1901 p. 711-712.
39 Om yrkesuppostran 1901 p. 711-712.
41 Vår praktiska bildningslinje. Folkskolan som bottenskola 1902 p. 492.
42 Vår praktiska bildningslinje. Folkskolan som bottenskola 1902 p. 492. As a matter of fact, it was possible since the late 19th century to go directly from elementary school to a technical upper secondary school. The upper levels of certain elementary schools (högre folkskola) adjusted the content of some subjects to the requirements of the technical schools, and the technical schools, in their turn, arranged admission tests for those who had attended elementary school. However, it was probably unusual for pupils to utilize this opportunity, especially those with a working class background, since the technical schools often charged an attendance fee (Ledig plats 1902 p. 684; Redogörelse för Tekniska Elementarskolan i Norrköping under läsåret 1903-1904, Norrköping 1904; Anderberg 1921 p. 132).
activities. Gardening should only be taught "the part of the year when such teaching is most appropriate," and therefore time had to be taken from other subjects when suitable. Sloyd was not part of the timetable either, but four weekly hours were recommended as an extra-curricular activity.43

The content of the subjects gardening and domestic science had been extended compared to earlier curricula, which was both an expression of a broader content and more detailed regulation on the part of the state. In the case of the former subject, plant breeding, fertilizing, and spraying with pesticides had been added to the earlier content. The content of the latter had become more specified, and thus included teaching about kitchen utensils and their treatment, economical fuel consumption and water management in the kitchen.44

The goal of educational sloyd was mainly to manufacture simple objects of various materials. For boys this meant all kinds of different materials, such as textiles, pasteboard, wood and metal, whereas girls had to content themselves with textiles. Boys’ sloyd emphasized the preparation, use and keeping of tools. The tools could be vices, anvils, screwdrivers, files, drills, planes, chisels, riveting and soldering equipment. Certain elements had also been mechanized, for instance, turning. In girls’ sloyd tools did not attract as much attention. It was instead various kinds of sewing skills that were focused. Nonetheless, technical development left its mark on the curriculum in that the sewing machine earned a central place, but not until the girls had learnt the basic manual sewing techniques. In this respect, there was more mechanization and a more substantial technical transformation for the girls.45

Natural science was also described in more detail than before, and there was an even stronger emphasis on the technical applications of physical and chemical phenomena, at least in the higher grades of elementary school. The breakthrough for electricity was particularly noticeable: "Something about the characteristics of fluids and gases, about the equilibrium and motion of solids, about water and steam as driving force, about magnetism as well as electricity and its most important practical applications."46 The higher grades should bring up these features in such a way that "above all, physical and chemical phenomena are seen from the point of view of their significance for practical life."47

Drawing and geometry had been enlarged as regards content and attention to detail. The focus on practical life outside school remained, but this curriculum also attached great weight to pupils’ activity, which was a central theme in all subjects. Drawing was connected more clearly to sloyd, and it also looked ahead to possible future technology education, at least for boys: "Linear drawing: for boys: projection drawing of elementary furniture and tools etc."48 A similar attitude was evident also

43 Undervisningsplan för rikets folkskolor, den 31 Oktober 1919 (Stockholm 1947), p. 7-16 (quote on p. 16). It may seem strange that educational sloyd was not made compulsory in Sweden until 1955, but this was how its originator Otto Salomon wanted it to be (Hartman, Thorbjörnsson, and Trotzig 1995 p. 34, 70-80).
45 Undervisningsplan för rikets folkskolor, den 31 Oktober 1919 (Stockholm 1947), p. 137-145. The notion that pupils had to learn basic sewing techniques before they could use the sewing machine was possibly inspired by female sloyd pedagogue Rosalie Schallenfeld (Hartman, Thorbjörnsson, and Trotzig 1995 s. 43-47). In Finland the mechanical sewing machine was introduced in girls’ sloyd at about the same time as in Sweden (Marjanen 2006).
in geometry: "The teaching in geometry should . . . be supported by modelling . . . the pupils ought to get to make the simple geometrical designs . . . that are most commonly used in practical life."49

The new subject local geography (Hembygdsundervisning), which would give the pupils knowledge of local geography, its nature and working life, was what we would call a thematic subject: "Local geography intends . . . to give basic teaching in geography and natural science as well as history, to some extent, furthermore . . . to provide preparatory teaching in drawing and sloyd."50 Examples of technical content in local geography were clothes, different kinds of materials, houses and their heating and lighting, furniture and household utensils, transport technology ("different ways of travelling") as well as working life such as agriculture, trade and industry. The subject should focus humans and nature in the local environment, but in cities it was evident that the emphasis would be on human activities and the designed world. Practical exercises were also included and these linked up with similar exercises in both sloyd, drawing and geometry.51

Neither of the studied journals made direct reference to the technical content of elementary school subjects in connection with the 1919 national curriculum. Regarding sloyd, for example, it was often emphasized in Svensk Läraretidning that it developed the pupils’ “spiritual and bodily powers” in a comprehensive way, rather than preparing for a profession.52 Sloyd was therefore a subject aimed at instilling allmänbildning in a very general sense rather than specific technical skills, which was typical of Swedish educational sloyd in the period 1880-1920. The 1920s became a period of transition from this ideal to one more focussed on craftsmanship.53

If we look at in what ways elementary school teachers were themselves further educated to improve their teaching another picture emerges. In Svensk Läraretidning there was a short paragraph on this in 1922:

This is a transition period for our elementary school. The societal mission of the elementary school is expanding and growing, which, not the least, the teachers have to sustain. 'Increase your knowledge' is the watchword for the individual teacher as well as the whole profession.54

The knowledge in question here was technical knowledge. In the summer of 1922 the National Agency for Education (Skolöverstyrelsen) consequently offered a course for elementary school teachers from the whole country in industrial metallurgy, electro-technology, chemistry and drawing.55 In 1923, a summer course in physics for elementary school teachers was held at Göteborg University. It included primarily electricity and the building of electric appliances.56

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50 Undervisningsplan för rikets folkskolor, den 31 Oktober 1919 (Stockholm 1947), p. 70.
51 Undervisningsplan för rikets folkskolor, den 31 Oktober 1919 (Stockholm 1947), p. 70-79. Since local geography was a new subject the instructions were lengthy and detailed. For an elementary school teacher the impression was that almost everything should find a place in the new subject (Johansson 1923 p. 351).
52 See, for instance, Om slöjdundervisning för gossar. Föredrag av undervisningsrådet Hjalmar Berg 1922 and Nilsson 1922.
54 Kursen i metallindustri och elektroteknik i Västerås 1922 p. 661.
55 Kursen i metallindustri och elektroteknik i Västerås 1922 p. 661-662.
56 Grimby 1923 p. 918. In the very early 20th century there were summer courses at Lund and Uppsala universities for Swedish and Scandinavian teachers, primarily attended by Swedish elementary school teachers. These courses were chiefly held in disciplines within the humanities and to some extent the natural sciences. A technical knowledge domain was almost entirely absent in these courses (see, for instance, Program för sommarkurserna i Lund 1900; Danell, Öhrvall, and Johansson 1901; Sommarkurserna i Uppsala 1901; Danell et al. 1903).
Early 20th Century Swedish Technology Education in Perspective

The curricula of 1900 and 1919 tell us a great deal about the technical content of elementary school and what the state considered to be teknisk allmänbildning. Yet this material has been complemented with views of possible interest groups to be able to say anything about their expectations on what elementary school should deliver in terms of technology education. Here this will also be related to technical education on higher levels, since there were many ideas about how elementary school should connect to further education during the period of investigation.

The curriculum of 1900 stressed primarily practical-technical skills necessary to deal with everyday life. The girls were also to become acquainted with certain household technologies, for example, stoves and kitchen utensils, and all pupils should obtain basic knowledge about established technical artefacts such as the steam engine, telegraph and telephone. In the 1919 curriculum the technical content had been enlarged and the level of detail increased in the existing subjects. It is particularly noticeable that the mechanical sewing machine, an innovation established since several decades, finally found its way into girls’ sloyd, while the much newer applications of electricity were added to the natural science curriculum. Local geography, a new subject, also added to the comprehensive technical content. Drawing followed the same pattern, but had also acquired a more distinct vocational touch.

Around 1900 there were those among elementary school teachers who saw elementary schooling, especially the sloyd subject, as comprehensive technical education. It was primarily considered a technical school for manual workers, which results in two conclusions. First of all, workers were restricted to elementary school, and, secondly, the kind of technical knowledge that was conveyed was comprehensive and practical to daily life and work. Class was indeed a crucial factor in Swedish society and schools at this time, and elementary school was generally seen as the school of workers.

57 This was also true in countries to which Uno Cygnaeus’ and Otto Salomon’s ideas of educational sloyd had been imported, for instance, the United States (Lewis and Zuga 2005 p. 5-8).
and farmers.\textsuperscript{58} Engineers educated at university level (teknisk högskola), who were often members of the middle and upper classes, did not even consider elementary schools as a part of Swedish technology education, but rather as a preparatory institution for basic skills in reading, writing, mathematics etc.\textsuperscript{59} The school teachers also saw elementary school as a preparatory school, but one with a core of technical content that anticipated technical-vocational education on the succeeding level(s).

\textbf{Figure 2. The Four Levels of Swedish Technology Education in 1900 and 1920}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2}
\caption{The Four Levels of Swedish Technology Education in 1900 and 1920}
\end{figure}

\textit{Source: Inträdesfordringarna vid de tekniska elementarskolorna 1903; Anderberg 1921a; Anderberg 1921b; Fredriksson 1921; Richardson 1987 p. 13.}

Around 1920 neither elementary school teachers nor engineers made explicit statements in their journals about the technical status of elementary school. The 1918 educational reform of vocational secondary schools,\textsuperscript{60} which had replaced, for instance, most Sunday and evening schools and now made up a level immediately above elementary school, was a victory for elementary school teachers (see Figure 2). The teachers had argued for such a solution as early as the turn of the century and they played a pivotal role in seeing the reform through.\textsuperscript{61} What the anonymous writer in \textit{Svensk}

\textsuperscript{58} Hartman 2005 p. 39-49.

\textsuperscript{59} This is obvious if we look at the university-trained engineers’ own historical writing, for example, Anderberg 1921a and Anderberg 1921b. Furthermore, the journal \textit{Teknisk tidskrift} primarily considered technology education on higher levels to be of interest to its readers, and consequently did not directly comment on the technical content of elementary school in either of the two studied periods (1900-1903 and 1919-1924). However, in the early 1920s \textit{Teknisk tidskrift} made an effort to involve its readers in the current situation in Swedish schools, particularly the technical upper secondary schools but also schools on lower levels (see, for instance, Fredriksson 1921; Fredriksson 1923). Cf. Berner 1996 p. 168-173.

\textsuperscript{60} Vocational schools on secondary level – praktiska ungdomsskolor – were several kinds of schools gathered under the same umbrella; fortsättningsskola, högre folkskola, verkstadsskola, lärlings- och yrkesskola. See left side of Figure 1 (Fredriksson 1921 p. 479).

Läraretidning in 1902 looked for – a tighter link between elementary school and technology education on higher levels – had consequently come to pass.

There was indeed an increased technical content in elementary school, which can be seen in the curriculum of 1919 as well as in the kind of in-service education that was offered to teachers at the time: courses in industrial metallurgy, electro-technology and electricity. School teachers thus had to increase their knowledge even of technical issues, which testifies to the influence of the new curriculum and organization, but also to the momentum of certain new technologies, which affected all of society.\textsuperscript{62}

The introduction of the lower secondary school exam (realskoleexamen) in 1907 and new regulations concerning technical upper secondary schools in 1919 meant that in 1920 the indirect link between elementary school and the technical upper secondary schools through entrance examinations had all but disappeared.\textsuperscript{63} The new exam became the main road to technical upper secondary schools, and the only that gave admission to the most prestigious one, tekniskt gymnasium, the transit to university education for engineers. Elementary school thereby lost its role as an indirect road to upper secondary and higher education but instead gained a role as direct precursor to technical vocational schools. It became even farther removed from the two highest levels, but tied closer to the third level (see Figure 2).\textsuperscript{64}

Yet the fact that most teachers, engineers and public debaters did not see elementary school as a provider of technology education in the early 1920s should not come as a surprise. When elementary education was talked about as basic and comprehensive (allmänbildande) it referred to a classical concept of Bildung. The notion of teknisk allmänbildning was then primarily associated with vocational training and most of all higher engineering education, which testifies to the still prevalent class divisions in Swedish technology education.\textsuperscript{65}

The analysis of the views and roles of different stakeholders in the development of Swedish school technology education 1900-1920 will have to be further elaborated in the future, for instance, the extent to which the introductory quote, which was apparently an argument for improved technology education, was representative of other interest groups. This paper has only begun this work and other source material will have to be researched in order to deepen the analysis. Therefore the conclusions are tentative.

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\textsuperscript{62} When the link to vocational training was established teachers in elementary school could incorporate more technological items in their teaching – many of them also taught in högre folkskola and fortsättningssskola.

\textsuperscript{63} Technical upper secondary schools were divided into two categories in the 1919 regulations; tekniskt gymnasium and teknisk fackskola (teknisk elementarskola continued to exist in some cities). Only the former gave admission to technical university (SOU 1963:42 p. 33).

\textsuperscript{64} Realskolexamen och folkskolan 1903; Anderberg 1921b; Fredriksson 1921; SOU 1963:42.

\textsuperscript{65} See, for instance, Engblom 1924. University-trained engineers and university teachers in engineering had their own discussion on and definition of teknisk allmänbildning around 1920, but it concerned the courses at the Royal Institute of Technology. This discussion was primarily propelled by the fact that Swedish society had been more and more technicalized since the beginning of the century and engineers thus were needed in other parts of society than trade and industry. There was consequently a need to broaden engineering knowledge beyond the purely technical (Lindmark 1920; Editorial 1922).


Chalmers University of Technology, [www.chalmers.se](http://www.chalmers.se), access date 2006-11-08.


PATT 18 Glasgow


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Situating Technical Learning and Thinking (TLT) in Schools

R. Hansen University of Western Ontario Canada
Email: hansen@uwo.ca

Abstract

Schools are places where technical learning and thinking is or should be important. The prominence of issues like ‘technological literacy’ in the world is evidence of this premise. Yet the presence of a TLT ethic is overshadowed by an academic tradition that governs learning and curriculum design in school environments. To understand how TLT is distinct this paper reviews the literature on the history of technical learning in and out of schools. By probing the historical roots of technical learning and thinking a ‘situating’ of technical education in schools, becomes possible.

Technical thinking is defined as an aptitude, ingenuity, and penchant for solving practical problems through experience (Autio, Hansen, 2002). From the beginning of civilization such thinking has been a significant part of human existence (Burke, J. and Ornstein, R., 1997, White, 1962). Learning associated with it is a natural and developed instinct for most people, young and old, who work in a technical field, pursue a practical hobby, or teach/learn practical subjects in schools. Historically the learning process, when formalized, involves learning with a master who conveys knowledge and competence by showing and doing. Today, but also over time, such formal learning or apprenticing is/was considered by many to be misplaced and inefficient. Why can’t the knowledge and competencies associated with technical thinking be taught some other way, e.g., using computers and books? A closer examination of the basic nature and form of technical learning and thinking and the pedagogy that drives human thought about it helps answer the ‘why’. It also underscores why the question itself is problematic.

It is generally accepted in the education literature (Willis, 1977), that technical programs in schools are rooted in economic rather than social soil. Adolescents and young adults are ‘trained’ with workplace skill, enculturation, and human capital in mind. Willis refers to this pedagogy as ‘learning to labour’. The social soil is more difficult to describe but crucial to clarifying the pedagogy of thinking and learning technically. Bacon, Comenius, and Cygneaus, among others in the 18th and 19th centuries, pinpointed and popularized a human learning tendency that was central to the holistic development of children and adults. That natural tendency and preference was to learn through the senses, particularly the sense of touch. This principle guided early educational thinking. The thought was that educating the senses should precede the educating of the memory. The ‘senses first’ principle, while greeted favourably by most modern educators, is seldom a beacon for teaching practice or curriculum development in western societies today. One national curriculum stands out as an exception. Finland recognizes the principle in its handcrafts program and ensures its continued application through national legislation. Referring to the educative benefits of handcrafts for children Cygneaus, the father of the Finnish public school system, argued the pedagogical aim of technical learning was to develop the eye, the sense of form, and general dexterity (Kananoja, Kantola, Issakainen, 1998). Harre and Gillett (1994), over two hundred years later, refer to this human tendency as having a ‘sense of physical location’. They argue that perceptual and motor skill in the physical and material world, gives human beings a sense of self and intelligence. It empowers them in ways that discursive learning does not.

The social perspective has a broader dimension that sheds light on why technical learning and thinking, as a viable model for learning, may be so unheralded/undervalued. Learning and thinking
technically is a cultural phenomenon. Anytime a society engages in solving technological problems, micro and macro level, it is defining itself and its culture. Yet, the learning tendencies and preferences used in such problem solving tend to go unrecognized as a model for learning. The social/experiential pedagogy that characterizes cultural transmission is also dismissed by it. The very special human and technical instinct associated with inventions and innovations in fields like transportation, communications, and building architecture are taken for granted. The consequence is that societies which defer their technical well-being miss an opportunity to build and sustain an ethic for technical achievement, for cultural definition, and for equating education and life. The fundamental known, that people give shape to society (through technology) and technology gives shape to people, is ignored. In doing so the social/experiential pedagogy is displaced.

Schools (the acknowledged transmitters of knowledge and culture in settler communities) ironically, suppress the technical problem-solving learning model in favour of an academic one (Donnelly, J. 1993, Hansen, 2004). We have been led to believe through the educational sciences literature that academic thinking and learning is more significant than technical thinking and learning. It is almost as if one is legitimized at the expense of the other. Greater understanding of how these two types of learning are distinctive and how they may or may not complement one another, especially in schools, is missing. To provide context this analysis includes a critical look at schooling itself. How is technical education situated or displaced in conventional school environments? Why is the awkward position in which technical education finds itself as a school subject so ironic? The paper, as such, sets the stage for a more complete analysis of how technical education is represented or misrepresented in schools.

One assumption adopted in the paper is that technical education has been the victim rather than the benefactor of an exclusive knowledge-based school curriculum. As such the importance and place of technical thinking and learning, as a human and social instinct/trait, is not well documented or established, partly because the pedagogical roots of technical education have been overlooked as an important historical element. Pannabecker (2004) suggests that this victimization is a ‘technical-learning-in-schools’ issue that dates back two centuries. A second assumption is that dichotomizing formal learning programs as either general or vocational clouds the issue of what it means to be technical in one’s learning and thinking. The Dewey/Snedden debates that took place seven decades ago may have led to more confusion than understanding, among education scholars, of what it means to learn and think technically versus to do so academically. Developing and perpetuating a viable and progressive technical education curriculum is awkward, perhaps impossible, when it is undertaken in an academic context.

The History of Technical Learning and Thinking
The early history of technical learning for this account includes the period from 700 BC to the industrial revolution. The earliest forms of ‘technical being’ were associated with the controlling of fire. Humankind was able to cook food, melt metals, and shape simple tools. Eventually people became miners, smiths, carpenters, masons, weavers, and so on. Systematic learning, if there was such a thing during this stage, is not well documented. It was a trial and error process. The first evidence of organized learning came from groups who valued a trade, skill, or craft. Jews, for example, sent their children, in ancient times, to school for religious studies in the morning and skill development in the afternoon. Failure to give a Jewish boy an honest means of livelihood (manual trade) was excluding him from becoming a useful member of the community (Bennett, 1926). Furthermore, the Jewish people felt labour held religious significance. It was regarded as a man’s [sic] duty.

At no point in the pre-renaissance period is there evidence of what would be called a system of instruction. Sons and daughters learned from their fathers and mothers. Their goals were always survival and betterment for the family members and eventually for larger communities of people. Even if a son was taught by someone other than his father or mother the relationship was a paternal
During the homeric age (700 to 300 BC) Greek handicraft people occupied a place of respect for their mechanical aptitude. Later, however, banausic or mechanical arts, lost their status. The beginnings of a stigma emerged. Manual arts were thought to be for the peasant class and not fit subject matter for upper class youth. In 300 BC upper class boys, according to Bennett\(^6\), were taught drawing. The lower classes continued to apprentice under a master as in earlier times. Interestingly, the orators, lawyers, physicians, and cooks of the time also employed the apprenticeship method in their training. Christian monks, much like the Jews, elevated manual labour. Labour was required of everyone – weavers, carpenters, curriers, and tailors. Similarly, the Benedictines made manual labour a cardinal principle. Their thought was that labour banished indolence (the enemy of the soul). For every time they celebrated the praises of God they devoted one hour to labour, and two to reading.

The religious zeal and missionary enthusiasm of the Benedictines\(^7\) carried them from Italy, north of the Alps, into Germany. Germany became filled with monasteries each of which became a centre of civilization. Many of the church structures in Germany dating from 900 to 1200 are the work of Benedictines. Bookmaking and modernized buildings followed with the development of the printing press in 1450. The sole educational institutions of this period (900 – 1500) were monasteries. Their subject matter was religious writing. Outside of the monasteries, participation in skilled labour was the principal means of education, though not the kind of education which was recognized as such by schools. As trades and crafts developed i.e., became more differentiated and specialized, apprenticeship included a large body of information, tools, and techniques. The master was to teach the recipes, rules, applications of science, mathematics, and art of the craft. The method was imitative and all instruction was outside of school walls.

A new conception of the process of learning began to emerge in the 1400’s - the same spirit that led to discovery of new methods for the schools. According to Bennett, this period spawned two new fundamental ideas upon which modern instruction in the manual arts has been built (p. 30). The first is that the senses are the basis of thought, and consequently, of knowledge. The second is learning by doing. The idea that children could learn by working through a process and making something by themselves, with tools, was seen as rational thinking. The placing of handcrafts in schools followed.

It was Francis Bacon (1561 – 1626) who helped make the transition from learning based in writings of antiquity to learning based on nature and the arts of daily life. Comenius followed (1592 – 1670) by advocating learning that starts with the senses, then memory, the intellect, and finally the critical faculty. “The child perceives through the senses; every thing in the intellect must come through the senses” (p. 36, cited in Bennett).

British thinkers began to contribute to the technical learning story in the 1600’s. In 1663 Moxon published a volume entitled ‘Mechanik Exercises or the Doctrine of Handy Works’. The subjects ranged from smithing to joinery and made extensive use of illustrations. Locke (1642 – 1727) became the main spokesperson for the idea that education should ‘fit a boy for practical life’ (Bennett, p. 61). Rousseau (1712 – 1778) took Locke’s ideas a step further. He believed agriculture was the most respectable of all arts and professions. Next to this came smithing and then carpentry. Bennett quotes Rousseau. “The great secret of education is to make the exercise of the body and mind serve as relaxation to each other” (p. 80). Ultimately, technical learning found its way into the school curriculum across Europe along side classic academic subjects of mathematics, science, language, history, and religion\(^8\).

Four distinct movements, three in Europe and one in the United States, are debated in the literature for their uniqueness and contribution to technical thinking and learning. Each provides an important element in the evolution of a socio/experiential pedagogy. Each shows how different cultures influenced or, adapted to, the industrial revolution: The Russian System of Workshop Instruction;
Sloyd in Scandinavia; Manual Training in Western Europe; and Vocational Education in the United States. These are discussed in length in another paper on the history of technical learning and thinking.

The Irony of Displacing Technical Thinking and Learning as a Model for Learning
Regardless of whether or not technical learning and thinking is marginalized in the school systems of most western societies, it is useful to critically examine the model that currently dominates and governs learning in school environments. Increasing numbers of pedagogues point to the flaws in the classic academic model of learning adopted in schools (Greenfield, 1993, McLaren, 1998, Rogers, 1997). Acceptance of and reliance on the school knowledge acquisition model also raises an important question. What are the limitations of that model of learning and thinking for technical teachers/students and for schools generally?

Debate about the validity of scientific knowledge seeking and ordering in recent decades has been robust (Kuhn, 1962) but also ubiquitous. Seldom is any credence given to a knowledge generation model or theory that emerges from people who value ‘doing’ as highly as ‘knowing’. Scholars point to the scientific method as a source for deriving new knowledge and validating it. The knowledge seeking and validation process is known in the literature as ‘positivism’. Acceptance of positivism, even though it enjoys a nineteenth century history, has come under increasing scrutiny. Kuhn’s challenge to positivism, along with that of Hooker (1987), points to a renaissance of thinking regarding sources of knowledge. Missing from the science-based knowledge-building model is a way of learning that recognizes technical knowledge and knowledge that comes from experience. Finnigan and Layton (1994) refer to this in their annotated bibliography on teaching and learning in the third culture.

So far as the schools are concerned these developments [the recognition that technological activity is fundamentally different from science] have a direct and practical implication. If there is a distinct ‘technik’[technical thinking and learning], with characteristics which distinguish it from the sciences and humanities, should it not have a place in the general education offered by the schools? Are there, indeed, three cultures, not two as C.P. Snow suggested, the third corresponding to the creative, problem-solving and productive activities of the engineer? Ought we not to recognize more clearly in curriculum terms that the fundamental difference between science and technology is social, a difference in values between a community whose sovereign value is ‘knowing’ and another whose ultimate goal is ‘doing’? And if the answer to each of these questions is ‘Yes’, what problems arise in relation to teaching and learning in the third culture? (p. 2).

Questions about the validity and verification of knowledge as the featured commodity of schools are also found in the field ‘sociology of knowledge’. Rogers, in her paper on new views of knowledge and its representation in schools, illustrates the differences between subject-based and disciplinary learning. She explores some of the problems posed by using the disciplines as the primary source of authority in shaping the curriculum, and goes on to propose a more radical, alternative model for thinking it. The alternative integrates the influence of the disciplines with other influences such as the child’s world, the particulars of context, and the knowledge of professions. She argues we should think more broadly about the possible sources of influence and authority for the curriculum in schools.

As nations and economies rush to claim a ‘knowledge-based’ lifelong learning model the need for technical education to have its true nature and form properly recognized and valued, in and out of the formal learning institutions, is vital. Why would anyone want to exclude knowledge from everyday life in a learning model? A paper entitled ‘Towards a sociology of lifetime learning’ (Rees, Fevre, Furlong, and Gorard, 1997) challenges the normative focus on ‘the learning society’ as one that can and should be driven by more than human capital theory. They conclude a narrow approach that looks
only at human beings as capital will detract from an adequate theory of lifetime learning.

There is a classic question that plagues educational policy and thought. It may also underscore why there was a lack of rebuttal from practical people who know how they learn when solving everyday problems. Can schooling, when separated from everyday reality, ever be relevant? Dewey writes: “Connect schooling to everyday life and the curriculum will, of necessity, be relevant”. Layton (1993) underscores the same point when he states that schools decontextualize knowledge (p. 15). “A general characteristic of school technology and one which makes it different from many other school subjects is its engagement with practical action in the made world. No subject challenges the historic role of schools as institutions which decontextualize knowledge quite so strongly as does technology.” Buchmann and Schwaille (1983) perceptively ask: Can knowledge be acquired and retained independent of practical action, by observing and imitating others and by extracting knowledge from experiences coded in text? Does learning in schools always have to be an interpretation of reality rather than reality itself (p. 11)?

Technicians and technologists who know how they learn through experience are often not informed about where knowledge and school curriculum comes from much less whether or not it is valid. And, even when they do their voices and the platforms from which they might express themselves, are remote. The fact that such knowledge and its dissemination was contrived or that something might have been lost in the translation, or that it might be at least once removed from world or human reality, as such, is not resolved. Sheridan writes: “schooling contributes to a priority of legitimacy of literacy, and this denies the legitimacy of experience, which is necessary for learning” (p. 23). School teachers unfortunately, technical or otherwise, are seldom aware of this dichotomy/irony and helpless to do anything about it.

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Two experimental learning arrangements in technology education: exploring the impact of the Finnish national framework curriculum on technology studies

Pasi Ikonen, Aki Rasinen, Timo Rissanen University of Jyväskylä Finland
Email: paikonen@edu.jyu.fi rasinen@edu.jyu.fi timo.rissanen@edu.jyu.fi

Introduction
The Finnish national framework curriculum provides the guidelines for local curriculum planning to the municipalities and individual schools for local curriculum planning. The guidelines are of very general nature (see Perusopetuksen opetussuunnitelman perusteet 2004). This means that the municipal authorities and teachers in particular have a lot of power, but also responsibility in planning, developing and implementing the curriculum and in designing the teaching and learning processes.

Technology education as a curricular component has often been justified by the fact that technology can be seen all around us. However, the technological culture around us cannot be used as such for justifying the teaching of technology. Rather, technology studies can be justified by the fact that society regards them as valuable for developing the cultural capital that is connected with technology. Therefore, a decision to include the new cross-curricular theme of human being and technology in the 2004 framework curriculum is a decision with underlying values. Similarly, including craft education in the framework curriculum is a decision, which has values behind it. It is assumed that some of the general educational aims listed in the curriculum will be achieved through craft education.

Education for work is regarded as a characteristic objective of craft education. It is, however, important to realize that when speaking about education for work in this context reference is not made to any kind of pre-vocational education. More appropriate expressions within general education would perhaps be “learning by doing” and “hands on” education. The features that characterise work today are among others co-operation, continuous change, problem solving and innovativeness (TT 2001). Education for work, which emphasises these features, is a term that has been developed in the past years and has been put into practise in many countries in technology education. However, the actual practices of “education for work” in craft education have unfortunately not changed much in the past decades in Finland.

In this article we will first introduce briefly the 2004 Finnish national framework curriculum from the point of view of technology and craft education. To exemplify the potential it offers for teachers we will then describe two different learning cases in which new approaches have been tested, and report on the experiences gained in these projects. In conclusion, some suggestions for the future are presented.

Human being and technology – a new cross-curricular theme
For the first time in the history of the Finnish general education curriculum planning the 2004 framework curriculum introduces a cross-curricular theme: human being and technology. Under this title, the significance of technology in our everyday life and the dependency of human beings on modern technology should be studied. The theme covers the basic know-how of technology, and teaching should improve the ability to understand how different devices, equipment, and machines work and how to use them. (Perusopetuksen opetussuunnitelman perusteet 2004, p. 40).

Technology has to be studied by all pupils at all levels. For as long as technology is a cross-curricular theme, the various subjects should consider how it should be studied from their point of view. There
should be continuous consultation and co-operation between different subject areas and, where it is advisable, the principle of integration should be applied.

**Relationship between craft education and human being and technology**

When analyzing the 2004 curriculum subject by subject one notices that technology education is mainly to be seen under the objectives and contents of craft education and to a minor extent also in science education (Lindh 2006, p.81, p.84; Rasinen, Ikonen & Rissanen 2005, p.455). The 2004 framework curriculum in craft education emphasises pupil’s development of perseverance, problem solving and group work skills and a positive attitude towards working. According to the framework curriculum craft education includes contents from both textile work and technical work and should be studied by all pupils. (Perusopetuksen opetussuunnitelman perusteet 2004, p.240, p.242)

**Experiment 1: The folding chair**

**Taking small steps**

Teachers have been encouraged to use methods through which pupils would learn problem solving, innovation and other skills that would foster their creativity. However, there are still many examples of pupils following the teachers’ models instead of planning their own projects. (Alamäki 1999, p.39; see also Sanders 2001, pp.50-53.) Reasons for this are many, including lack of learning materials and in-service education. Older teachers in particular are used to the “copying method”.

One way of introducing new methods has been to try to encourage teachers to experiment with something different. Nothing too radical, but at least move to take small steps. This type of an approach was used when teacher trainees from the University of Jyväskylä went to do their teaching practice during the spring term of 2006. Instead of asking their pupils to prepare a traditional stool the pupils were asked to plan a chair that could be stored in a small space, would be light to carry and would fit the pupil’s anatomy (Hacker, Burghardt 2004, pp.74-75). The experiment was conducted during craft lessons. One of the aims was to integrate technical work and textile work. The materials used were wood and textile material. Altogether 59 pupils (age 10-12) were involved in this experiment.

The pupils were firstly asked to study different types of folding chairs, do some sketching and after combining the best features of the different sketches, to make a final drawing. After this the pupils made cardboard models of their designs to test the function of their plan before they started shaping wood and textiles. When the project was completed we wanted to survey pupils’ experiences of it and to find out how girls and boys feel about studying combined technical work and textile work. The data was collected with a questionnaire composed of both multiple choice and open questions.

**Survey findings**

Almost half of the pupils (28 out of 59) considered the project interesting while 25 pupils thought that it was not that interesting but not that uninteresting, either. Only six pupils did not like the project at all.

*girl A:* “*The project was interesting.*”
*boy A:* “*The project was good fun.*”

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1 In informal discussions between teachers and teacher educators, technology education in schools has been said to include more copying and reproducing processes, such as the copying of wooden and metal items than modern design-oriented processes (Alamäki 1999, 39).
Only four pupils answered that everybody should have completed an identical stool following the model given by the teacher. In other words, four pupils did not like to do their own planning.

*boy B:* “A normal stool would have been more fun.”

Although the pupils were guided in their own planning, the teacher trainees gave limits regarding the materials, techniques and functions of the chair, which caused some frustration because some pupils experienced that their creativity was being limited. This may indicate that these pupils were used to planning their own projects independently.

*boy C:* “I would have liked to design a different kind of a chair.”

Ever since Finland moved to the comprehensive school system in 1970 the national curricula have encouraged creativity and problem solving in craft projects. Obviously the aims of experimenting, investigating, innovating, problem solving, perseverance and understanding materials and processes have been achieved in these classes. Yet, the pupils of one particular class regarded the making of the cardboard model as a waste of time. A comment from one girl describes the feelings of many other girls and boys in this class.

“What was the idea of making a model out of cardboard? It was mere misuse of time.”

It is possible that these pupils were not used to making soft material prototypes before starting with the final project. It is also possible that the teacher trainee doing his teaching practice used too much time for the cardboard model and was not able to justify the method to the children. None of the pupils in the other classes commented on this type of an approach. Either they were used to it or they were convinced of the usefulness of making a prototype first.

Contrary to the letter of the framework curriculum 2004 the pupils in the teaching practice school as well as in the municipal schools of Jyväskylä have to choose their main line of craft studies after grade four, opting for either technical or textile crafts. When the pupils were asked if there should be more projects where technical work and textile work are integrated the pupils were both for and against such an approach. Moreover, the responses to the statement “I would like to do only textile work/I would like to do only technical work” varied again from positive to negative. There was slightly more opposition to the idea of studying only one of the two.

*boy D:* “I liked both textile and technical work.”

*girl B:* “It was good to have a chance to do both textile and technical work.”

Only eight boys and three girls supported the idea of not separating technical and textile at all. The idea of everyone having to study technical work and textile work equally much was both supported and resisted. The boys were slightly more positive about this. There was much more support than resistance for the idea that those who have chosen technical work as their main line should also study textile work. The same was true about those who have chosen textile work as their main line of craft education.

One of the classes in the experiment had made their choice of either technical or textile work one year before the experiment and the other classes two years before. This may have had an effect on the answers. The main factor in making the choice seemed to be the sex of the pupil, in other words, the girls had chosen textile work and boys technical work. This complies with e.g. Gottfredson (2002) who has suggested that different choices are made more on the basis of sex than actual interest. The dominant factor is primarily one’s sex, secondly social suitability and thirdly what is nice to do. The majority of either girls or boys in a group may also have an effect on what type of projects will be
chosen by the teacher – are they either girls or boys biased. On the other hand, if the experiences from the first four grades are that in technical work “male” projects are worked on and in textile work “female” projects are worked on it may well influence the pupils’ choices.

The findings of this small study give reason to believe that it is advisable to test different kinds of learning projects and that more attention should be paid to the planning process in these classes. This study also shows that these pupils are quite able to study both technical work and textile work in mixed groups without any prejudice if they are only given a chance to do so.

Experiment 2: The moving toy

This Functions -competition
The Technology Industries of Finland has been organising an annual national This Functions –competition for the past four years. The aims of the competition are to inspire children to familiarise themselves with technology and to figure out solutions and tasks connected to technology in some creative manner. These aims have been derived from the cross-curricular theme human being and technology. The competition encourages participants to take a holistic approach whereby integration of different subjects is emphasised. At least an integration of the contents of mathematics, science and physics in particular, as well as those of the mother tongue, art, craft and music, should be considered. There are two series: 1st – 3rd graders’ series, and 4th – 6th graders’ series. In 2006 more than 6 900 pupils took part in the competition, completing over 1 700 projects. (for details, see http://www.teknologiateollisuus.fi/openet/index.php?m=2&s=5&id=4072)

The participating groups are given a set of different materials like springs, screws, strips of wood, staples, etc. Groups of four pupils including girls and boys are supposed to build a moving toy, take notes and write a diary and design and prepare an advertisement of the toy. The time allotted is from 4 to 5 weeks. The best projects from both series in the local competitions are selected to the finals. Three main areas are assessed: how well the toy moves, how well the advertisement has been planned and how good the diary is. (ibid.)

Experiences of the teacher
In order to gain some information about the experiences that classes have had of their participation in the competition, we conducted an open interview with a teacher who had been involved in the project. Our aim was to explore how this type of a competition fits the school’s technology studies. The taped interview material was first transcribed and then interpreted by distinguishing the non-essential material and categorising the essential findings. (see Kvale 1996, p.189) The following themes arose from the interview: taking part in the competition, roles, planning, setbacks and ideas worth developing. The quotations from children given below are mentioned by the teacher during the interview.

Our interviewee’s impression was that the teachers had taken a doubtful and hesitant attitude to the word technology at the beginning. It seems to depend on the image, interest and valuation of the teacher whether she or he wants to introduce the competition to her/his pupils. In addition to the attitude of the teacher the opinion of the principal is also important. In the particular school concerned the competition is included in the annual plan of action, and it is usually the same teachers and their pupils that take part in the competition annually. However, the number of teachers involved has been growing all the time because after becoming acquainted with the projects they have realized the meaningfulness of the approach. If a teacher has had a reserved attitude at the beginning her/his attitude has changed towards enthusiastic while the process has proceeded. The final decision on whether to take part or not is made by the children.
The children could themselves decide on their roles and on how to share their duties within the group. The boys were in general more active at the beginning than girls, who were more shy, but as the process continued the girls became braver and presented ideas that turned out to be very useful. The children’s comments describe their different roles in the group:

“That one invented everything.”

“I made only the advertisement.”

According to our interviewee the children benefited greatly from what they had learned during their technical work lessons. The roles of those children who had studied more technical work were often connected to inventing and realising the technical solutions. They were the ones who knew how to shape and connect materials. The technical work classroom was a natural learning environment. One comment from a pupil

“Oh, this can be studied also elsewhere than only in the technical work classroom”

describes a close connection with technical work. The role of the teacher is to guide and assess the projects instead of giving models of solutions.

According to the interviewee the planning process differed very much from group to group. In one group one idea was invented and the children tried to put it in practice. When it did not work they returned back to planning. In another group several ideas were developed and the children had to reject many to choose one of them. The significant features in the process were creativity and brainstorming for ideas. For instance, understanding the function of a spring and applying it in the moving toy was learnt by trial and error. Planning took place also outside the actual working sessions:

“Jesse discovered last night that we are going to do it this way.”

Some children continued planning and working at school even after school hours. Some groups succumbed to copying the project that had won the competition the previous year, which naturally did not bring success. The groups that had ended up with only simple solutions did not have great success either, because not only the functionality of the moving toy was assessed but also how well the group had managed to take advantage of the various materials provided in the material package.

Besides many feelings of a success

“Yay, it works!”

the children also experienced disappointments and setbacks which did not, however, diminish their enthusiasm. This can be observed in the following:

“Now we are in a dead-end, and it’s already late, so let’s continue tomorrow.”

Some groups concentrated too much on the aesthetic side instead of functionality:

“How can a project like that be sent to finals, it does not look good.”

In general it was frustrating for the children if their project was not placed well. The disappointment was, however, shared within the group and children with similar experiences were able to work out their disappointment together. The disappointments were also discussed together with the teacher. Partly the disappointments can be explained by not having a chance to win the better prizes like a bicycle, mp3-player or digital camera.

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According to our interviewee the know-how of the teachers was not always enough to supervise the work. This was seen for instance when shaping and joining the pieces. The children of ages 7 to 9 were in the same division and there was much more variation in this group than in the group of 10–12-year old children. According to the teacher the project could be developed by including themes from environmental education, for instance, how to sort out and recycle the waste produced during the project.

**Experiment 2 in the context of technology studies**

This Functions—competition gives a teacher a chance to carry out technology education that is not restricted to any specific school subject. The role of the teachers taking part is in line with the prevailing concept of learning according to which the teacher is not a distributor of knowledge but rather a facilitator of a learning process. The teachers engaged in this kind of a project are also required a higher tolerance of uncertainty because they cannot affect the children’s results with their own ideas. This type of an activity can be described as having the approach of acting together and sharing the expertise. Some pilot teachers have participated from one year to another, which indicates that the competition has been experienced as a meaningful school activity. When the competition is carried out as part of the annual plan of action, it also has an official status among staff and can be considered to belong in the operational culture of the school. Moreover, the competition supports gender equality because the project is suitable and relevant for both girls and boys and the groups consist of both genders.

The children can decide themselves on their roles and on how to go about with the project. Therefore, they also commit themselves to the working process, and pupils get the feeling that everybody’s input is important for the final result. Commitment to the project can be seen clearly in the willingness to engage in it after school activities.

There are features in this competition that are regarded as essential in technology education, for instance, the pupils can use their creativity and their innovative skills in searching for different solutions in their projects. As the work proceeds they need to solve several problems and understand the functions of their devices. However, because of a long history of copying and reproducing work in craft lessons, some of the children and teachers may experience a method based on creative activity and innovation as something very unusual. Furthermore, for some pupils and teachers it is still more important how the final product looks like than how it functions. Some teachers are critical about using a competition as a pedagogical method. Therefore, in this kind of a competition-based approach it is also advisable to consider the effect of high quality prizes on pupils’ motivation.

This Functions—competition, as well as other similar learning projects, serve to achieve the learning outcomes mentioned in the national framework curriculum. It fits the school curriculum but does not use any material resources of the school. Teachers are often short of planning time, and therefore they are pleased to try new ideas and new ways of acting.

**Conclusion**

When sixth graders were asked what the criteria might be for ensuring that school attendance is meaningful, they listed the following: 1) pupils feel that they are competent and are able to demonstrate that; 2) each pupil’s relationship with teachers and other pupils is good; and 3) the issues which are studied are interesting and require practical work. (Korkeakoski, Hannen, Lamminranta, Niemi, Permu & Uurto 2001, p.13). These types of criteria are quite possible to follow during the kinds of activities presented above and in technology education in general because of its focus on learning by doing and collaboration.

According to the national framework curriculum technology must be studied in every school. Technical work could have a leading role in fulfilling this requirement. In Finland we do not have
updated learning materials for technology education, and therefore the implementation of the framework curriculum varies considerably from school to school. It would be ideal to create a forum where good and meaningful learning projects could be introduced and shared. Moreover, there is a need for practical learning and research projects. Pre-service teacher education should also be developed and a systematic in-service education system for teachers created in order to ensure and enhance the implementation of technology education in Finnish schools.

References
Training of Technology educators in South Africa – a model for short course in-service training

Gerda Reitsma and Elsa Mentz  North-West University, South Africa
Email: gerda.reitsma@nwu.ac.za; elsa.mentz@nwu.ac.za

Abstract

Technology is a relatively new learning area implemented in the South African curriculum for the Intermediate (grade 4-6) and Senior phases (grade 7-9). The problem is that educators, who qualified before the implementation of this learning area, are not specifically trained for this learning area as they have specialized in subject disciplines other than Technology. It is therefore important for educators to have adequate subject knowledge and skills, as well as subject specific pedagogical knowledge and skills to teach the subject effectively. Qualified educators can be re-trained in a new subject field by attending in-service training courses.

In-service training in the South-African school system is currently uncoordinated, done on an ad-hoc basis and is not regarded as part of the professional development of educators. It is especially short courses that show shortcomings with regard to the needs of educators, time available and form of training. Educators who do attend in-service courses experience problems to implement the new knowledge and skills in the school situation, due to a lack of support.

The need for a comprehensive short course model based on the specific needs of learning area Technology educators was identified. A model for the in-service training of educators is presented, based on the needs of and realities faced by Technology educators, as identified in a comprehensive research study. The model is based on four variables, namely context, process, strategy and structure, and content. These four variables determine the further development of the model and influence the outcomes, design, implementation, evaluation and closing of the model. Central to the model is the concept of reflection that is integrated with the four variables that support the three phases in the model. Through critical reflection, problems in each phase could be identified in time after which the necessary adaptations could be made. This will contribute in ensuring that training is still done according to the specific participants’ needs and that it is done as effectively as possible.

Introduction

The implementation of the learning area Technology coincided with the implementation of a new educational system, namely the outcomes based approach, described in the Curriculum 2005 policy and later in the Revised National Curriculum Statement (DoE, 2002). The learning area has developed and undergone various changes since the first pilot studies were conducted in 1994 (Potgieter, 2004; Ankiewicz, 1995). Unfortunately the South African school system did not provide the ideal scenario for the promotion of Technology education due to various reasons, one of which is the lack of trained Technology educators. Most of the educators who had to teach the learning area Technology had no or very little training in this learning area (Potgieter, 2004; Ankiewicz et al, 2001). Current pre-service and some formal in-service educator training programmes include one or two modules on Technology (Stevens, 2004). However, these programmes do not address the need for adequate re-training of already qualified educators. These educators are expected to teach Technology although they are qualified in another subject or field. Ingersoll (2000) calls this out-of-field teaching.

The South African educator needs opportunities for professional development where subject knowledge as well as methodological skills can be updated and improved (Davenport & Šmetana, 2004:20,22; Seromo, 1996:5). According to the Ministerial Committee on Teacher Education (SA 2005:7), in-service training of educators is done uncoordinated and at random. The type of in-service
training currently available tends to be driven by specific short-term needs without a clearly defined focus or direction. There are no clear policies regarding in-service training, nor any standards concerning the financing of such training in South Africa (Mashile, 2002:174). The Department of Education is currently investigating a system of awarding professional development points to teachers attending accredited in-service training courses (Samual & Morrow, 2004). There is however, still a lot of groundwork to be done.

Institutions involved with in-service training are basically the Department of Education, Institutions of Higher Education, Teacher Unions, Non-governmental Organisations and some schools. In South Africa, short-courses are the typical approach to in-service training (Mashile & Vakalisa, 1999:91-98), and vary in scope and depth. The traditional short-course approach includes workshops, holiday schools and cascade training. Teachers are seldom rewarded for attending these programmes, other than receiving a certificate of attendance.

The purpose of this paper is to present a workable model for short-course in-service training. In order to design and develop the model, a study was undertaken to investigate current in-service training programmes in South Africa and to identify problems and limitations experienced by the Technology educators during training and implementation.

Methods
A comprehensive literature review was conducted to describe in-service training in South Africa. Shortcomings with regard to the in-service training of educators were identified. The empirical research was conducted by following a design of triangulation. Qualitative research methods were combined with quantitative methods, thus confirming and supporting data found from various sources (Thyer, 2001). Semi-structured interviews (focus groups and individual) were conducted with learning area Technology specialists (subject advisors) from all nine provinces in South Africa. Learning area specialists are educators appointed by the Department of Education to act as advisors, trainers and liaison officers between the schools and the Provincial Department of Education. Four key questions were asked during the interviews and focused on the following: a description of the problems experienced in schools with regard to the implementation of the learning area Technology, the training of Technology educators, the training of the learning area specialists and recommendations with regard to training programmes. This was followed by a survey on the teaching of Technology and in-service training. Structured questionnaires were mailed to a stratified random sample of 998 educators from 6000 schools teaching the learning area Technology in the senior phase. Schools ranging from rural areas to city schools were included. A total of 261 questionnaires were received back and used for analysis. Statistical analysis of the data included factor analysis for construct validity, Cronbach- for reliability, frequency distributions, means and standard deviations and correlations between relevant concepts.

Development and elucidation of the model
The information gathered from the literature review, interviews and questionnaires were used to identify the forms of in-service training in South Africa, as well as the factors influencing the training of educators and implementation of new knowledge and skills. This information was then used to design and develop a model for in-service training, appropriate for the South African scenario and addressing the current problems experienced in in-service training.

• Training and qualifications of Technology Educators.
Data from the questionnaires showed that most of the educators (84.2%) had a three year educators’ diploma, but had specialized in a wide range of subjects. It is seldom a qualified learning area Technology educator who teaches the learning area, but usually educators from varied academic backgrounds. Only 18% of the educators indicated that they have received specialized training in the learning area Technology. This small percentage was confirmed by the learning area specialists
during the interviews. Other formal training did not necessarily include training in the learning area Technology. Institutions such as universities and colleges provided the formal training programmes.

Most of the educators (66.1%) had undergone some form of in-service training. It ranged from short workshops during an afternoon or a weekend, to a week-long training workshop. It was mainly the provincial learning area specialists who facilitated the workshops. The Department of Education financed these workshops and it was compulsory for the educator to attend. The content of these workshops were mostly about implementation of new procedures and policies, rather than knowledge and skills in the learning area Technology. Other institutions that were mentioned and that were involved with in-service training were Orttech and RAUTECH. Some of these workshops addressed the knowledge and skills associated with the learning area Technology. Funding of these workshops were mainly bursaries or sponsorships. The cascade-model of training was also implemented in some programmes.

- **Description of a short-course training model.**

A model for the short-course in-service training programme of learning area Technology educators is presented in Figure 1. This model forms the basis for a comprehensive training programme that could be applied to any short-course training programme for educators. Factors influencing training and implementation identified during the research study were taken into account during the design of the model. This information is presented with the explanation of the model, to clarify each phase and to describe the applicability in the South African context.

According to Loucks-Horsley (1999), four variables form the basis of quality professional development, namely context, process, structure and strategy as well as content. Although the four variables are presented as four separate components, they form a unit in the sense that each component influences and guides the other components. An important part of this model is reflection. Reflection is done on a continuous basis to ensure that the training is done effectively by identifying and addressing problems and changes early enough during the training process. The reciprocal arrows between the variables and between the successive phases indicate the relationship between the phases.
In this model the situation analysis forms the centre of the training process. Only after the needs of the educators and the school environment have been comprehensively researched and described, the rest of the programme can be planned and implemented. Henning (1994:206) describes the situation analysis as a basic principle of design and it implies that the participant can be accommodated holistically. The situation analysis is not a quick and easy step to complete. During this phase as much information as possible regarding the individuals that will attend the training, as well as the organizations in which they work, must be collected. In the case of educator training, information about the educator in practice, the adult learner, as well as the school environment in which the educator must function should be collected. A comprehensive situation analysis will address the deficiency found in current in-service training programmes when the needs of the participants are not addressed or when the training does not relate to the real school environment. It is possible that some aspects of the context, content, process and structure and strategy may change during the training period. These changes may have an impact on further training and may necessitate a revision of the situation analysis. This reflection is indicated by the two-headed arrows.
Context
The context of the model includes the school environment, including the available resources and support systems, as well as the educator as an individual person with prior knowledge and experience. Learning area Technology educators do not always experience the necessary support in schools. Some of the shortcomings are lack of resources, as well as ignorance regarding the content of the learning area Technology. The South African school environment varies from schools with very little resources, such as only water and electricity, to schools with adequate resources such as computers, libraries and internet access. It is thus important that the context, in which the educator is teaching, should be described.

The training needs of individual educators may also differ. The needs of the educators may vary from a need for training in subject content and basic teaching strategies, to educators who have enough subject knowledge and teaching experience, but who want more enrichment and innovation. It is especially in the learning area Technology where educators from different subjects and backgrounds teach the subject.

Content
The content will include the outcomes that must be achieved, such as new knowledge, skills and comprehension. After completion of a short-course training programme, learning area Technology educators should dispose of the following knowledge and skills:

- Subject content knowledge and skills to be able to function as a knowledgeable person in the learning area Technology;
- Pedagogical knowledge and skills to be able to function as a knowledgeable learning area Technology educator in the school environment; and
- Pedagogical content knowledge developed through adequate implementation and support in practice.

These general outcomes can be further specified according to the information gathered from the situation analysis. In the South African situation the learning area Technology educators need both academic as well as pedagogical training.

Process
The process should be learner-centered, knowledge-, skills- and attitude-centered and assessment-centered in order to help with reflection. The focus of the process should be quality training. The prior knowledge and experiences of the educators do have an impact on the type of training activities planned. The need for subject content as well as pedagogical aspects should be acknowledged. It is advised that educators should be given the choice of which modules they need to complete, determined by their specific need for training. A typical example is the Electronics educator who needs more training in Processing, but not in Systems and Control, or the Home Economics educator who needs more training in Electrical Systems. The training should be conducted with holistic assessment in mind. Pre- and post testing of knowledge, observation of classroom practice and assessment of outcomes should be planned as part of the training process. These assessment strategies should also enable the educator to receive an accredited certificate. Results from the research indicated that most short courses are not accredited and that assessment does not form an integral part of these training courses. By accrediting the training programme, the motivation of the participants could increase.

Another aspect that is also important in the South African environment is the acknowledgement of the educator as a specialist in Technology. Awarding accredited certificates will provide such acknowledgement. The training process should also be community-centered as educators function within a teaching community. The teaching community should be integrated into the training to improve the implementation of newly acquired knowledge and skills. If the school as a whole is not involved in supporting the educators, the educators seldom apply their new knowledge and skills on a
continuous basis and easily fall back on the “old ways” of doing. The value of sustainable follow-up activities must be realised.

Structure and strategy
The structure and strategy of training can be explained through the five components identified by Loucks-Horsley, (1999). The first component is the format of training. Adequate contact sessions should be provided so that educators could obtain new knowledge and skills, but it should be sustainable over a longer period of time. The implementation of the training programme should be conducted in two parallel sessions. An introductory workshop is followed by in-school training opportunities such as classroom implementation, discussion groups, observations and demonstrations. Mentors and trainers are also involved. The in-school training is followed by additional workshops for report back and problem solving.

There should be a balance between out-of-school teaching, classroom practice and in-school support. Once-off workshops do not have the desirable impact. Although South African educators experienced workshops as positive and helpful, they very seldom applied what they had learned. By combining out-of-school training with in-school training, the necessary and very important support is provided to help educators apply their new knowledge and skills in their specific school situation. This will also contribute to the concept that training is not a once-off independent experience, but that it forms an integral and ongoing part of their professional development and of the work situation.

Another aspect of the strategy and structure is the approach. Although a constructivist approach is proposed, it is seldom realized. The research showed that due to lack of time and the large number of participants, trainers used lectures most of the time.

The duration of training is also essential for better implementation. Effective training can not be done as a single short course out of the school situation. Training should be done over a period of time such as a year, with a combination of different training opportunities.

The trainers themselves should be well-trained. Partnerships with other organizations will provide human and other resources that would enhance the quality of training. It is advised that in-service training should be approached as a combined project where different institutions (education, non-government organizations, industry) work together to exploit their strong points and available resources to be used to the advantage of the participants. Educators also experience problems developing their own study material. Due to the different contexts in which they teach, it is also not advisable to just present them with ready-made study material to use, as this will make them dependent on that study material even if it is not always applicable to their school situation. The study material must be of such a nature that there is room for their own creative interpretation and adaptation during implementation.

Evaluation and closure
The final phase of the training model is the evaluation and closure phase. Evaluation should include formative assessment opportunities both during in-school and out-of-school sessions, as well as summative assessment. Formative assessment plays a very important role in the whole training process. With formative assessment, it will be possible to identify problem areas which need more attention and which can be rectified as the training progresses. Adequate and comprehensive assessment will lead to a certification process where educators receive accredited certificates for completing the training successfully. The closure phase of the programme acts as a conclusion and final reflection opportunity within the training programme. During this phase the programme as a whole is analyzed, shortcomings and strong points are identified and advice for future programmes is compiled. Follow-up activities such as monitoring and support over a period of time can also be planned.
**Conclusion**
The survival and expansion of the learning area Technology in South Africa necessitate the purposeful targeting of educators, empowering them with the correct knowledge and skills to do justice to the purpose and scope of Technology. There are currently no specific policies or procedures for in-service training of educators in place. There is, however, a need for the short-course in-service training for learning area Technology educators who are forced to do out-of-field teaching. This can be addressed by a well researched and sustainable training programme. The in-service training must address their specific needs regarding the content of the learning area as well as the problems that they experience in their work environment. By implementing the proposed short-course model in a systematic way, it may help in addressing this need. To improve the success of in-service training and implementation of new knowledge and skills afterwards, a situation analysis must form the core activity for the planning and implementation of the training model.

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Same syllabus – different kinds of subject

Veronica Bjurulf. PhD Student in Educational work at Karlstad University, Sweden
Email: veronica.bjurulf@kau.se

Abstract
Two Swedish compulsory school teachers were interviewed about technology and technology as a subject in school. A series of classroom observations covering an entire section of each respective teacher’s course was also carried out. This paper is part of an ongoing research project the aim of which is to present the different kinds of variation that were made available to the pupils in the two teachers’ classrooms. The present discussion is part of an ongoing research project based on variation theory. The findings, so far, indicate that technology is not one and the same subject; on the contrary, depending on what the teacher focuses on in class, the pupils encounter different kinds of the same subject.

Introduction
In recent years, several surveys of current research carried out in the fields of technology and education have been published (de Vries, 2003; Petrina, 1998; Zuga, 1997). These surveys show that most research has focused on curricula and other official documents regulating the teaching of technology. In a few cases the surveys focused on the teachers’ teaching or what the pupils actually learned. The authors of these surveys call for further research looking into what is going on in the classroom and the teachers’ actual teaching. My study aims to answer precisely these questions. Another reason to study the technology subject and its continued process of development is that it is a rather new subject in Swedish compulsory school.

Sweden has had four curricula: Lgr62, Lgr69, Lgr80 and Lpo94. In Lgr62 and Lgr69, technology was an optional subject aiming to prepare pupils for working in the industry. In Lgr80, technology became an obligatory subject for all pupils, but it was not until Lpo94 that it achieved the status of having its own syllabus. The current syllabus, the one relevant to the present study, states that by the end of year nine (at the age of 16), pupils should have attained the following goals:

Pupils should
- be able to describe important factors in the development of technology, both in the past and in the present, and give some of the possible driving forces behind this development,
- be able to analyse the advantages and disadvantages of the impact of technology on nature, society and the living conditions of individuals,
- be able to build a technical construction using their own sketches, drawings or similar aids, and describe how the construction is engineered and how it operates,
- be able to identify and investigate some technical systems and explain them using their own words and describing the functions of the components forming it [sic!] and their relationships. (Skolverket, 2002)

1 Lgr and Lpo are abbreviations of Curriculum for the compulsory school. The number states the year in which the curriculum was approved.
The formulation of the goals in the syllabus is open to interpretation, so teachers and pupils have a
great deal of freedom as they implement it in their own work. The content and methods of the teaching
may thereby vary between classrooms.

Before presenting the results of my empirical study, I will give a brief introduction to variation theory,
the analytical tool used.

**Theoretical framework and method**
The theoretical framework of my study is variation theory, a theory which has emerged over the last
ten years. It is a learning theory which examines the consequences of teaching, on the basis of the
three concepts of discernment, variation and simultaneity (Marton & Booth, 1997). My research
project focuses on the intended and enacted object of learning (see Marton, Runesson & Tsui, 2004, p.
4). Earlier studies have shown that teachers teaching the same learning content offer students various
different possibilities of understanding, depending on their approach to the learning content (Marton &
Morris, 2002). Determining factors were: the teachers’ focus in class, variation, simultaneous variation
and constants.

**Discernment, Variation and Simultaneity**
In this section I will explain my understanding of the fundamental concepts of variation theory.

We are always aware of a number of things, but not in the same way and not at the same time (Marton
& Booth, 1997). Some aspects can be foregrounded while others remain in the background. If we lack
awareness of a certain aspect, the aspect in question can be said to be either absent or taken for granted
(ibid.). In order for us to discern something in a certain way, variation is necessary and there can be no
variation without simultaneity and no simultaneity without discernment (Marton & Pang, 1999).
Logically, these concepts are interrelated and they are essential when it comes to experiencing a
particular aspect of any given phenomenon.

Runesson (1999) puts it like this: “to know what something is, you have to know what it is not” (p.
31). Every aspect that we discern must be seen to relate to the possibility that it could be in a different
way, and every aspect must be identified if we are to discern it in its context at all (ibid.). A parallel
can be drawn here to pairs of opposites such as heavy-light, high-low and so on.

To discern something in a particular way we must discern its features and relate them to something
else. The concept of simultaneity can be defined as different aspects being discerned simultaneously.
To discern a wagtail as a small bird presupposes that it is compared to a swan or an eagle for example.
On the other hand, the wagtail is a big bird compared to a humming-bird. Such discerned aspects
constitute values in experienced dimensions of variation. Marton, Runesson & Tsui (2004) make a
distinction between diachronic simultaneity and synchronic simultaneity. Diachronic simultaneity is
the simultaneous experience of different instances at the same time and synchronic simultaneity is the
experience of different co-existing aspects of the same thing at the same time. Both kinds may occur in
a classroom context. Furthermore, in a classroom context students and teacher probably discern
different things. There is no guarantee that the students learn what the teacher intends, but what
teachers can do is to create possibilities for students to learn something in some way. From this
perspective, it is interesting to study what aspects of a subject teachers tend to focus on, as these
aspects constitute part of what the students can learn.

To understand what is or is not possible to learn in a certain situation, we need to pay attention to what
varies and what is invariant or constant (Marton, Runesson, & Tsui, 2004). Marton et al. argue that
variation in general does not lead to better learning possibilities, but rather, that variation is what
enables the learners to discern the various aspects required for the learning process to succeed:
It is necessary to pay close attention to what varies and what is invariant in a learning situation, in order to understand what can be learnt in that situation and what cannot. (p. 16)

To illustrate this, Runesson and Mok (2004) give the example of the critical features of a square: the size of the angles, the number of sides and the relations between them. The critical features vary with different learning objects and for each learning object the relevant critical features must be discerned. The critical features also vary between different groups of individuals. Learning to understand and handle a particular object of learning involves discerning its critical features (critical in relation to a certain aim) and focusing on them simultaneously. The features must be experienced as dimensions of variation. This means that there are different values that can vary within a dimension of variation.

To study learning from the perspective of variation theory previously meant studying teachers teaching the same learning object. Patrick (2002) means that such episodes can be looked at from a broader perspective, by seeing how the study of the discipline itself is constituted for students:

> The analysis of variation presented in Runesson and Marton (2000) focused on the teaching of particular concepts introduced in particular teaching episodes. I argue that we can look at such episodes from a broader perspective, to see how the discipline itself is constituted for students. What kinds of variation are made available? And what kinds are excluded? How does this affect the students’ comprehension of what is involved in the study of the discipline? (Patrick, 2002 p. 95)

Dahlin (forthcoming) agrees with Patrick. He suggests that if a limitation is imposed for the sole purpose of studying variation and critical aspects when teachers and students are working with a delimited learning object, there is a risk of overlooking what he calls possible implicit learning objects. With this understanding in mind, there are implicit dimensions of variation for all learning objects related to different conceptions of the subject as such. The teacher may have a broader understanding of the learning object that she or he takes for granted. This broader understanding can be reflected as well as unreflected. Dahlin argues that the implicit learning object is not so much about the specific content of the subject as about the subject in general. Irrespective of what teacher and students are working on in the classroom, there may be a limitation as to what can be learnt as a consequence of what the teacher is focusing on, what varies and what varies simultaneously. The learning object may differ and yet the understanding of the subject as such as constituted by the students may be the same.

The findings of the present study will be analysed using the ideas and concepts of variation theory, but in the broader perspective which has been advocated by Patrick and Dahlin.

**The sample**
In the spring of 2004 a questionnaire was sent to 123 technology teachers teaching grades 7-9 (pupils aged 13-15). 99 questionnaires were returned, after two reminders, and 29 teachers had marked their interest in participating in the continued study. Five teachers were contacted by phone and visited at their place of work in the spring of 2004. The teachers selected had indicated in the questionnaire that they utilised the time at their disposal in different ways, in relation to practical work, and social or historical perspectives, combined with a great amount of education in technology. This way of

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sampling is described by Cohen, Manion and Morrison (2000) as a purposive sampling. This paper presents results from two of the five teachers, Gustav and John.

Data collection
I carried out a series of classroom observations covering an entire section of each respective teacher’s course and I also interviewed the two teachers both before and after the observations were carried out. The interviews can be described as semi-structured (Cohen, Manion, & Morrison, 2000) as the teachers had a great deal of freedom with regard to the point of departure of some of the questions, as long as they remained within the scope of the technology subject.

I observed one course section per teacher. The lessons were videotaped and the teachers were also recorded on a tape recorder attached to their belts. Table 1 gives an overview of the data collection.

Table 1: The table shows when the observations were conducted. All data applies to year 2004. The table shows both numbers and the total amount of time of the observed lessons.

<table>
<thead>
<tr>
<th></th>
<th>August</th>
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<td>Gustav</td>
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<td>1</td>
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<td>John</td>
<td></td>
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<td>10</td>
</tr>
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</table>

Below follows an overview of each of the two observed course sections. The shaded fields indicate that some pupil is working with the task in question during at least some part of the specific lesson. The left column shows the different tasks going on in the classroom, as derived from the lessons observed. It can be seen as the teacher’s interpretation of the syllabus, implemented in the classroom.

Gustav taught 15 pupils in grade 9 (15 years old). Ten lessons were observed and they all lasted 80 minutes. Gustav called this particular section of the course Handy at home. Table 2 presents all tasks included.

Table 2: Disposition of lessons within the theme “Handy at home” in Gustav’s teaching

<table>
<thead>
<tr>
<th>Content _</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 3</th>
<th>Lesson 4</th>
<th>Lesson 5</th>
<th>Lesson 6</th>
<th>Lesson 7</th>
<th>Lesson 8</th>
<th>Lesson 9</th>
<th>Lesson 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartment drawing</td>
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<tr>
<td>Circuit diagram</td>
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<td>Electric cable</td>
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<tr>
<td>Build a brick wall</td>
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<td>Paper a wall</td>
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<td>Windpower station</td>
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<td>Hook on a wall</td>
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</table>

3 All names of teachers and students are fictitious.
Table 2 shows that several tasks were in progress at the same time, especially from the fifth lesson onwards.

_John_ taught 17 pupils in grade 7 (13 years old). Ten lessons were observed and all lessons lasted 60 minutes. John called this section of the course _Transports_. Table 3 presents all tasks included.

**Tabell 3 Disposition of lessons within the theme “Transports” in John’s teaching**

<table>
<thead>
<tr>
<th>Content</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 3</th>
<th>Lesson 4</th>
<th>Lesson 5</th>
<th>Lesson 6</th>
<th>Lesson 7</th>
<th>Lesson 8</th>
<th>Lesson 9</th>
<th>Lesson 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is technology?</td>
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<tr>
<td>History of Technology</td>
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<td>Valuation exercise</td>
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<tr>
<td>Build a vehicle</td>
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<tr>
<td>Write a report</td>
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</tbody>
</table>

Table 3 shows that throughout this section of the course, pupils worked with one task at a time.

**Data analysis**

There were several tasks in progress throughout the course sections (see tables 2 and 3). I analysed every single task using the following procedure:

1) What did the teacher focus on?

In other words, what did the teacher say or show in a presentation to the whole class or what did he repeat on several occasions when the pupils worked individually or in groups? For every single task the focused aspects that constituted dimensions of variation became points of departure for the continued analysis.

2) What varied, i.e. what kind of variation was it?

The different dimensions of variation were analysed with reference to what kind of variation they represented.

In total there were 5 categories in the two teachers’ teaching: _material variation, example variation, gradation variation, principle-apply variation_ and _function variation_. In the following the different categories are described, with special attention given to what characterised them. The categories are exemplified with quotations from the data.

**Kinds of variation**

**Material variation**

Different materials can be used for the same purpose. The task is constant, but the material varies.
When John’s pupils built vehicles, they were given some basic material. The aim was to build a vehicle that could move 1 metre in any direction. The pupils were allowed to bring material from home and they could also ask John for any additional material that they might need.

John: Did anyone else bring things from home? You asked for an electricity pipe and you have brought it. Very good.

Pupil: Electricity pipe? Or what did you say?

John: Yes.

Pupil: What is that?

John: Yes, it will be exciting to see what it will be used for. (Lesson 5)

The quotation shows that the supply of material is unlimited, and therefore variable, whereas the task of building a vehicle is constant.

**Example variation**

Different examples can illustrate the same phenomenon. The phenomenon is constant but the examples vary.

John introduced the course section “Transports” with a question: “What do you think about when you hear the word technology?” He wrote the pupils’ responses on the whiteboard:

- What is technology?
- Engines
- Batteries
- Computers
- Rubber bands
- Lego

One of the pupils said that everything is technology, and John said that what he had written on the whiteboard were *examples* of technology. Later that lesson John put some household goods on a table. He held up one item at a time and asked the pupils if they knew what it was. The items included a potato peeler, a rolling pin and a baking tin. He was surprised at the pupils recognizing all the items:

> I thought I had brought things you did not know what they were used for. Obviously you have some of these things at home. And your mum and dad use them and thereby use technology. Don’t they? But it is important to remember that everything we do with a specific purpose is about technology. (Lesson 1)

In the quotation John emphasises that technology is everything you use for a specific purpose. The items listed on the whiteboard and the household goods are all together examples of artefacts – technology, according to John’s definition.

**Gradation variation**

In this kind of variation, what varies is the gradation of a property. The material is constant but the gradation of the property varies.

Gustav’s pupils built a brick wall. They mixed their own mortar, and Gustav told them how to do it. In the quotation below he instructs the whole class.

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*All quotations in the paper are my translations from Swedish.*
Gustav: When casting, you use one part cement and one part water. Sometimes you need sand too, but for the kind of cement we have today, you just mix it with water. Usually you mix one cup of cement with two cups of water.

Sebastian: Twice as much in other words.

Gustav: Yes, approximately. But you have to feel your way too, because it mustn’t turn into some kind of slush. It mustn’t be a mess, but rather dry. So it mustn’t be too wet, because then it doesn’t set. It is called it does not burn. The cement burns. It sets. (Lesson 5)

Gustav told the pupils the proportions between cement and water, but he also told them that the proportions were approximate: “But you have to feel your way too”. This means that in order for the pupils to succeed, a certain perceptual ability is required. In the practical task it was Gustav who determined when the consistency was just right. The mortar was constant and the gradation of its consistency varied.

**Principle-apply variation**
In order to be capable of making appropriate choices or acting in an appropriate way, you need to understand a fundamental idea. The principle is constant, but its application varies.

When John’s pupils built vehicles he gave them some basic material: 4 wooden wheels, 1 balloon, 3 straws and 2 sticks. The aim was to build a vehicle that could move 1 metre in any direction. The pupils worked together in pairs or in groups of three. No practical instructions were given, so the pupils had to figure it out for themselves. One solution that was discussed concerning the fuel was to construct a circotherm balloon, as in the quotation below.

Pupil: Can I build a circotherm balloon?
John: It is so hard to get them to work.
Pupil: Yes, but still…
John: I have done it twice, and on both occasions there was a fire.

(Lesson 5)

After having discussed circotherm balloons, traps, electric motors and steam engines, all the pupils built vehicles that looked like cars with the balloon as fuel. The material supplied directed them to use the balloon as fuel and the principle was to use the atmospheric pressure to get the vehicles to move. This was done in two different ways. Six of seven vehicles were driven by a balloon attached to the vehicle. They inflated the balloon and when they let it go the atmospheric pressure drove the vehicle forwards. The seventh vehicle was driven by a balloon that the constructor held in his hand. He inflated the balloon and ran behind the vehicle. The air from the balloon drove the vehicle forward. The principle was the same in both cases, but the application of the principle varied.

**Function variation**
Whenever there is a problem requiring a solution, there are different possibilities of handling the situation. It is characteristic of this kind of variation that there is a need that must be satisfied, but the functions of the solution vary.

The pupils in Gustav’s classroom made drawings of apartments and interiors according to scale 1:100. The apartments had to be 40 m$^2$. In the quotation below, Gustav advises a pupil to choose a high bed rather than a low one, to make room for other furnishings under it. The quotation is an example of how Gustav directed the pupils’ attention towards functional choices when they chose their interiors.

Gustav: There is not much space, so you must think about different solutions. You know that you can build things up, a bed for example.

Pupil: Can I draw six times seven instead?
Gustav: No, you can keep it as it is. Think about a loft. You can have the bed in a loft and thereby save space under it. (Lesson 1)

In the quotation Gustav directs the pupil’s attention towards a functional solution. What lies behind Gustav’s suggestion is the need to make room for more furniture. Another solution they discussed was using a sofa bed. If you have a sofa bed you do not need a bed and thereby you economise on space. Both loft bed and sofa bed fill the need for somewhere to sleep. The two functions of the solution, accounted for above, vary.

**Distribution of kinds of variation**

The kinds of variation described above derive from empirical data. Tables 4 and 5 give an overview of the distribution of the kinds of variation found in each respective section of the course. The left column lists all dimensions of variation which were found for every single task (the tasks written in bold typeface). The other columns name the different kinds of variation. The shaded fields show kinds of variation for every single dimension of variation.

I found 4 kinds of variation in Gustav’s teaching (see table 4):

**Table 4** Distribution of the kinds of variation in Gustav’s teaching in the course section “Handy at home”

<table>
<thead>
<tr>
<th>Dimensions of variation</th>
<th>Kind of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Material</td>
</tr>
<tr>
<td>Apartment drawing</td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td></td>
</tr>
<tr>
<td>Circuit diagram</td>
<td></td>
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<tr>
<td>Number of wall sockets</td>
<td></td>
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<tr>
<td>Sort of wall sockets</td>
<td></td>
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<tr>
<td>Placing of wall sockets</td>
<td></td>
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<tr>
<td>Electric cable</td>
<td></td>
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<tr>
<td>Sort of plug</td>
<td></td>
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<tr>
<td>Build a brick wall</td>
<td></td>
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<tr>
<td>Consistency of the mortar</td>
<td></td>
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<tr>
<td>Wetness of the bricks</td>
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<tr>
<td>Paper a wall</td>
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<tr>
<td>Paste consistence</td>
<td></td>
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<tr>
<td>Sort of wallpaper</td>
<td></td>
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<tr>
<td>Ways of join wallpaper</td>
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<tr>
<td>Build a wind power station</td>
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<tr>
<td>Propellermaterial</td>
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<tr>
<td>Propellermodel</td>
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<tr>
<td>Mount a hook on a wall</td>
<td></td>
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<tr>
<td>Wallmaterial</td>
<td></td>
</tr>
<tr>
<td>Sort of hook</td>
<td></td>
</tr>
</tbody>
</table>

In John’s teaching I found 4 kinds of variation (see table 5):

**Table 5** Distribution of the kinds of variation in John’s teaching in the course section “Transports”

<table>
<thead>
<tr>
<th>Dimensions of variation</th>
<th>Kind of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Material</td>
</tr>
<tr>
<td>What is technology?</td>
<td></td>
</tr>
<tr>
<td>Artefacts</td>
<td></td>
</tr>
</tbody>
</table>

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Discussion
Tables 4 and 5 show that there were five kinds of variation in the two teachers’ teaching, and three of them were represented in both classrooms: material-, principle-apply- and function variation. This means that the technology subject was shaped as a question about the necessity of understanding fundamental ideas to be able to make appropriate choices or act in an appropriate way. The technology subject was also about satisfying a need, using a variety of possible solutions and methods. Furthermore it was a matter of using different materials to manage a certain task. The findings are interesting since Gustav and John taught pupils in different grades different subject contents. But there were also differences between the kinds of variation found in the two classrooms. Tables 4 and 5 show that there were some kinds of variation that appeared in the teaching of only one of the teachers. In Gustav’s teaching it was gradation variation and in John’s teaching it was example variation. I will discuss both teachers’ teaching further, starting with Gustav.

Gradation variation is about the gradation of the variant property. In Gustav’s classroom there were three dimensions of variation of the gradation kind, namely the consistency of the mortar, the wetness of the bricks and the consistency of the paste. The consistency of the mortar and paste varied while the pupils mixed it. They could discern a variation of consistency, and when Gustav told them that the consistency of the finished mixture was fine they were able to compare it to the earlier one. The pupils performed the different tasks on one occasion, and had the opportunity to compare the consistency of the mortar and paste only on that specific occasion. Gustav discerned variation in the paste between different lessons and between different materials (paste and mortar), so-called diachronic simultaneity (Marton, Runesson, & Tsui, 2004). This variation was not evident to the pupils unless they had experienced this kind of paste or mortar outside school. They were not offered this possibility in class.

In Gustav’s classroom the principle-apply variation was the most common one, which meant that there was a fundamental idea that the pupils had to understand in order to be capable of making appropriate choices and or act in an appropriate way. The work proceeded through Gustav’s instructions step by step as he demonstrated the procedure. On several occasions throughout this section of the course, the pupils asked Gustav what to do and whether or not their result was acceptable.

In John’s classroom there was a great range of example variation, as demonstrated by John’s focus on artefacts. Furthermore, he told the pupils many stories about different inventions and inventors. In his classroom, the technology subject was essentially designed to teach the pupils to see examples of what technology is, starting with the idea that it is all about artefacts and their uses. In the practical task – building a vehicle – the pupils worked without detailed practical instructions. The task was thereby open to interpretations and solutions of their own. None of the dimensions of variation were isolated.
or examined with respect to what solutions benefited the aim of the task (getting the vehicle to move one metre).

Conclusion
The aim of this paper was to present what kinds of variation were made available in two teachers’ classrooms. This study has shown that if we compare the results of two teachers’ teaching, we will find both differences and similarities. I have shown that some kinds of variation were made available in both classrooms, namely material-, principle-apply- and function variation. The learning content differed, but the kinds of variation made available in the teaching was to a large extent the same. The study also showed that the most frequent kind of variation in John’s classroom was example variation, which meant that he showed the pupils examples of technology as artefacts. In Gustav’s classroom the principle-apply variation was the most common type, which meant that there was a fundamental idea that the pupils had to understand in order to be capable of making appropriate choices and/or act in an appropriate way. My conclusion, therefore, is that pupils meet different aspects of the technology subject depending on what the teacher focuses on in class and depending on what variables are present.

Of course, it is not possible to generalise these findings – the issue is more complicated than that. Gustav and John are two representatives of technology teachers in Sweden, and discussing their teaching is a good starting point for a wider discussion about the technology subject as such and also about how different school subjects are shaped depending on what the teachers choose to focus on in class. Another aspect of some interest in relation to the continued development of the technology subject in school is that of studying the skills that pupils practise in class. This will be the focus of my continued analysis of the data.

Finally some words about variation theory and its influence on the improvement of learning. A substantial amount of current research proves that variation plays a critical role in student learning (Marton & Tsui, 2004; Patrick, 1998; Rovio-Johansson, 1999; Runesson, 1999; Vikström, 2005), and that the teacher plays an important role in determining what learning is made available to the students. This is so because, when you are going to learn something, there are certain necessary conditions for success and the teacher has to find out what these conditions are as well as bring them about (Marton & Tsui, 2004). In accordance with the variation theory, variation in general does not improve learning, but the variation of critical aspects does (Marton, Runesson, & Tsui, 2004). In other words, variation enables learners to experience features that are critical in order to learn something. One way to improve learning is thus to make teachers, or trainee teachers, develop an awareness of the variation theory.

References
Göteborg: Acta Universitatis Gothoburgensis.


Teacher education in technology through a constructivist approach

Wendy Fox-Turnbull  University of Canterbur  New Zealand

Email: Wendy.Fox-Turnbull@cce.ac.nz

Abstract
This paper describes a number of constructivist learning theories and illustrates how these theories underpin one significant task undertaken by tertiary students in a primary teacher-education degree programme. The activity aims to develop students’ understanding of technological practice and theory and to help them determine how they can bring these understandings to the primary classroom. By involving students in a collaborative and cooperative activity where they need to develop a technological solution, reflect on theirs and others technological processes and make explicit links to literature on authentic technological practice, the students are able to construct understanding and knowledge, not only of technological practice in the real world but how this can be adapted and taught in the primary classroom.

INTRODUCTION
The New Zealand Curriculum: Draft for Consultation 2006, recently released to schools, provides a clear directive for teachers to encourage students to work cooperatively and collaboratively with others and to be involved in managing their own learning. This paper, in documenting an activity used within a primary teacher education programme, discusses how learning theory relevant to technology education and to technology teacher education in the tertiary sector can intersect to meet the Ministry directive within the context of an evolving technology curriculum. On the premise that any such discussion must consider principles of sound education, the paper also discusses the theoretical underpinnings of such practice, and attempts to demonstrate that it is possible to apply and model sound education theories within both the primary classroom and teacher education.

BACKGROUND TO THE ACTIVITY
The activity referred to in this paper is a collaborative, cooperative task completed as part of the course, ‘Experiencing Technology Education (TE 261)’. This activity, in turn, is part of the three-year Bachelor of Teaching and Learning degree for primary-level (children 5 to 13 years of age) currently offered to pre-service teacher education students at the Christchurch College of Education, Christchurch, New Zealand. The course involves 20 hours of face-to-face class time and 30 hours of independent study, and students take it in their final year of study. To meet the learning outcomes of the course relevant to this paper, students must:

• compare, analyse and appraise the nature of technological practice in different technological communities
• explore and analyse underlying technological principles and examine and appraise complex systems in terms of how they are linked
• identify a technology unit of work which meets the requirements of the technology curriculum and the place of critical reflection in the design of technology units of work

1 The author firmly believes that all students from early childhood to tertiary deserve the right to education based on sound current education theory.
2 As from January 1 2007 the Christchurch College of Education merged with neighbouring University of Canterbury and is now known as the University of Canterbury College of Education.
• demonstrate their own technological capability, document and use this, with their own technological knowledge, to further their understanding of the holistic and integral nature of technology in the primary classroom
• participate in, analyse and appraise the nature of technological practice in the primary classroom (Fox-Turnbull & Haynes, 2003).

Classes in the School of Primary Teacher Education typically have 30 to 35 adult students from a range of ages and backgrounds. Course content covers a mix of theory and practice. To complete this course the students have one two hour lecture per week for a period of ten weeks. The course includes a number of different learning activities, each grounded in constructionist theory, one of which is used in this paper to illustrate how constructivist theory can be applied to teacher education. Lectures take place in a specialist room which includes seven hexagonal tables with chairs for written and group work, a food preparation area with two ovens and general cooking facilities and equipment and a ‘workshop’ area which includes a range of tools and equipment. The room represents facilities that are likely to be found in a primary or intermediate specialist technology facility in New Zealand schools.

THE IMMIGRANT BISCUIT ACTIVITY

The activity described in this paper has been developed in a constructivist paradigm, it is used to illustrate how a constructivist approach can be used in tertiary teacher education and is predicated on the understanding that students’ practice must be as close as practicable to authentic technological practice (Turnbull, 2002). It requires students to develop and market a packaged biscuit that could be given as a gift to an immigrant group, welcoming them to New Zealand and at the same time giving them a nostalgic feel of home. The packages must meet legal food labelling and packaging requirements. The target market groups for the packaged biscuits are charitable organisations that gift the biscuits to immigrants. Students are required to complete this activity in a culturally sensitive manner and are directed to thoroughly research their immigrant group to avoid any stereotypes.

Example 1: A selection of slides from a marketing PowerPoint to welcome immigrants from Hungary

The students work in teams, within their class cohort, using a mock company approach. This activity occurs over the first five weeks of the course. Students are given approximately half of the allocated class time to work independently within their groups. The activity culminates with a presentation to
the group by each ‘marketing’ team. All students are required to record their individual technological practice in a portfolio which is handed in for assessment purposes. The assignment represents 50% of the course assessment. Figure 1 is a copy of the brief given to the students.

Figure 1: Brief given to the students for the activity ‘immigrant biscuit’

![Biscuits For Immigrants Design Brief]

Situation:
In New Zealand we are lucky enough to have a large number of immigrants from a variety of cultures. Many find it difficult fitting into our culture and can suffer from depression and loneliness.

Need:
Develop a biscuit for a determined group of immigrants that combines aspects of their culture with New Zealand culture (the biscuit). The biscuits need to be developed, produced and packaged. You must package 6 - 8 of the biscuits at least. You also need to develop a marketing campaign, with a poster and video advertisement or PowerPoint presentation. Your target market is charitable groups who would gift these biscuits to immigrants when they arrive.

The Company Approach:
Your group is to become a company to develop this new product. You need to establish a company name and logo and appoint a CEO. Three teams will make up your company:
- Production Team - develop and produce the biscuit.
- Packaging Team - develop the packaging for the new biscuit meeting all legal requirements.
- Marketing Team - develop a marketing campaign targeted to charitable organisations, and must use product examples.

Added Information:
- You need to establish a chief executive officer (CEO) who will co-ordinate the three teams.
- A base recipe is provided, you may find another that is more suitable.
- Select the ingredients you want and check we have them, if not let us know and we will attempt to get them.
- You are only allowed the equivalent of \( 1 \times \) the recipe. To complete a trial you can halve the recipe. Make a variety of biscuits with the first half of the recipe to trial and produce “your” biscuits with the second half.
- You have limited time to produce, package and market your biscuit so maximise your time management. Use the systems given.
- Your presentation to the class should include the development process of all three teams.
- Remember your immigrant group and target market. What ingredients and other aspects will encourage charity groups to buy the biscuits as a gift to make the immigrants ‘feel at home’ and welcomed to New Zealand at the same time?
- Materials are available or packaging and marketing.

Good Skills:
- [Wendy Fox-Turnbull CCE]

The immigrant biscuit activity fits into the strand ‘technological practice’ as set out in the New Zealand Curriculum Draft for consultation 2006 (Ministry of Education, 2006). It engages the students in two components of practice—‘planning for practice’ and ‘outcome development and evaluation’ and it is identified in the ‘technological practice’ strand proposed in the draft New Zealand Curriculum document (Ministry of Education, 2006). This strand requires students to plan (in detail) and implement their own technological practice within the broader aim of developing and evaluating a specific technological outcome.

Example 2: An example of a biscuit and its package produced by the student teachers doing the immigrant biscuit activity.
Other purposes of the biscuit activity are to introduce and model ‘the company approach’ to student-teachers and to give them opportunity to work in a situation that requires cooperation and collaboration in order to meet identified needs, as stated in *Technology in the New Zealand Curriculum* (Ministry of Education, 1995, p. 16). It is this notion of learning through participation and collaborative thinking processes that is the root of apprenticeship and underpins the practice of many modern production companies (Daniels, 1996; Hennessy, 1993). The level of cooperation and coordination required for this activity is clearly illustrated in Examples 1 and 3. The packaging team needed to liaise with the marketing team about the logo and colours used and the production team needed to get an accurate list of ingredients to produce a nutritional information panel (see second photo) using the Australia New Zealand Food Standards Authority (ANZFA) nutritional panel calculator. Production team needed to complete the biscuit so that the packaging team could use it on their label and the marketing team needed to understand the ‘flavour’ of the biscuit and package so that they could accurately represent the product in their advertising Powerpoint.

*Example 3: The biscuit package, nutritional information panel and an advertising poster for the biscuit to welcome Hungarian immigrants*

The activity allows modelling of an experience that student-teachers can use directly or modified for use in the primary classroom. It further allows them to experience the authentic technological practices of planning for practice and product development (biscuit, package and marketing campaign) and to engage in reflective practice in terms of making links between theories of social constructive ways of learning, theories of technological practice and their own learning within technological practice. During the activity, the students are taught task and time-management strategies, and they also experience the use of the portfolio as an assessment tool within technology activities.

The company approach requires the course lecturer to assign each member of the class to one of two competing companies. The lecturer does this through an alternate alphabetical approach. Once in their company, the students are ‘given’ a specific immigrant group and asked to appoint a chief executive officer (CEO). The CEO facilitates the division of the company into three teams—production, packaging, and marketing. Teams work together to develop the biscuit, its packaging and a marketing
PowerPoint or video that advertises the product. The division into teams is usually done so that students are working in an area of interest which increases motivation and given the tight time frames students are working in makes most efficient use of time. This model has been used successfully within a Year 5-7 (ages 9-11) primary classroom by the researcher. In the primary classroom teachers need to consider carefully whether children are working to their areas of strengths, it may be advantageous to challenge children by getting them working in unfamiliar areas. The emphasis is on teamwork, collaboration and cooperation. The researcher, as lecturer, has observed a relationship between the quality of the developed outcome and the quality of relationships within each team and across the whole company. Working with adults there is little need for or time to teach collaboration and cooperation skills and techniques but when working with children these skills are necessary prerequisites.

Through experience, observation and anecdotal evidence, the course lecturer (author of this paper) determines that the company approach is particularly useful in allowing students to work on quite different technology-related areas within the same project. This of course can cause difficulties in teaching a wide variety of skills, knowledge and processes and with assessment especially when focussed on skill and product. However this can be successfully managed with careful planning of skills sessions and assessment that focuses on process rather than product. Teaching skills and knowledge to small groups of children / students as they determine a need for them is motivating and makes learning meaningful and authentic (Hennessy, 1993). An example of teaching a skill to meet a specific need is illustrated in Example 4. The packaging team wanted to protect the biscuits and stop them sliding when inside the box. After some discussion and experimentation they elected to develop a tray using the vacuum forming process. At this point the “teacher” took a skills session teaching the students to safely use the vacuum former to and to develop suitable patterns.

Example 4: Biscuits inside a plastic vacuum formed tray

RELEVANT SOCIO-CULTURAL CONSTRUCTIVIST THEORY

The acquisition of technological knowledge accords with several socio-cultural/constructionist theories of knowing. Constructivist theories (and theorists) such as; Situated Cognition and Authenticity (Hennessy, 1993 and Bereiter, 1992), Scaffolding and Modelling (Bruner, 1966 and Vygotsky, 1978), Integrated Inquiry (Murdoch, 2004 and Blythe, 1998), Abstract to Concrete Theory (Engeström 1996, and Davydov, 1988) and Higher Order Thinking (deBono 1992) claim that people construct knowledge through interaction with others in the socio-cultural environment. As such, knowledge is socially constructed. In their discussion paper on the nature of technology, Compton and Jones (2004) state that technological knowledge is socially constructed. This is because the social and cultural values of particular groups of people influence the technological advances made at any one time. Technological activity accordingly is embedded in the ‘made world’ and is influenced by social, cultural, environmental, economic and political influences.

The relationship between societal and technological development is thus complex and inseparable (Compton & Jones, 2004). Hennessy (1993, p.11) clearly supports this notion: ‘It is obvious that merely presenting children with new information and experiences in the classroom is insufficient to promote learning.’ Within the context of technology education, giving students problems that allow them to work within a specific technological culture or practice motivates them because they find it
has direct and perceivable relevance to their work (Fox-Turnbull, 2006; Hennessy & Murphy, 1999). Similarly, when children are given opportunity to solve technological problems through use of activities and practices that are authentic to or mirror a specific culture of technological practice, their knowledge and understanding of practices and issues are likely to be stronger. This is because they are able, through activity and reflection, to make connections to real needs, issues and practice within society (Turnbull, 2002). The ‘Immigrant Biscuit’ is a case in point. The remainder of this paper examines this activity against several social-constructionist theories. Each theory begins with a brief description of it, and is followed by a reflective examination, on the part of the author, of relevance of the theory for the activity and of how well the activity meets the precepts of each theory.

EXAMINATION OF BISCUIT ACTIVITY AGAINST SELECTED THEORIES

A. Situated Cognition and Authenticity
Situated cognition encompasses thinking as a part of a culturally organised activity carried out within a community of practitioners. Procedural and conceptual knowledge is an active part of this process (Bereiter, 1992). Cognitive apprenticeship methods of learning aim to enculturate students to authentic practices through activity and social interaction. Cognitive apprenticeship programmes develop students through situated learning, enabling students to observe, engage and invent or discover strategies in context (Hennessy, 1993) and facilitating the development of expert knowledge through the persistent solving of problems in relevant domains (Bereiter, 1992).

Turnbull (2002) argues that technology within the classroom needs to reflect authentic technological practice as much as is practical. She determines that if children are to understand technological process, they must be actively engaged in practice that reflects the culture of real technological practice. The immigrant biscuit activity, while not totally authentic, is a valid approximation of a technologically authentic context for children. The Christchurch Press ("Join Together", 2006) recently reported a similar exercise completed by a group of Year 11 (15-16-years-old) students at a local secondary school, which led to the production of the ‘Salam Biscuit’ for the ‘Unity Biscuit Company’. This biscuit is currently available in a number of cafes throughout the city and the developers hope it ‘will come to symbolize Christian–Muslim unity.’

Hennessy (1993, p.15) reminds us that within our understandings of situated cognition, ‘Learning is most successful when embedded in authentic and meaningful activity, making deliberate use of physical and social context’ (Hennessy, 1993, p. 15). The Immigrant Biscuit activity meets this requirement. Throughout their technological practice, students are required to write detailed reflections in a portfolio, which clearly articulate and demonstrate the learning that is occurring during this activity. The Immigrant Biscuit activity encourages students to behave and act like technologists. Theories of situated cognition and cognitive apprenticeship (Hennessy, 1993) highlight the issue of the disjunction between traditional classroom learning and cognition in practice. This activity minimizes this disjunction by allowing the participants a freedom to discover new and exciting possibilities, often taking learning in unexpected directions and well beyond ‘teacher’ expectations, thus modelling real world technological practice.

Authenticity is also evident in that the student-teachers, before being able to teach children to model authentic technological practice, need to understand what technological practice looks, feels and sounds like. An earlier ‘technologist’ assignment begins the facilitation of this process. In preparing for the biscuit activity and for a comprehensive understanding of authentic technological practice, the student-teachers, in their first technology education course, are required to identify a technologist from their community, interview them, observe and record their practice, then make explicit links between actual practice and the curriculum, models and definitions of technology practice. During the immigrant biscuit activity students continue to build their understanding of technological practice by
being immersed into a technological practice. Primary children also working in a similar activity gain the same benefits.

B. Modelling and Scaffolding
In a constructivist approach, modelling and scaffolding are an integral approach to teaching and learning. The expert (teacher) begins by modelling the effective strategies and techniques and may make explicit their tacit knowledge. Scaffolding is the process whereby teachers guide learners through activity in a manner that gradually increases the confidence and competence of the learners (Hennessy, 1993). Bruner (1996) uses it as an umbrella term to describe a range of actions and strategies that an adult uses to help the children’s learning efforts. The form of these supportive interventions vary but all aim to help the children gain goals that would be beyond them without the support. With gradual withdrawal of the scaffold, the learner becomes progressively independent.

Both these approaches relate to Vygotsky’s (1978) notion of the ‘zone of proximal development’. Within this zone, students and teachers engage in dialogue about knowledge students have and the knowledge students need. They also consider how the teachers, ‘as experts’, can assist and guide students in a manner that has the teachers gradually withdrawing their support for students as they become more proficient at the task or learning at hand (McLachlan-Smith, 1998).

One example of scaffolding used in the immigrant biscuit activity is related to task and time management. These skills are a major part of any technological practice, whether involving a very simple craft activity or a complex industrial activity. Technologists manage their time, tasks and practice in various ways, and the biscuit activity builds in opportunity to engage in and consider these methods.

The immigrant biscuit activity requires the students to use and reflect on three different types of task and time management models. The first of these is a simple listing of the required tasks, identifying who is responsible for each one and determining when it needs to be completed. This in itself is a useful tool as it enables students and children to comprehend the scope of the activity. The other two methods are more complex in nature and are specifically taught using the modelling through scaffolding to independence method of teaching (Bruner, 1996). More specifically, in session three the students are introduced to the ‘critical path’ and ‘herringbone timeline’ models of management; they are modelled in class and fully explained in course notes. They are then presented with an exercise to help them work through the process of developing each model (scaffolding of the process) before they work through the process themselves on a provided template (moving towards independence). This theory and practice works particularly well as student teachers immediately see a need for and then use their new still. Within a primary classroom modelling and scaffolding theory works very successfully but only one time management method would be used at any one time, and must be carefully matched to the level and ability of the children.

Use of a template is a particularly useful scaffolding strategy within technology education. A template is a guide or pattern that guides the user towards the achievement of consistent outcomes. In the Immigrant Biscuit activity, the portfolio, in which students maintain a detailed record of their technological practice, is initially provided to the students in the form of a written template. This is to give the students structure and direction for their eventual writing. This has proved a very useful tool by very clearly setting out expectations and facilitates greater consistency across assignments submitted. Many students have modified their portfolio templates to use when teaching technology in the primary classroom. This indicates not only an increasing independence but also an ability to adapt and design solutions to meet individual needs.

C. Integrated Inquiry Learning
The inquiry approach reflects the belief that, for learners, active involvement in construction of their knowledge is essential for their effective learning (Murdoch, 2004). Inquiry is guided and systematic learning that proceeds through a number of teaching/learning phases. It is very different from ‘open’ discovery learning in that the teachers have a major and continuing responsibility to structure a range of activities sequenced to maximize the development of skills and thinking processes of the learners. Inquiry uses a wide range of teaching approaches from teachers’ exposition to independent student research (Murdoch, 2004). Inquiry methodology and integrated curriculum are also supported by Caine and Caine (1990, cited in Murdoch, 2004). They argue that the brain seeks pattern, meaning and connectedness—methods that move from rote memorization to meaning-centred learning (Murdoch, 2004). Integrated inquiry learning involves students in developing deep learning through the process of self-motivated inquiry that strives towards development of ‘big understandings’ and ‘rich concepts’ (Murdoch, 2004) about the world and how it functions (Blythe, 1998). Inquiry is centred on both process and content (Murdoch, 2004). New Zealand Inquiry learning is beginning used in a number of primary schools.

Quality technology-education programmes that use authentic learning offer an excellent model for inquiry-based learning because they allow integration of numerous curriculum areas. Compton and France (2006) recognize that technology is increasingly interdisciplinary and requires technologists to work in an integrated manner. Technology topics generally are ‘vehicles’ for learning from which students can engage in ‘worthwhile exploration of meaningful content that relates to and extends … [their] life experiences and understanding of the world’ (Murdoch & Hornsby, 2003, p 19). Within this sphere of learning, and within technology education, students also are given authentic opportunity to measure, speak, write reports, discuss and consider all manner of issues (e.g., social, health).

During the process of participating and learning in technology and technological concepts, other areas of the curriculum become more accessible (Lewis, 1999). Inquiry learning is clearly a teaching approach that lends itself to the authentic delivery of technology in the classroom. In a recent case study report on quality teaching in technology by the New Zealand Education Review Office (ERO), teachers in all case-study schools mentioned the value of authentic, real-life problems or situations selected for study (Education Review Office, 2006). One school specifically mentioned that students’ inquiries and interests played a major role in directing learning.

The Immigrant Biscuit activity is a strong example of inquiry learning. The activity begins with a series of lessons that teach the student-teachers a range of skills they will need to conduct the activity. There is a clear structure and purpose to the learning, and students also have the freedom to research and take their product in a number of different directions. The learning associated with the activity is also integrated with learning in a range of other disciplines, among them; social studies, visual and written English. This is illustrated in Example 5. The marketing team who developed these posters were involved in a number of inquiries in order to achieve their final outcome, a series of four posters, two of which are below, on continuous PowerPoint with nostalgic music to accompany and voice over about the product. These inquiries included such things as investigating Israeli culture to identify the difference between truth and stereotype; taking into consideration M_sori protocol when sourcing and selecting suitable pictures and investigating potential possibilities when using PowerPoint i.e. layering pictures, incorporating voice over, adding music, adding text, inserting photos and locating and isolating a picture of a family.

Example 5: Two of the posters welcoming immigrants from Israel, note the different New Zealand backgrounds and the packaged biscuit in the foreground
D. Abstract to Concrete Theory

Another socio-cultural/constructivist theory relevant to the delivery of technology education is that of ‘abstract to concrete theory’, built on the premise that children’s thinking ascends from the abstract to the concrete (Engeström, 1996). Engeström proposes that students analyse subject-matter content to identify the primary general relationships and then link new learning to other known contexts, and from there to construct further abstract ideas related to the original subject-matter. Continuing analysis discloses rule-governed links between the original idea and its manifestations that, in turn, allow generalisations about the subject. Students use these generalisations to deduce more abstract ideas, turning the primary mental formation into a concept that registers as a ‘kernel’ (growing idea or understanding) of the academic subject. This ‘kernel’ subsequently serves as a general principle whereby students can orient themselves in the entire multiplicity of factual curricular material they encounter, and which they continue to assimilate in conceptual form via an ongoing ascent from abstract to concrete. This process leads, for the student, to new types of theoretical concepts, theoretical thinking and consciousness. These theoretical concepts entail high-level metacognitive functions, such as reflections, analysis and planning.

The strategy of ascending from the abstract to the concrete thus has two characteristic traits. First, the students identify the ‘kernel’ as their mainstay to deduce particular features of the subject matter. Second, they strategically discover and reproduce the conditions of origination of the concepts they need to acquire. What this process means in terms of the school is that students reproduce the actual process whereby people have, over time, created concepts, images, values and norms that make for collective understandings within society (Engeström, 1996).

Davydov (1996) distinguishes six learning actions that follow the logic of ascending from the abstract to the concrete:

1. Transforming the conditions of the task in order to reveal the universal relationship of the object under study
2. Modelling the unidentified relationship in an item-specific, graphic or literal form
3. Transforming the model of relationship in order to study its properties in their ‘pure guise’
4. Constructing a system of particular tasks that are resolved by a general mode
5. Monitoring the performances of the preceding actions
6. Evaluating the assimilation of the general mode that results from resolving the given learning task.

Davydov’s theory suggests that many misconceptions students have about key learning concepts are due to the empiricist, descriptive and classification of traditional teaching and curriculum design. Knowledge gained at school often fails to become a ‘living instrumentality’ for making sense in the complex real world (natural and social), and so school knowledge is inert. This is because children do not have opportunity to discover ‘kernels’. Nor do they get a chance to use the ‘kernels’ to deduce, explain, predict, and master in a practical way. However, according to Davydov, when the learning process is organised differently, children’s thinking and understanding can be improved considerably. Davydov (1996) illustrates this point by stating his finding that many secondary school students
explain the phases of the moon in terms of Earth’s shadow, but then begin to question that understanding when asked about a lunar eclipse. Davydov believes these misconceptions have come about through commonly used abstract ideas and diagrams. What he suggests is a more constructivist approach where students interact with and actively discover ‘kernels’ for themselves.

I believe the idea of Davydov’s ‘kernels’ is similar to Murdoch and Hornsby’s (2003) definition of ‘concept’. They write, ‘Concepts are ideas which synthesise and bring meaning to parts of knowledge. A concept groups related facts (specific data for which evidence exists). A concept can often be identified by words or simple phrases that classify, categorise and define a group of related facts’ (pp. 137–138). Their definition aligns with McCormick’s (1997) discussion of ‘know how’ (procedural knowledge) and ‘know that’ (conceptual knowledge). Conceptual knowledge includes knowledge of facts, gained not in isolation but as part of an active process that includes enculturation. Conceptual knowledge can cause problems in technical activities because of a lack of knowledge transfer (Jones, 1996). As a number of commentators stress, transfer of knowledge involves the ability to learn in one area and apply that knowledge in another curriculum area, and is a vital component of technological practice (Compton & France, 2006; McCormick, 1997; Moreland, Jones, & Chambers, 2001).

The Immigrant Biscuit allows students to develop a clear concrete concept of a ‘development company’ and what it means to be part of such a company. One student at the end of the immigrant biscuit activity was heard to say ‘I didn’t realise how difficult and complex working within a company environment can be’. The activity is a time of discovery, students learn first-hand the importance of a collaborative approach, the importance of open clear communication and indeed the frustrations when this does not occur. They also discover how and when skills and knowledge combine. Through the team approach, they are able to produce something that is well beyond any individual’s capability. During the activity, the ‘teacher’ is a constant presence in the room, facilitating learning by making links and questioning students about their practice and understanding. A very simple example of this is identifying students’ understanding of the concept of ‘biscuit’. In New Zealand a ‘biscuit’ is closer to the concept of the North American ‘cookie’, and the North American concept of ‘biscuit’ is more aligned to the New Zealand concept of ‘scone’. Awareness of the difference between knowledges across a range of settings, cultures and disciplines requires technologists to debate, prioritise and use sophisticated decision-making within their technological practice (Compton & France 2006).

E. Thinking Theory/Strategies
Edward de Bono (1992) is at the forefront of thinking-based strategies, and his means of developing, challenging and extending children’s thinking are well-known. One of his best-known strategies is ‘thinking hats’, which encourages people to think from a range of perspectives or points of view. Here, six hats, each of a different colour, represents a different perspective, for example: white—what are the facts?, red—what do I feel about this?, green—what new possibilities are there?, blue—what thinking is needed?, black—judgements, what is wrong with this?, and yellow—what are the good points or benefits? In New Zealand primary classrooms de Bono’s thinking hats are regularly used to engage children in higher level thinking. For this course the concept has been modified to encourage teacher-education students to think from two perspectives as they participate in both theoretical and practical sessions (see Figure 3). The need for this strategy was realised when a student, after completing an investigation into functionality for which the context was the potato-peeler, stated ‘I would never use this activity in the classroom because I don’t like potatoes.’ He had completely missed the point of thinking as a teacher, of considering his students’ learning needs in terms sound education theory and his future classroom practice.

The students are given an outline of the two Thinking Hats in the first session and encouraged to reflect on their technological practice and learning using both hats to demonstrate their ability to link their experiences to both theory and classroom practice. The ‘Two Thinking Hats’ strategy is a useful tool that guides students to link requirements and concepts of the Technology in the New Zealand
Curriculum, theory of three models of technological practice and constructivist learning theory to individual technological practice and to their eventual classroom practice through engagement in in-depth reflections. The students record these reflections in their portfolio.

**Models of Technological Practice**

The Kimbell Model of Technological Practice [is evident]. The production team are using their reflective capability to create a biscuit that will be enjoyed by Korean taste buds … At every step we are asking ourselves, “Is this appropriate? Does it have good design qualities? Are people going to want to purchase our product by seeing the ad? How can we make it better?” (female student 1, 03N, Christchurch College of Education, 2003)

**Critical Path**

This was completed by our CEO. It is a great overview of the whole process and allows you to see where you are up to and how far you have to go. This is quite useful in the classroom for the children to be aware of the timeframes available. According to Gawith (2000), the technologists must organise their resources such as time. (female student 2, Yr 3 D, Christchurch College of Education, 2006)

**Herringbone**

I really like this timeline process, as it clearly displays what I need to do in order to complete my task with the rest of the company. The times are not as specific for this model, which gives the necessary scaffolding while allowing some flexibility. In a class situation, most children would understand the
concept and be able to see what they need to do to contribute to the final outcome. (female student 1, 01N, Christchurch College of Education, 2003)

**Materials/ Resources/ Skills ‘Clouds’ (brainstorm)**
This is a useful brainstorm to narrow down the vast range of resources and skills available to us. Gawith (2000) states that technologists need to organise materials and resources as well as the process. Pacey’s (cited in Burns, 1997) model relates the skills and tools available to the restricted meaning of technology, the technical aspect of the process. I think this is useful to be aware of, amongst all the creativity that goes with this task. There are certain skills and resources that have to be used to achieve the desired outcome. For children’s understanding, it is important to think about the skills they need, and have, to complete the given task. It would need some guidance from the teacher to complete this brainstorm. (female student 2, Yr 3 D Christchurch College of Education, 2006)

**Planning and Construction**
The first try of making the plastic insert for the box according to our plans failed as the cardboard box inserts collapsed in the vacuum former. We then had to change the resources and apply knowledge to the problem at hand. This is an excellent example of Kimbell’s (1991, cited in Burns 1997) Reflective Active Capability Model of technological practice. (female student 2, Yr 3 D, Christchurch College of Education, 2006)

**Classroom Applications**
The value for me is in my turning this back to the classroom and my role as a technology teacher. I having a realistic situation, authentic context and technological area, I am able to see how this practice relates to the curriculum document and not just what I teach but an insight into how I will teach it. (Male Student 1, 01N, Christchurch College of Education, 2003)

**CONCLUSION**
This paper illustrates how the constructivist based theory in teacher education facilitates reflecting thinking and enables students’ insight into teaching technology education in the primary classroom. Technology education in New Zealand is based on a holistic and practically based curriculum, which is ideally suited to socio-cultural constructivist approaches to teaching and learning. As such, technology teacher-education programmes need to teach student-teachers a range of constructivist approaches that they can bring to their own classrooms and technology. The immigrant biscuit activity facilitates this approach which enables students to think critically about technology and how it is best implemented.

References


In the 1970s, curriculum theory was plagued by many problems. Curriculum theorists found themselves spending more time in highly contentious, eristic, and ad hominem debates (Schwab, 1972); the number of subject specialists (professors of history, English etc.) writing curricula was increasing, while the number of curriculum theorists involved in this process was declining (Lagemann, 1997); and the number of debates about research methods were multiplying rapidly (Lagemann, 1997). These problems led many curriculum theorists to question the direction in which their subject was heading. Foremost among these critics was Schwab, who argued that, “the field of curriculum is moribund, unable by its present methods and principles to continue its work” (Schwab, 1972, p. 79). In Schwab’s opinion, curriculum studies had become too focused upon the development of theories- that were usually based on unquestioned assumptions- and had failed to consider the reality of the teachers who must turn theory into practice. A great deal has changed since Schwab first wrote his stinging critique of curriculum studies. However, many areas within curriculum studies are still plagued by unconstructive debate; the key question is why?

I believe one reason that these debates continue to plague the discourse of educational researchers is the failure of these theorists to adhere to Schwab’s advice to analyze our unquestioned and unproven assumptions. An excellent example of the damaging effects of unquestioned assumptions can be found within the history of technical education. Since the time of Plato, if not earlier, philosophers and educators have debated the place of technical education within schools (Plato, 1991; Layton, 1984). While this debate has taken many forms it had often dissolved into a conflict between those who prize what Ryle (2000) has labeled “knowing that” and those who value “knowing how”. While this distinction is a useful one, the dichotomy has been pushed past its logical extreme (Lewis, 1993; Kessels & Korthagen, 1996). In this paper I will argue that a re-examination of our assumptions about the nature of knowledge is needed if we are to get past this divisive debate. I will also endeavor to show how the ideas and methods of the sociology of knowledge can help researchers to do this.

What is the Sociology of Knowledge?
The sociology of knowledge is somewhat difficult to define. It has a long history, and has undergone several notable shifts in focus. However, it is safe to say that the sociology of knowledge is concerned with the relationship between human thought and the social context within which it occurs. At its core are four beliefs (Stark, 1971; Berger & Luckmann, 1967):

1. An individual’s world-view is in part the product of his/her society.
2. These pre-existing beliefs, which Stark (1971) has labeled the axiological layer of the mind, guide the individual as he/she tries to understand the world.
3. This world-view is relative to a society’s socio-historical situation, though it appears to the individuals in these societies as natural.
4. Any attempt to fully understand an individual requires an investigation of the axiological layer of his/her mind, and any attempt to understand an institution or society requires an investigation of its socio-historical situation.

1 Cognitive psychologists and some philosophers use the term “procedural knowledge” in place of “know how,” while “declarative knowledge” is used to signify “knowledge of facts” and “conceptual knowledge” deals with the relationship among items of knowledge (McCormick, 1997).
The sociology of knowledge has strong ties to epistemology, and in many ways it owes its existence to the work of Kant (Stark, 1971; Merton, 1937). Kant’s epistemological treatises focused on the way in which individuals construct their mental image of the physical world. Working from a belief that humans cannot experience the world as it truly exists, Kant postulated that the human mind possesses categories (e.g. time, space, and causality) through which we process our experiences. This means that the intellect is not a passive receiver of data but an active creator (Cole, 2002). The sociology of knowledge departs from Kant’s epistemology by focusing upon the society in which an individual lives, and arguing that society also creates mental categories, through the socialization process, which affect our view of the world².

The Sociology of Knowledge is Born

The sociology of knowledge proper began in the 1920s when Scheler investigated the way in which social factors and institutions (e.g. race, states, economy) acted as selective agencies for ideas, either retarding or quickening their spread (Merton, 1937). Scheler’s idea- that socio-historical context could affect the development and spread of ideas- was a major advance in the history of the sociology of knowledge. However, it failed to have a great impact outside of Germany, largely because Scheler’s work was not immediately translated into English (Berger & Luckmann, 1967).

Within Germany, however, many researchers were intrigued by Scheler’s ideas. Most notable was Mannheim, whose *Ideology and Utopia* would have a profound impact upon the sociology of knowledge. In this book, Mannheim focused upon political life, as he sought to understand the relationship between various social milieu and the political problems and modes of thought they produced (Merton, 1937). Mannheim was especially intrigued by the way that an individual’s ideological beliefs could influence his/her interpretation of a situation.

The sociology of knowledge was introduced to a wider range of scholars in the late 1930s when first, Mannheim left Nazi Germany for Britain in 1933, and second, *Ideology and Utopia* was translated into English in 1936. Unfortunately, the reaction of British and American scholars to the sociology of knowledge remained cool during this period, most likely due to the dominance within sociology and educational studies of the functionalist paradigm and positivist methodology (Karabel & Halsey, 1977).

One of the first concerted attempts to apply the beliefs and methods of the sociology of knowledge to education occurred in 1971, when Young edited a reader on the development of “school” knowledge. The contributors to this work criticized sociology and educational studies, claiming that the fields suffered from a lack of perspective due to the researchers’ tendency to accept the assumptions inherent in our Western system of education (e.g. that “academic” knowledge is superior to “practical” knowledge). In particular, both Bernstein (1971) and Young (1971) were highly critical of the “almost total neglect by sociologists of how knowledge is selected, organized, and assessed in educational institutions” (Young, 1971, p.19). Unfortunately, few scholars, including current sociology of knowledge theorists, have heeded the call of Bernstein and Young, and the sociology of knowledge remains an underused theoretical lens.

What can the Sociology of Knowledge Contribute to the Study of Technical Education?

The sociology of knowledge had a great deal to offer to educational researchers. In particular, the sociology of knowledge leads researchers to try to understand the relationship between a point of view and the socio-historical context in which it developed. By doing this, the sociology of knowledge also allows us to question our everyday assumptions. Once this is done we can more easily see

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² In taking this approach the sociology of knowledge is also borrowing from the ideas of Marx (Menzies, 1995; Marx, 1977), Nietzsche (Nietzsche, 1989), and Dilthey (Stark, 1971; Berger & Luckmann, 1967).
alternatives, which might have otherwise been missed. In this next section, I will demonstrate the usefulness of the sociology of knowledge by tracing the origins of the knowing that/knowing how debate and discussing the socio-historical context in which it was formed. I will then conclude this paper by showing how researchers, who have questioned our assumptions about knowledge, have pointed out a way in which we can get beyond this debate.

Technological Studies: The Origins of the Debate

According to Lewis (1993) and Layton (1984), the dichotomy between practical and liberal ways of knowing can be traced back to Plato, who made a distinction between rational and irrational thought, or what Plato called episteme (knowledge) and doxa (opinion). According to Plato, one arrived at the form of pure truth, which is absolute and transcendent, through episteme, which was to be found only through intellectual speculation and contemplation. Knowledge gained through practice or physical activity was seen by Plato as second rate, as it could only reflect the transcendental form of pure truth and never lead to it directly. In making this argument, Plato was echoing a theory that was common to Greek thought. The general belief within his society was that “art”, which included all human practices, was imitative and had no transcendent aspect. To the Greeks, an artist or laborer did not create; he/she simply changed pre-existing matter so that the form, which it had always contained, could be visible. Scholars suspect that this conception of knowledge, which reifies theoretical knowledge, and degrades practical knowledge, can be traced back to the sharp cleavage that existed between citizen and slave in Greek society (Lewis, 1993; Durant, 1926).

The medieval universities passed the Platonic conception of knowledge onto Western civilization, as they developed a hierarchy with the most transcendent subjects- theology and philosophy- at the top, and the most practical subjects- law and medicine- at the bottom. The readiness with which Plato’s beliefs about knowledge were accepted by the universities is not surprising, when we keep in mind the fact that the medieval universities were supported and influenced by the Church, which had itself been strongly influenced by Neo-Platonism (Lewis, 1993; Peters, 1989).

When the industrial era began and helped to beget public education in the eighteenth and nineteenth centuries schools were quickly seized upon by administrators as institutions that could prepare individuals for their positions in society. For many this meant a vocationally oriented education that would ensure factories could function efficiently. By the 1890s education in Britain, for example, was effectively divided into two tiers; one had an academic focus and sought to develop the mind of the individual, the other had a vocational orientation which served the needs of industry (Dakers, 2006).

Once this hierarchy of subjects was established, schools and universities developed mechanisms, sometimes intentionally, sometimes unintentionally, for its maintenance. For example, subject associations, like the Society of Art Masters in England, fought to maintain the high-status of the “liberal” disciplines (Goodson, 1987). Tradition also helped to sustain the hierarchy of knowledge. For example, the historical prestige given to the classics and mathematics meant that more scholarships and fellowships were available in these subjects. This in turn attracted individuals to these subjects, and helped to maintain the idea that they were superior (Lewis, 1993).

Slowly over time the idea, born in a particular socio-historic context, that practical knowledge was different from abstract knowledge became engrained in our society and formed what Stark would call an axiological layer of the mind. As a result, when the knowing that/knowing how debate resurfaced

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3 It is important to note that while Western society has retained a good deal of Plato’s conception of knowledge our view of technology is in many ways quite different. Most notably we no longer believe that an artifact possesses a pre-existing essence that the artist uncovers. Instead Western society tends to believe that technological artifacts are neutral items created to serve humans (Feenberg, 2006).
in more modern times the proponents of each side tended to speak past one another due to their unquestioned belief that practical and abstract knowledge were different and that one must be superior to the other.

**Technological Studies: The Modern Debate**

In Britain, the modern dispute over practical education can be traced back to the early nineteenth century when Edgeworth published his *Essays on Professional Education* in 1809. This book began a contentious public debate that would involve prominent thinkers, such as Arnold, Mill, Newman, and Huxley (Lewis, 1993).

In this debate, Arnold and Mill argued in favor of the “liberal tradition,” claiming that a focus on the classical subjects offered students an introduction into the best of their culture, and at the same time instilled habits of thought which could be applied to any future endeavors. Huxley defended the practical arts and sciences, arguing that an education should be useful above all else, and must therefore provide practical skills, which will help students find jobs. This would also ensure that Britain remained technologically advanced. This debate would continue, off and on, for the next two centuries. Overtime, the practical arts and sciences managed to gain ground - winning places in colleges, universities, and public schools- but these victories were hard fought and the place of the practical arts remained insecure (Hansen, 2004; Lewis, 1993).

In fact, even as recently as the 1980s attempts by the British government to increase the prominence of technical education led to vociferous attacks which drew upon the liberal/utilitarian dichotomy. For example, O’Hear (1987), a supporter of liberal education, wrote a scathing critique of the British reforms, in which he questioned the motives of the British government, claiming that the “market-obsessed new Right” was seeking:

> to produce a population ready only to fulfill technological functions in society, their minds being left to their own weightless and autonomous choices among the stimuli produced by that technology and the mass media (p. 102).

O’Hear also attacked the government’s attempts at reform by implying that they detracted from the ability of the education system to teach students to see beyond their immediate needs, and to understand and reflect upon their culture. O’Hear feared that the result of these changes would be “a race of Kierkegaardian ‘aesthetic’ men who act on immediate impulse, on the stimulations of the moment” (p. 104). Johnson (1988) added to this line of argument by claiming that a focus on skills - be they technological or general skills- was dangerous as it could lead to a society where people were concerned with ends and not means.

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4 A very interesting explanation of this tendency has been developed by Gamble (2001), who has analyzed traditional school knowledge and craft knowledge using Bernstein’s (1999) concepts of discourse and grammar. Essentially, Gamble argues that practical knowledge, such as craft knowledge, is characterized by a vertical discourse structure and a weak grammar. As a result it is usually difficult to describe how the elements that make up the discourse fit together and build upon one another. This difficulty leads to the false belief that practical knowledge does not build upon itself, as theoretical knowledge does, and is instead a series of unrelated ways of knowing. The inability of the practical arts to identify key concepts that hang together to form an easily distinguished discipline has been highly problematic, and has certainly contributed to the entrenchment of the liberal/practical divide.

5 It should be pointed out that in spite of the political polarization of the time there were a number of curriculum models being argued for by different factions; many of which do not fit within the strict liberal/utilitarian dichotomy discussed thus far. The growing complexity of the debate over the practical arts will be discussed more fully later in this paper. The discussion above is merely meant to highlight the continued prominence of the knowing that/knowing how dichotomy.
The response of pro-utilitarian educators to these attacks has been to argue that education should provide students with useful skills. Usually this line of reasoning focuses upon economics—claiming that practical education will benefit the individual and the nation by ensuring the workforce remains competent—on occasion, however, theorists have attacked the liberal tradition head-on, by challenging its claim to be the best way of developing habits of thought. A good example of this approach can be found in the *Education for Capability* manifesto (1980), put together by the Royal Society for the Arts. In this document the RSA argues that:

A well-balanced education should, of course, embrace analysis and the acquisition of knowledge. But it must also include the exercise of creative skills, the competence to undertake and complete tasks and the ability to cope with everyday life…Educators should spend more time preparing people in this way for a life outside the education system (quoted in Lewis, 1993, p. 187).

In this modern debate, one can see evidence of the axiological layer of the mind at work. The way in which proponents of practical and liberal knowledge attacked one another, assuming that a gain for one side was a loss for the other, shows how deeply the Platonic conception of knowledge had been engrained in our society. This is unfortunate as Plato’s ideas about knowledge represent only one set of possibilities. However, once scholars have recognized that our conception of knowledge is based upon a particular world-view derived from a particular socio-historical context it is possible to analyze that perspective.

**Technological Studies: Contemporary Directions**

Today the place of technology in school systems around the world is being redefined (Layton, 1994). Due to the large number of factors influencing this development and the differences that exist within individual nation-states it is difficult to draw specific conclusions or to uncover patterns. However, it is safe to say that there are two broad variables at play.

**Philosophic developments.**

A number of philosophers and educational theorists (e.g. Dakers, 2006; Feenberg, 2006; Pring, 1995) have challenged the belief that technological knowledge only involves “knowing how”. Pring, for example, has argued that while the liberal and practical traditions have strengths, both are equally flawed when applied individually. According to him, the academic tradition focuses on the type of theoretical knowledge that Ryle (2000) had labeled “knowing that.” At it’s best, this type of knowing goes beyond common sense, and raises questions that are not immediately self-evident. However, this way of knowing is also problematic for three reasons. First, when the focus on the acquisition of knowledge becomes all consuming it is possible for schooling to turn into an exercise in memorization, as students familiarize themselves with a great many facts that have no personal meaning to them. This sort of education not only leads to disengagement but it may also fail to meet the standards of the traditional analysis of knowledge (de Vries, 2006; Feldman, 2003). According to this definition I “know” something when: 1. I believe it. 2. It is true. 3. I am justified in believing it. When education is reduced to my ability to make a declaration upon command it is likely that I lack

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6 Further evidence of the deeply rooted nature of this dichotomy can be seen in a study conducted by Hansen, Gurney, Carter, and So (2002). This piece provides researchers with a series of very interesting vignettes from interviews with graduates of Ontario’s comprehensive school system. While these vignettes provide their reader with many insights it is quite noticeable that time and again the research subjects claim they felt like “outsiders” (p. 6) who were “stigmatized” (p. 8) because academic subjects were of little interest to them. These negative feelings illustrate that the Platonic conception of knowledge, which valued the liberal over the practical, was deeply engrained in the minds of these individuals.

7 It should be pointed out that many philosophers object to this definition of knowledge (e.g. Geittier, 1963). However, given that there is no agreed upon alternative I will use this definition for my critique of an education that focuses on “knowing that”.

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sufficient justification for believing the declaration in question, as I am simply repeating something that I have not analyzed myself. Second, a focus solely on the development of declarative knowledge neglects the development of the concepts required to determine if one’s beliefs are based on sound reasoning, judgment, or argument (Pring, 1976). Third, a focus only on “knowing that” is unwise as it disconnects theoretical knowledge from practical knowledge. That this dichotomy is false is easy to see. A doctor, for example, must possess practical, tacit knowledge if he/she is to successfully remove my appendix. However, he/she must also possess substantial theoretical knowledge to understand the meaning of the steps involved in this process. To divorce one type of knowledge from the other leads to a half-educated person.

The practical tradition, on the other hand, is focused on “knowing how”. This practical knowledge, often acquired through some sort of apprenticeship, plays a role in everyone’s education. The value of such practical knowledge is self-evident; without it I could not drive a car, ride a bike, or use a phone. However, a focus entirely on knowing how is also problematic. When education is reduced to the reproduction of a series of steps, students are no longer taught moral virtues, intellectual habits (e.g., questioning), or the value of our intellectual heritage.

The realization that both “knowing that” and “knowing how” are unsatisfactory on their own leads Pring to conclude that educators need to combine the academic, vocational, and life-preparation traditions. Hansen (1997) also argues in favor of the blending of theory and practice, arguing that such a mixture would have the virtue of building upon our natural psychological desire to solve problems, and would also help us to integrate theoretical information by providing it with a meaningful context. In following this route, Hansen is advocating that we follow the philosophy of Plato’s student Aristotle, who: “knew the differences between intellectual grasp of a theory (episteme), mastery of arts and technique (techne), and the wisdom needed to put techniques to work (phronesis)” (1997, p. 115).

Changing societal beliefs regarding technology.
At the same time that philosophers of technical education have challenged the knowing that/knowing how dichotomy in theory, a more nuanced view of technology has also emerged in many segments of society, including some school systems (Layton, 1993). Essentially, this transition has involved a re-conceptualization of technology that sees the “traditional view”, which focused upon the use of techniques and tools in the production of artifacts, replaced by a broader conception of technology that combines the older aspect with an interest in the cultural impacts of technology and the organizational aspect of technology (Layton, 1993). The exact shape and focus of this more general view varies from nation to nation. While the causes of this transition are still debated it is safe to say that it has been affected by:

1. A growing awareness that technology is not neutral and it’s affects upon society can be devastating (Feenberg, 2006).
2. Changes in the use of technology (e.g., proliferation of computers, development of new equipment and modes of production) that create an environment in which the place of technology can be debated (Hill, 2006).
3. The proliferation of factions among those who support the place of technology in education (Layton, 1994).  

I use the word “likely” here, as what constitutes sufficient evidence for belief is still hotly debated among philosophers. However, I believe that most educators would agree that a student who parrots a response is not being educated in the sense that the word is commonly used.

Layton (1994) identified five such groups of stakeholders—economic instrumentalists, professional technologists, girls and women, defenders of participatory democracy, and proponents of multiple intelligences—though there are certainly other groups waiting to be identified.
4. The unique history of technology and education within individual nations. The impact of this factor can be obvious, such as when a nation with a strong traditional interest in handicrafts chooses to maintain this, or subtle, as when a lack of teachers trained to use a new piece of equipment leads a school system to neglect this new technology. 

5. A growing understanding of cognition and the resulting changes to teaching. For example, McCormick’s (1997) discussion of conceptual and procedural knowledge has illustrated that these two types of knowledge are interwoven and that one is ineffective without the other. As this information spreads it may be adopted by school systems, schools or teachers and thereby lead to changes in the classroom.

The relationship between current philosophic beliefs and changing societal beliefs is an area outside the purview of this paper and is also in need of further investigation. What is important for the present discussion however, is the fact that the more sophisticated view of technology that is emerging was made possible by the willingness of researchers, philosophers, and society in general to question taken-for-granted assumptions. I believe that curriculum studies would benefit from more of these difficult, quasi-philosophic inquiries. I also believe that the sociology of knowledge is one of the theoretical lenses that could lead researchers towards a more complete basis for curriculum decisions in schools. Of course, some researchers will ask: given that a more sophisticated view of technology is being developed, why should theorists concern themselves with the knowing that/knowing how dichotomy and the sociology of knowledge? I believe there are two responses to this question:

1. While the knowing that/knowing how dichotomy is being challenged it is still influential. As mentioned above many members of society see practical knowledge as inferior to theoretical knowledge (Hansen et al., 2002), and many school systems are still structured in ways that pit theory against practice (see for example, the description of Ontario given by Hill, 2006). It will take time and hard work to vanquish the practical/liberal divide from all aspects of society and the axiological layer of the mind.

2. Just as the sociology of knowledge can help us to understand the development of the practical/liberal divide it can also help us to deconstruct the debates about technology that are now emerging. In doing so, the sociology of knowledge could help to ensure that these debates are productive by forcing us to consider the origins of our beliefs.

Conclusions

Schwab (1972) may have been correct when he argued that curriculum studies in the 1970s were in danger of becoming moribund. The intense focus at this time, upon theory and the development of many protracted debates, detracted from curriculum studies’ ability to make a positive contribution to teaching and learning.

In spite of the many positive changes, which have happened within educational studies in the intervening thirty years, I believe there is still a possibility of curriculum theory becoming moribund; not because of an obsession with the theoretical and the neglect of the practical, nor because of a failure to ask important philosophical question, but instead because of the failure of some researchers and practitioners to seriously consider the philosophic questions raised by other theorists. Some of the pieces written in favor of liberal education, already discussed above, are good examples of this phenomenon. When scholars begin to speak past one another honest academic debate can give way to unproductive diatribes.

10 Examples of the affect of history upon a nation’s unique paths of development abound. See for example, Layton (1993) who has shown how the teaching of ‘general techniques’ in the Netherlands influenced the content of the revised technical program introduced in 1987, or Kananoja (1994) who has traced the historical impact of sloyd on the development of technical education in the Nordic countries.

11 Examples of research that raises broad, and important, philosophical questions can be seen in the work of McLaren (2003), Pinar (2004), and Apple (1990) among others.
The sociology of knowledge can help researchers to avoid this problem. Because this rather overlooked and neglected branch of sociology reveals the relationship between an individual’s understanding of reality and that of his/her society research that is informed by the sociology of knowledge cuts at questions and points to solutions. The work of Pring (1995), Hansen (2004; 1997), and Gamble (2001) are all good examples of this. By tracing the origins of the practical/liberal debate and illustrating how the underlying assumptions about the nature of knowledge are questionable at best, these scholars have pointed out the road to the end of this debate: the recognition that the dichotomy between practical and theoretical knowledge is problematic and in need of unfettered philosophic investigation.

References:


Technological Literacy – What is that?

Eva Blomdahl. Stockholm Institute of Education. Sweden
Email: eva.blomdahl@lhs.se

Introduction
The somewhat incredible technological development that has taken place during the last century has provided us with an enormous amount of new facts and data. A consequence of this sudden increase in our stock of knowledge is that today, the amount of information available to us is so great that it is impossible for any single individual to get a grip of it all. This is no less true of the total amount of knowledge pertaining to the field of technology. For this reason, a discussion has arisen as to what kind of knowledge should be selected in order for pupils within compulsory school to get a liberal education in technology. The general debate concerning learning and knowledge that has taken place over the last decades has centred on the ability to handle information, whereas one earlier tended to focus on the ability to remember information. The ability to handle and classify information, to draw conclusions as well as to perceive relations and therewith to create meaning, is regarded as central, as well as of promoting a competence that will make one able to deal with different kinds of situations in the future (SOU 1994:92; Risberg & Madsén, 1997). But what does this mean specifically for technology as a school subject? What should be included in a liberal education in technology? What kind of abilities do we think it should be possible for our pupils to acquire, so that they can live in this quickly changing world, which requires man to be flexible and able to adjust to new situations, at the same time as he also has to be able to create meaning in these unstable times? In this paper, I try to elaborate my view as to what a liberal education in technology in compulsory school could be like.

By way of introduction, I describe an example derived from the practice at school. On the basis of this example, I proceed to a discussion concerning what content and working methods are proper to technology as a school subject, where I will also touch upon the abilities and qualifications that the suggested working method might grant to pupils.

An example from school practice
The example concerns sixth grade (100 twelve-year old pupils in 4 classes) and shows how a projected change in the local environment is used as basic material in a project within the education in technology. The project was going on during a period of six weeks and was under that time documented. The collection of data consists in observations, video recordings, documentation in the form of teachers' diaries as well as pupil’s work, taped interviews with pupils and interviews with the teachers after the project was finished.

The background is that the local authorities planned to build a high-rise building in the vicinity of the school, which would change the scenery of the landscape. Various architect’s offices had delivered their proposals in the form of sketches and models, which at the time of the beginning of the project were put on display in the lobby at the District council office. The papers were full of articles and letters to the editor devoted to the issue in question, regarding the exterior and structure of the projected house as well as its expected effects on nature. The different articles were used by the pupils at the beginning of the project, in order for them to get acquainted with the current issue. In what follows, I describe how the project was carried through.

a. Formulating the assignment
The assignment was worked out together with the pupils of each class after they had acquainted themselves with the different articles, the letters to the editor and the proposals for a new high-rise building delivered by the architect’s offices. The assignment was: Design your own version of a high-rise building.
During this phase of the work, the pupils had the opportunity to develop an interest in the assignment by asking questions, noting similarities and dissimilarities between the different suggested solutions, as well as by discussing and arguing for their respective standpoints and in virtue of being open to the views of others.

b. Analysis
The work began with a visit to the site of the projected building, and at this stage one also studied the surrounding buildings with respect to their history and design, as well as reflected upon what consequences the erection of a new high-rise building would bring with it as regards man’s way of living, traffic problems, interventions in nature, etc. Among other things, one made a study on the traffic situation. Moreover, the pupils watched a film on house design from different epochs, and the film also touched upon modern house design with respect to the aspects of solidity, building-material and aesthetics. The film showing was followed by a guided tour in the city of Stockholm conducted by staff from the Swedish Museum of Architecture. Three technical systems connected with the building were examined (namely, water and drainage, electricity at home and waste management).

During this phase of the work, the pupils had the opportunity to develop their capacity to seek information from different sources (library, Internet, city architect), observe relations, and to acquire knowledge about different systems in the buildings as well as about different concepts, etc.

c. Construction/visualization
The pupils were divided into groups with two, three or four pupils in each group. At first, they tried on their own to make outlines of their versions of the house. This occurred after the teacher had given an exposition of sketch technique regarding the features of perspective, scale, front-, above- and side-view of the building. The work on the model was conditioned by: the material at hand, the scale of the model, etc. The content of the technical report (documentation), of the presentation and of the evaluation was settled, together with a general time-table for the project.

The groups began drawing up different suggestions for solutions in order eventually to be able to choose the most appropriate one.

When working on their sketches, the pupils had the opportunity to develop, among other things, their creative powers and drawing skills, as well as their capacity to present and evaluate different ideas, etc.

The models were constructed after the previously finished sketches had been discussed and revised within the groups. The pupils were also briefed on different materials, how to fasten things together, tools and aesthetic presentation in connection with model construction.

When working on the models, the pupils had the opportunity to develop their capacity to make use of technical principles and appropriate tools, to choose and use suitable material for the model, to make use of scale, to construe models and to think in three dimensions.

When the work was finished, the pupils could simulate the townscape with the help of PhotoShop and with the group model fitted into it. Each pupil also got to document the finished work in the form of a technical report. The report included sketches, pictures of the finished model, a description of the working method, a description of the technical system and history of one of the buildings, as well as personal reflections on the project.

When working on the technical report, the pupils had the opportunity to develop their capacity to sort out, structure, complete and summarize the material, to write, to use the computer as a tool for presentation, to reflect upon their work and to suggest possible improvements.

The models were put on display at school together with the technical reports. Moreover, the pupils presented their models to the class and also to a wider audience, namely as the school on one occasion kept open house and invited parents, members of the District council and news reporters. The pupils’ dedication to their work was later noted in the press.
d. Evaluation/Reflection

When the work was finished, it was evaluated together with the pupils. They proved to have gained an understanding of what the house meant to man and his life in general, as well as of how it had developed historically. They had also gained an understanding of one or some of the technical systems connected with the house. Moreover, they understood and were familiar with concepts such as “architect”, “construction”, “foundation”, “frame”, “window”, “roof”, “roof truss”, “building material”, “community planning”, and they had also acquired an insight into the effects the house would have on nature and on the city environment.

The pupils were proud of their work but expressed self-critique as regards their model constructions. They knew what changes they would make if they ever were allotted the assignment again.

The pupils had also developed their ability to plan, organize, work systematically, cooperate and to be patient.

But reflection also took place both before and during the work (see above).

Shaping of Technology

If we now regard this example from school practice as containing an idea concerning what content and working methods should be included in technology education within compulsory school in order to provide the pupils with a liberal education in technology, we could summarize the procedure followed in the realization of the project in the following way:

You take your point of departure from such technology that happens to be available in your local environment, which also constitutes the pupil’s reality, where the pupil’s experiences and interests make up the point of departure for the choice of artefact or technical system (the place with different artefacts and technical systems). In the example above, this choice concerned a high-rise building that was about to be erected in the local environment. By employing technology available in the local environment as learning material, it also becomes natural to use the place as a space of learning. The choice between different artefacts or technical systems that the teachers and pupils are facing must take into account the age and interests of the pupils, as well as local conditions. The teaching process (The process of shaping of technology) is initiated as an assignment is drawn up by teacher and pupils together. In the example, the assignment was to model one’s own version of a high-rise building. The pupils acquire knowledge about the current assignment. Each assignment presupposes a penetrating analysis of the product’s or the system’s development, function, constitution, as well as of the advantages or disadvantages as regards its effects on nature, the society and the living conditions of the individual. Different perspectives may here serve as tools for the teacher and the pupils with which to direct the analysis so as to situate the technology in question. Within the analytic phase of the work, they may analyze the learning material in the following different ways:

- from a perspective centring on the history of development, which may grant to the pupils an opportunity to understand different driving motives behind technological development,
- from a system- and component-based perspective, where studies on single technical solutions and their place within larger systems may give the pupils the opportunity to acquire important insights into the specific character and conditions of the technology selected,
- from a functional perspective, which can provide the pupils with the opportunity to achieve an understanding of and familiarity with technology and technical principles, namely, by studying and practically testing how different techniques or technical solutions are construed and how they work, as well as what function they have in our society,
- from a technological perspective that also includes the aspect of lasting development. “Lasting development” refers to an appropriate use of technique, which consists in: improving, recycling, being economical with resources, material and energy,
from a perspective centring on technology, man and the society. In order to understand the role and meaning of technology, the interplay between human needs and technology has to be elucidated. This perspective throws light on the consequences and effects of the use of some specific kind of technology as far as both the individual and the society is concerned.

The third phase is visualization/construction of one’s understanding with the help of sketches, descriptions, models, documentation and simulations, which thus reveal the pupil’s understanding. At the same time as the pupil’s understanding becomes visible, the teacher gets a basis for evaluating the pupil’s way of creating experiences.

Before, during and after the work has been completed, the pupils are given a chance to reflect. Finally, reflected experiences issuing from that shaping process of technology that has been carried through are taken to the next technology project.

When the place is situated within the entire process of shaping of technology, the resulting model can look like this:

In order for the above didactic model to give a fair picture of shaping of technology, it should be made clear that the different phases included in it do not illustrate any “step-by-step”-action. The danger with this kind of simplified model is that it may mislead the reader into believing that shaping of technology is a linear process, when it in fact rather consists in a kind of oscillation between analysis, visualization/construction and reflection.

Understanding is something that evolves over time. These pupils had worked for two years in a similar fashion on projects within other technological areas and were rather familiar with this way of working. That is to say, during their time at school they had improved their ability to work in projects. The teachers in the present example were functioning mainly as supervisors. However, when one tries to carry through technology projects in earlier grades, where the pupils for obvious reasons are not yet capable of this way of working to the same degree, the teacher’s role is different. Here, the teacher is more of a co-constructors who within the project explores the environment, in this case the technical environment, together with the pupils (Dahlberg et. al., 2001). But the goal is the same, that is, to develop the pupils’ ability to work in projects and to make sure that the pupils gain an understanding concerning the technology related to the place.
Hence, “shaping of technology” refers to the visualization or presentation of artefacts and systems of artefacts for the purpose of understanding them. Shaping of technology is a process that generates knowledge in which theory and practice are interwoven. In the actual course of teaching technology, the shaping process is reminiscent of the modelling working method employed by the engineer, the industrial designer and above all the architect. The architect does not build the house himself, but in the models and drawings which he supplies for future production there is much knowledge embedded. The projected house should be suitable for man, fit into the surrounding nature, stand the climate, fit into other buildings typical of the period, etc. Unlike the architect, however, the pupils will not invent, create or develop usable technical products but instead through analyses based upon different perspectives as well as upon physical models, sketches, simulations, documentation, etc., seek to understand the genesis and function of technology, as well as its effects on man, nature and our society. I have elaborated the philosophical foundation for this way of thinking about the content and working methods within technology education in previous articles (Blomdahl, 2005; 2006).

Goals for technology as a subject in compulsory school
The goal that should be set for technology as a subject in compulsory school is thus, as I see it, that of developing a technological awareness concerning technology in the local environment. By consequently working with different perspectives on one and the same learning material, the content is organized so as to provide a more holistic (general) view of the selected technology. These perspectives concern specifically technical knowledge about the design and mode of operation of artefacts, as well as their function within technical systems, but also knowledge about the way in which technology has evolved over time, as well as about the interplay between technology, man, the society and nature. Technological awareness also involves an understanding of technological concepts connected with the chosen technology, and is central to the understanding of our technical environment. During the years in compulsory school, different technological areas are dealt with, which means that in one sense at least, it is possible to say that the pupils’ understanding will grow and expand.

Another goal for technology as a school subject is in my view that the pupil should develop his or her ability to work in projects. During the years spent in compulsory school, however, the pupils are in need of much support in order to develop their ability to work in projects, but this ability is one that will be useful for them in the future, both at work and in connection with higher education. By working with projects where tasks of solving problems to which no previously fixed solutions are available, the pupil may develop a technological way of thinking. That is to say:

- a practical thinking concerning how to solve problems, use relevant material, tools and technical principles in connection with modelling. At the same time, the pupils also have the opportunity to understand the technology of their local environment.
- a visual thinking that involves displaying one’s understanding in the form of sketches, simulations, three-dimensional models, and also understanding the ideas that others are communicating. At the same time, the pupils also have the opportunity to understand the technology of their local environment.
- an innovative (creative) thinking because there are different solutions.
- a conceptual and analysis/synthesis thinking, an ability to express one’s understanding with the relevant concepts, to observe relations, etc. (Franus, 2000).

The pupils are also given the opportunity to develop their communicative powers, e.g. in the form of sketches, images, models and with the help of computer technology. These capacities are thus developed at the same time as the pupils are attaining an understanding of our technological environment.

On the basis of the above example from school practice, I am thus finally able to state what I see as central parts of technological literacy for compulsory school,

- technological awareness within various technical areas
ability to work in projects and on problem solving
ability to communicate one’s thoughts and ideas with the help of different presentation techniques, such as speech, writing, sketches, images and models, both manually and digitally

The parts I have emphasized as essential to grant to the pupils the opportunity to acquire within technology as a subject in compulsory school are hopefully useful tools with respect to future work.

Summary
The aim of this paper has been on my part to give a contribution to the discussion concerning the nature of technological literacy. On the basis of an example borrowed from the practice at school, I have described how I regard the content and working methods of technology education, and what abilities and qualifications I think are worth focusing on when teaching technology. I conclude the paper with a quote from the writing Foretagsamma skolan, SAF (Risberg & Madsén, 1997, p. 21), regarding what one within the industry regards as central to develop in pupils within compulsory school, which in connection with the subject of technology would be precisely technological literacy.

A school that shall create an enterprising spirit as well as conditions for lifelong learning has to be based upon “problems that seek knowledge”! If the school is to provide its pupils with a human competence that grants to the individual an ability to cope with the role as a citizen in a complex society, this means that the school has to create situations where the pupils are able to develop this competence. Situations that provide conditions similar to those pertaining to life outside school. The task of the school will be to develop forms for supporting the pupils’ efforts at taking hold of these situations.

References


How does Technology Education stand in Latin America today? A Report on an International Project

Haris Papoutsakis. Technological Education Institute (TEI) of Crete. Greece
Email: harispap@career.teicrete.gr

Abstract
It was only a few years ago when the concept of Technology Education (TE) emerged in the curricula of certain Latin American countries. This article is an attempt to answer the question of its own title and comes as a by-product of a project financed by the European Union. The project, aiming to the harmonization of the different training courses used for the training of TE teachers and their instructors, has been carried out by a European and Latin American inter-university network. The results have been published in a book available in English, French and Spanish. This article reports on experiences related to TE and Vocational Training (VT) in the four Latin American countries participating in the project, and attempts to draw some conclusions, on the status of TE and VT in LA, today.

1. Introduction
This article was prompted by an international project, financed by the European Union (EU) through its ALFA programme. ALFA stands for America Latina Formación Académica and it was under the ALFA framework that an inter-university network for the initial and life-long learning of the teachers of the Technology Education (TE) discipline was created. The RIUFICEET network (from its French acronym) was initiated by the Institute Universitaire de Formacion de Maîtres (IUFM, Marseille, France), and brought together universities and research Institutes from eight countries: four from Latin American (LA) and four from the European Union (EU). This resulted to a total of ten partners, namely the:

- Instituto Universitario de Formacion de Maîtres (IUFM, Marseille, France)
- Technische Universitat Braunschweig (TUB, Braunschweig, Germany)
- University of Central England (UCE, Birmingham, United Kingdom)
- Technological Educational Institute of Crete (TEI, Heraklion, Crete, Greece)
- Programa Interdisiplinario de Investigacion en Educaciones (PIHE, Santiago, Chile)
- Universidad de Concepción (UC, Concepción, Chile)
- Universidad de Ancama (UA, Copiapó, Chile)
- Universidade da Regiao de Joinville (Univille, Joinville, Brazil)
- Universidad Peruana Cayetano Heredia (UPCH, Lima, Peru) and
- Universidad Pedagógica de El Salvador (UPES, San Salvador, El Salvador).

The ten partners of this EU-LA network worked together for a two year period (February 2004 to January 2006) in order to carry out the first phase of the project aiming to the harmonization of the different training courses used for the training of TE teachers and their instructors. They have also taken certain steps in order to prepare the ground for the second phase of the ALFA project, expected to be announced by the European Commission in the first quarter of 2007. This second phase is aiming to the creation of an inter-university exchange and research network, in the same area (European Commission, 2004).
This article reports results and specific highlights of the RIUFICEET project, as captured and assessed by the author. We would like to declare that by no means does it reflect any official EU assessment or even the collective project findings. In the next session, Technology Education and Vocational Training (VT), the focus point of the project are briefly outlined. In section three, the background and the objectives of the project are presented. Section four, the nucleus of the article, portrays the author’s Latin American experience, indubitably from his European point of view. Finally, from the same point of view, conclusions are presented in section five.

2. Technology Education and Vocational Training for All

Although this article has a limited theoretical perception, we consider that the issues of Technology Education and Vocational Training need to be briefly presented in order to enable the reader to comprehend the experiences presented in it. We shall build this section upon the pioneer work of the researchers Clare Benson, Marc de Vries and Jacques Ginestié listed here in alphabetic order. J. Ginestié coordinated the project reported in this article; C. Benson actively participated in it as the UCE partner, while all three were part of the team which organized a series of introductory lectures on TE during the pre-ALFA phase, in Chile, in the year 2000.

For over twenty years, many countries have been setting up programmes of technological education for all, adopting, to a certain extend, the UNESCO’s recommendations delineated during a number of international conferences, starting with the one in Paris in 1982. Equivalent to any education, technological education is inscribed in the perspective of a school that aims at turning children into citizens (Benson, C., de Vries, M., Ginestié, J., et al, 2001). The term technology education (TE) is increasingly being used throughout the world to define and describe curriculum organizations that can be assimilated within a subject (Ginestié, 2005b, p. 8). During the last ten years an increased number of countries around the globe have included courses of TE in their national or regional educational programmes. LA was not an exception, with Chile being the pioneer. As noted in many EU countries, in LA likewise, TE courses have inherited from different forms of pre-existing classes such as manual work, professional techniques, domestic education or the application of sciences (Ginestié, 2005b, p. 8).

During the last ten years, many countries have paid increased attention to the development of a Vocational Training infrastructure that addresses almost every profession and level of qualification (Busetta, 2000; Ginestié, 2000; Oskarsdottir, 2000; Papoutsakis, 2000). And as it is very sharply stated by Jacques Ginestié, to look into vocational training is to watch the life of a society under a particular point of view, but an essential one; to view vocational training is to view the development of a society (Ginestié, 2006). The main characteristic of Vocational Training is that it is a multi-phase process, in which more parties are involved than in traditional education. These parties, in most cases are employees, Trade or Industrial Unions, the federal and regional governments.

 Properly developed Vocational Training has lead to the creation of new professions. For example, the combination, through VT programmes, of three preceding professions (Electrical Engineer, Electronic Engineer and Computer Scientist) gave birth to three new professions: Systems Engineer (hardware or software), Industrial Computers Engineer and Electronic Service Engineer. The latter, came as an answer to the consumers’ need for service of every-day electronic appliances from ‘one single hand’. Efforts to offer a vocational training for all, during compulsory schooling or at one point in every individual’s life-long course of study, reveals many difficulties, i.e. introducing the appropriate training programme and, what is more, stabilizing it.

Although the development of technological education and vocational training for all is very essential, the connection between technological education and vocational training is not exactly self-evident in every country. Developments in several countries over the last twenty years show that the position of TE in the educational landscape is not well defined yet (Ginestié, 2005b, p. 9). As obvious differences,
very often referred to as strong opposition, are noticed even among European countries, we shall come back to this issue, from a Latin American perspective, in our conclusions section.

3. The ALFA Project

Early on, upon deciding on our project’s strategy, we had agreed that we were not about to conduct an independent, autonomous and solidly anchored study of the technology education systems of the four Latin American and four European countries involved. We built our methodology based on the idea that both European and Latin-American partners have a lot to learn from each other and we decided to seek answers to the above stated questions. The eight partners in this project have each implemented their own systems for initial and life-long teacher training in TE and VT. Long before 2003, the four European universities had been working towards the direction of harmonizing the TE curricula and the relevant teacher training organizations. Progressively, this European network opened itself to Latin America. Exchanges of experts had already taken place, for example for the organizing of a series of lectures in Chile, to boost the introduction of TE courses to all students in secondary schools.

For the new EU-LA network to be successful, a long lasting cooperation, allowing the emergence of shared investigation projects, had to be established. First, we agreed upon the research axes to be used as contextual bases for exchange between researchers, teachers and students. Then, a lot of effort was made to optimize the institutional relations among the partners, so that they could structure their own fundamental or development research projects, under this new, cooperative perspective.

Phase one of the EU funded ALFA project dealt exactly with the establishment of networks, and the “RIUFICEET” project was included in this programme under the heading “development of initial lifelong learning organizations for teachers of technology education in academic and vocational training” (Martinez at al, 2003). Its objectives were to:

- Initiate a comparison of the organization of courses in technological and vocational education, in the different countries belonging to the network, in order to harmonize the different training courses for trainee teachers and/or their instructors.
- Establish cross-research in order to develop educational modules for trainee teachers and/or their instructors so as to harmonize the training courses among the participating universities.
- Compare assessment practices concerning students, trainee teachers and/or their instructors.

At this point in time, when phase one has been completed, the tangible result of the RIUFICEET project is a book, a collective work coordinated by Jacques Ginestie (2005a). In the first part the book presents a general description of the organization of TE in each country and in the second it provides a detailed description of the TE teachers’ training together with an exemplary module of a certain TE teachers’ training course for each of the partner institutions. The following section of this article exhibits some personal experiences, together with TE-oriented highlights gathered during the two extended RIUFICEET seminars and visits to Latin America.

4. The Latin American experience

Within the RIUFICEET project, two visits in LA and two more in EU were conducted. Each visit had a duration of two to three weeks and was structured in a way that provided time for a seminar in the main host country and visits to the partner universities in other countries. In every country, visits to technical colleges and vocational training organizations of particular interest were organized by the host partner. This article reports experiences from the four LA countries visited (Chile in 2004, Brazil, Peru and El Salvador in 2005) and we hope that one of our Latin-American partners will do the same, regarding his/her EU experiences.

4.1 Chile

TE in Chile is a separate and obligatory subject throughout the first ten years of general schooling. There are approximately 18,000 TE teachers in both primary and secondary schools, but only a small number are members of APETECH, the National TE teachers’ Association. This outstanding figure is
outshined by another extraordinary fact: only five per cent have received some kind of training in teaching TE courses, while for the rest the only guidelines are the curriculum and the syllabus developed by the Ministry of Education (Elton et al, 2005).

The Programa Interdisciplinario de Investigación en Educaciones (PIIE) was our host partner in Santiago de Chile. PIIE was the first among our LA partners to develop relations with EU as it had earlier been the host of the first series of lectures in 2000. Besides PIIE, two regional Chilean Universities, the University of Concepción and the University of Atacama, participated in the project. Visits to a number of technical colleges in all three regions (metropolitan Santiago, Araucania and Atacama) were suitably arranged.

In the Colegio Carlos Oviedo in Maipú, a low working class neighbourhood in the suburbs of Santiago, we experienced an unexpected situation. The school provided evening classes for those of its parents who lacked basic education, technological or general. The 5th grade TE class we attended dealt with a sophisticated issue: packaging design and the effect of publicity on consumers’ attitudes, using only basic material, scissors, paper and glue. In a more affluent school, the Liceo Industrial Victor Besanilla, which belongs to the Cámara Chilena de la Construcción, TE courses and laboratories were offered to its secondary level students in classical areas of training i.e. carpentry, mechanics, computers, etc.

In the region of Araucania, the host University of Concepción arranged a very interesting agenda that included visits to both traditional and special schools. In Concepción, in two secondary schools Liceo Industrial de Lota and the Colegio Salesianos TE courses and labs were geared around the traditional areas of mechanical, electrical and metallic constructions. After a four hour bus trip we visited two very distinct schools at the highlands of the Altos de Biobio: the Micro Centro Callaki, a traditional Mapuche school and the Colegio Ralco Lepoy, a Spanish-Mapuche bi-cultural school. There again, TE courses were geared around the very basics (knighting, paper-collage, etc.) but the Mapuche students, supervised by their teacher during the TE class, prepared and cooked their own meals on kūtral (open fire), according to the long lasting traditions of the Mapuche tribe in a wooden shed out in the school yard. This, we were told, is a daily practice.

Finally, the third host University, of Atacama, prepared an agenda that best demonstrated the existing variety of technical schools within the Chilean TE system. In Copiapó, we visited three Technical schools and each one of them demonstrated some exceptional feature. In the Liceo Politécnico “Belén” the young female students had organized a Technological Exhibition for the end of the academic year, where they demonstrated a noteworthy variety of products and handicrafts, with emphasis on the product’s appearance. In a similar exhibition¹ organized by the students of the Escuela "Isabel Peña Morales", the emphasis was on simulating the real product’s operation and it included from simple windmills to traffic light controls and wind-run pumps. The young pupils played active roles in their own Microempresa Infantil (Pupil’s Mini-enterprise) some of them still dressed in the costumes of the amazing multi-performance they had prepared as a welcome to the visitors of the ALFA group. Finally, boys and girls of the Liceo "José Antonio Carvajal" had fully undertaken the construction of an entire house (bricks, wooden roof, windows etc) for a five-member family in a working class suburb of Copiapó. A lot of materials had been pre-fabricated in the TE lab of the high school and installed on the site.

¹ By coincident, both EU partners’ visits to LA were organized during the month of November, the last month of the academic year in the south hemisphere. Thus, we benefited from visits to Technology Exhibitions organized for the end of the academic year in a number of schools, which gave us the opportunity to observe the results of the TE projects that had been running in each specific school throughout the year.
In Caldera, Copiapó’s seaport on the Pacific, we visited the Granja Marina Colegio Parroquial “Padre Negro”, an elementary and high school level Marine College, where the high-school students took full care of the marine farm, growing sea shells and looking after the labs supporting it. They steered the school speedboats to the shell fields, they arranged nets and checked chemical analysis levels. Back in Copiapó, we visited to the Escuela Técnico-Profesional (Vocational Education High School) where the University of Atacama, runs a programme to train TE teachers for the elementary school level (grades 5th to 8th). The programme applies the methodology of Problem Based Learning and the core of the curriculum is focused in activities developed by the students in a learning environment with instructional material arranged around technology modules, i.e.: construction technology, transport, communications, materials science, etc. With the use of a computer and the instructional material a couple of students work together in each module, learning from each other, from their classmates and from the professor, who acts as a ‘learning facilitator’ for the students. This particular methodology for teaching TE resulted from an agreement between the University of Atacama and the Colorado State University in the USA.

4.2 Brazil
As one can gather from the RIUFICEET project’s book (Ginestié, 2005a) TE in Brazil is organized under a totally different perspective. Although there is very little foreseen in the National curricula in respect to TE courses in primary or secondary education, there is a real revolution in the way professional and vocational training have been organized. The Brazilian Professional Training System has been built, both by the state and the private sector, to guarantee that well trained people will staff the Brazilian industry. The so called S System includes SENAI for industry, SENAC for business, SENAT for transportation and SENAR for agriculture, among others, and has very strict objectives (Buschle, 2005). SENAI’s objective, for example, is to promote professional and technological education, innovation and the transfer of industrial technology in a way that will increase the competitiveness of the Brazilian industry (SENAI, 2006).

Our host in Brazil, the Univille University of the Joinville Region in Santa Catalina, arranged for us to visit a number of both private and public training organizations during November, 2005. The TUPY, a private technical school, and SENAI and CEDUP, the two public schools visited, were really impressive. The SENAI campus was outstanding, not only from the technological infrastructure point of view which was comparable to that of many European universities or Technical Colleges, but also for the sport and leisure facilities made available to its students. This may be partly explained by the fact that SENAI, a public school, is associated and co-financed by the Chamber of Business & Commerce (Empresariado do sector).

4.3 Peru
TE in Peru is defined by law as Productive Technical Education (PTE). It is a ‘type of education’ oriented towards the acquisition of professional competences and is intended both for people who want to enter into the labour market and students of Basic Education. It is exactly these last five words that relate TE, as it is understood in Europe, to Peru’s PTE. Only the Universidad Nacional de Educación Enrique Guzmán y Valle (UNEEGV), located in the outskirts of Lima, offers a teacher degree in the specialty of Education in Technology. The qualifications that prospective teachers obtain at UNEEGV are much more oriented towards the technical specialty they shall teach rather than towards any pedagogical aspects. The UNEEGV graduates are entitled to teach either in the Basic Education or in one of the mainly private Technological Superior Institutes (TSI) awarding non-University diplomas (Rodríguez, 2005).

During our visit in Peru our host, the Universidad Peruana Cayetano Heredia (UPCH), arranged for us two visits. In the highlands of Cusco, the Vallejos Santoni Technical School founded and initially equipped by a Swiss priest, is still supported by European religious funds. Despite the remoteness of Cusco and the limited funding of the school, a variety of TE courses and labs were organized in the traditional areas of sewing, shoemaking and carpentry. In Lima, we visited the SENATI (Servicio
Nacional de Aprendizaje en Trabajo Industrial) one of the four state education institutes co-funded and managed by the relevant private sector. Here again, like in Brazil, the campus and the infrastructure were of very high standard.

4.4 El Salvador

El Salvador is a small Centro American country, where TE is organized under a totally different perspective, as indicated in the RIUFICEET project’s book (Ginestié, 2005a). Technical education is offered by Technical Colleges and Technological Institutes aiming to train professionals and technicians in the application of knowledge and skills in different scientific and humanities areas. Technological careers are offered in two areas: Production Engineering (i.e. civil and construction, industrial, electrical and electronic, agricultural, etc.) and Administration (i.e. teaching, social work, commerce, nursing, etc.). Technological degrees are awarded after two or three years of studies, while University degrees, in similar areas require four or five years of studies (Larios, 2005).

During our visit in El Salvador we had the opportunity to visit the annual Technological Exhibition organized by our host, the Universidad Pedagógica de El Salvador (UPES). Students from a private secondary school, where teachers of the UPES who study for the degree of Licenciatura en Ciencias de Educación do their teaching rounds, exhibited a variety of self-made products and a number of panels explaining natural phenomena. Here, emphasis was given on simulating a real life operation of the products exposed (i.e. eggs were cooked in a solar oven, and a boat, powered by a candle, was sailing in a water canal). In San Salvador, we visited the Instituto Tecnológico Centro Americano (ITCA), the most popular of the nine that exist in the country, with 3,500 students. Despite the obvious difference in size between El Salvador and Brazil or Peru, ITCA ranks quite high in terms of both technical and administrative infrastructure.

5. Conclusions

The answer to this article’s question ‘How does Technology Education stand in LA today?’ is neither simple nor uniform, for the four LA countries under consideration. TE and Vocational Training are very often mistaken or used the one in the place of the other as concepts, state policies and educational practices in LA. A large diversity of state or private organizations offering technological education, and an even larger diversity of training programmes has been noticed in the four LA countries visited during the years 2004 and 2005. Evidently, this affects the status of these organizations as well as of the teachers and professionals graduating from them. The issue is not irrelevant, to a smaller extend though, regarding certain European countries.

Chile is the LA country of the RIUFICEET network that has made the most significant steps towards introducing TE in its national curricula. The fact that the Ministry has included TE in the national curriculum, developed syllabuses and has employed 18,000 TE subject teachers is positively reflected on our findings. Sophisticated TE courses in schools that lack the resources; adaptation of the TE curricula to the indigenous culture; end of the academic year Technological Exhibitions where both simple and advanced products are exhibited and pioneer ideas, like the Microempresa Infantil, flourish; a TE class that undertakes the entire construction of a house; the high cost investment of the Marine College and advanced teaching methodologies, as a result of an international cooperation, are some of the highlights of our Chilean experience. As our Chilean hosts filled-up our agenda with TE-oriented visits, there is little we can say about the country’s stance on VT. Additionally, the impression we gathered from the Vocational Education High School of the University of Atacama, though, is a very promising sample.

Brazil, and Peru to a certain degree, appear to have invested more in VT than in TE. Brazil’s Professional Training System and the Peruvian Productive Technical Education have as their main objective to provide well trained personnel for their national industry but, in parallel, they promote innovation and the transfer of industrial technology in a way that increases the competitiveness of their local industry. Thus, the two nations at least partly fulfil the basic social principle by offering, at least
to the citizens of Lima and those of certain industrially developed Brazilian regions, some kind of vocational training at some point in their course of studies. The two national systems have many things in common as they are both built upon the apprenticeship idea (of the German technological education system) and even use similar acronyms for their industrial training organizations: i.e., SENAI in Brazil and SENATI in Peru. Brazil ranks first in excellence of public and private technical schools, while Peru has lately made a significant effort to introduce TE courses in basic education. The example of the Cusco technical school is self evident and, as indicated by the principal, there are other schools seeking international cooperation in order to acquire the equipment necessary for adequate TE labs.

El Salvador, the Centro American country with only a few peaceful years in its recent history, stands very well in VT infrastructure and has, at the same time, made the necessary steps for the implementation of TE in basic education. We have to admit, though, that the basic social principle partially fulfilled in the other three countries, has not yet been seriously tackled in El Salvador. Although it is not faire to compare it with countries of much larger size, more prosperous economy and less historical unrest, we have experienced that most of the indicators used for the other three LA countries (i.e., the Technological Exhibitions and the Technological Institutes visited) stand very well for El Salvador, too.

And a final conclusion drawn from our overall Latin American experience: The way TE and VT have developed in Chile indicates that in countries where the state has taken the necessary measures, the results are rewarding. Looking at Brazil we may say that a properly developed VT system can balance, at least as far as the current industry’s needs are concerned, the shortage of TE in the basic educational system. The example of these two nations shows the way to Peru and El Salvador towards a sustainable TE and VT development for the benefit of their national education systems, their economy, the wellbeing of their people and, why not, the preservation of their culture.

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Creativity as a feature of technological literacy

David Barlex. Brunel University, Uxbridge, UK
Email: dbarlex@nuffieldfoundation.org

Introduction
The aim of this paper is to show that creativity as manifest through designing can be an important feature of technological literacy and that intellectual tools used to enhance student’s creativity in designing are also useful for enabling them to be constructively critical of the way technology plays out in society. To achieve this aim the paper is divided into five parts. The first part will consider the place of designing within technology education, describe features of creativity as outlined in the report 'All Our Futures: Creativity, Culture and Education' (Robinson 1999), and demonstrate that designing can be seen as a creative activity. The second part will justify how the act of designing can be construed as making a range of interrelated design decisions and develop a model that can be used to describe how the design activity of school students can be considered in terms of making such decisions. It will also consider briefly the spontaneous and scientific knowledge that students may have acquired and how their interaction, as orchestrated by the teacher, may support making design decisions. The third part will describe the conditions needed for creativity as revealed by a joint Nuffield Foundation and Qualifications and Curriculum Authority investigation and demonstrate how the work of the Young Foresight project meets these conditions and enables pupils working collaboratively to make conceptual design decisions. The fourth part will consider some of the implications of collaborative creativity and the importance of pedagogy in supporting creativity. The fifth part will revisit the tools for creativity and demonstrate how students can use them as evaluative instruments to probe the interaction between technology and society. The conclusion will consider the role of these tools in broadening the scope of technology programmes as a means of achieving technological literacy.

Designing and creativity
In design & technology lessons in England the main aim of the curriculum experience is to engage the student in “doing” technology: “the pupil is transformed from passive recipient into active participant. Not so much studying technology as being a technologist” (Kimbell & Perry, 2001, p. 7). In the classroom “being a technologist” is achieved by completing designing and making activities. Designing lies at the heart of being a technologist for the student, as it is the designing that sets the agenda for the making. The report 'All Our Futures: Creativity, Culture and Education' (Robinson, 1999) argues that a national strategy for creative and cultural education is essential to unlock the potential of every young person. It saw creativity in terms of the task in hand as having four features:

• using imagination;
• pursuing purposes;
• being original;
• being of value.

Although to many it is obvious that designing is a creative activity it is necessary to establish the relationship between creativity and designing. Nigel Cross (2002) has considered the nature of designing in two ways. From a brief review of designers on designing he clarifies what designers do:

• produce novel, unexpected solutions
• tolerate uncertainty, working with incomplete information
• apply imagination and constructive forethought to practical problems
• use drawings and other modelling media as a means of problem solving (Cross, p. 127).
From a review of studies of designing he summarises the core features of design ability as compromising the ability to:

- resolve ill-defined problems
- adopt solution-focusing strategies
- employ abductive/productive/appositional thinking
- use non-verbal, graphic/spatial modelling media (Cross, p. 131).

How does Cross's view of design activity and ability relate to creativity as described in the Robinson Report? Producing novel, unexpected solutions can be seen to correspond to being original. Applying imagination and constructive forethought to practical problems can be seen to correspond to both using imagination and being of value. Using drawings and other modelling media as a means of problem solving can be seen to correspond to pursuing a purpose. Resolving ill-defined problems can be seen to correspond to pursuing a purpose. Adopting solution-focusing strategies can be seen to correspond to being concerned with value. Employing abductive / productive / appositional thinking can be seen to correspond to using imagination. Using non-verbal, graphic/spatial modelling media can be seen to correspond to being imaginative and original.

This brief analysis shows clearly that design activity and design abilities match the view of creativity as expressed in the report 'All Our Futures: Creativity, Culture and Education' (Robinson, 1999). However, whilst it is likely that the activities of professional designers as described by Cross will be creative this begs the question as to the classroom conditions that will enable children, who are fledging designers (Trebell 2006), to design in a creative way.

According to Buchanan (1996), designers are challenged to conceive and plan what does not yet exist. This activity is complex, and a designer must attend simultaneously to many levels of detail and make numerous decisions as he or she designs. Ropohl (1997) has further described this activity as requiring:

[The development and design of] a novel technical system, anticipat[ing] the object to be realised through mental imagination. [The designer] has to conceive of a concrete object which does not yet exist, and he [sic] has to determine spatial and temporal details which cannot yet be observed, but will have to be created by the designing and manufacturing process. (p. 69)

In moving the design activity from the arena of the professional into the classroom, it is important to develop a description of the activity that reveals how the teacher might teach this activity and how students might carry it out. “Conceiving … what does not exist” (Buchanan, 1996) and “developing and designing a novel … system” (Ropohl, 1997) indicate that students will, on occasion, be required to make conceptual design decisions. “Developing and designing a … technical system” (Ropohl) indicates that students will need to make decisions about the way their design will work, that is, make technical design decisions. “Spatial and temporal details which cannot yet be observed” (Ropohl) indicates that students will need to make decisions about the appearance of their designs, that is, aesthetic decisions. Finally, “created by the … manufacturing process” (Ropohl) indicates that students will need to consider how they will make their design, that is, constructional decisions.

Product designers have commented on how important it is to consider the user when developing design proposals. For example, Jonathan Ive, the designer of the iPod states, “the design of an object defines its meaning and ultimate utility. The nature of the connection between technology and people is determined by the designer” (Qualifications and Curriculum Authority, 1999, p. 14). This indicates that some of the decisions made by students should be informed by a consideration of the user. As these considerations will be broader than any one group of users, such considerations are perhaps better described as market considerations. This indicates that students will need to make decisions related to the market for their product.
Decisions in these five domains (conceptual, technical, aesthetic, constructional and marketing) are not made independently of one another, for as Buchanan (1996) states, “[design] activity is complex [and] a designer must attend simultaneously to many levels of detail and make numerous decisions as he or she designs.” Hence, Barlex (2004) has suggested that these areas of design decision can be represented visually, with each type of design decision at a corner of a pentagon and each corner connected to every other corner. This is shown in Figure 1.

Figure 1. The design decision pentagon

This interconnectedness is an important feature of making design decisions. A change of decision within one area will affect some, if not all, of the design decisions made within the others. For example, a change in the way a design is to work will almost certainly affect what the design looks like and how it is constructed. It may also have far-reaching effects in changing some of the purposes that the design can meet and who might be able to use it. One can envisage a student making a series of “What if I did this” moves (Schön, 1987) as he or she considers possible decisions about a feature and its effects on decisions made or yet-to-be-made about other features. This interconnectedness reflects a constructivist reflection-in-action paradigm for the student considering the process of designing as a reflective conversation with the situation (Dorst & Dijkhuis, 1995). The use of “What if I did this” moves is more than a mere ad hoc tool to cope with the complexity. Its repeated use also increases the designer’s understanding of the issues, thereby informing, guiding and stimulating further designing both within and outside the given design situation (Schön & Wiggins, 1992). It is, in effect, a powerful learning tool that the designer uses to learn about the design proposal as he or she is creating it (Sim & Duffy, 2004).

**Design decisions and student’s spontaneous and scientific knowledge**

To what extent does the ability to make design decisions depend on spontaneous concepts as opposed to scientific concepts or a judicious mix of the two? In Vygotsky’s (1934/1986) model of cognitive development, the aim for the teacher, in general terms, is to support the student in developing a coherent body of understanding in which any conflicts between previously acquired spontaneous concepts and recently taught scientific concepts are resolved. There can be little doubt that students acquire a wide range of spontaneous concepts with regard to areas of knowledge and understanding needed to make some design decisions. Students are surrounded by and immersed in a wide variety of sophisticated visual and aural media. The teacher should expect and even demand interesting and perhaps controversial aesthetic design decisions based on spontaneous concepts derived from this
arena of popular culture. It will also be important for the teacher to teach formal ideas concerning aesthetics and techniques of presentation so that students aren’t reduced to knee jerk acceptance and mimicry of whatever is currently in vogue. In making technical design decisions the situation is slightly different. Young people use a wide variety of technical artifacts and are familiar with what products can do. They have learned spontaneously ‘what can be done’ by simply using the products. However this understanding does not encompass how ‘what is done’ is achieved i.e. how something works, although there is clearly a strong relationship between these two ideas. So in supporting students in making technical design decisions it will be important for the teacher to help pupils relate their knowledge of what things do (spontaneous knowledge) to how they might work (scientific knowledge). The way things are made has changed radically over the past 25 years. The advent of computer aided design linked to computer aided manufacture has made it possible to make items impossible, or at least extremely difficult, to make by conventional hand and machine tool techniques. So it is often the case that students in school have little in the way of spontaneous knowledge about the way things are made. However, this manufacturing technology is easily used by non-professionals as has been demonstrated many times over by Neil Gershenfeld at MIT (Gershenfeld 2005). Here he runs a course called “How To Make (almost) Anything” open to graduate students from all disciplines. The students could, and did, make (almost) anything they wanted – motivated by their desires rather than curriculum imperatives; the result of this was that, apart from making them aware of the equipment available and its capabilities, Gershenfeld was unable to construct a taught curriculum for the course. Instead the learning process was driven by the demand for rather than the supply of knowledge. He describes this as ‘just-in-time’ learning and contrasts it to the ‘just-in-case’ model that dominates traditional educational systems. The manufacturing technology that was once available only to industry is now becoming available in schools. Here is an interesting challenge for our pedagogy based on two sorts of knowledge. The students will be speculating along the lines of “Can I get it (the manufacturing technology) to do this?” based on the design decisions they have so far made about the nature of the product they are designing. The teacher will need to scaffold their growing understanding of the capabilities of the manufacturing technology in relation to the requirements of their overall design idea.

Students are exposed to a wide range of advertising, some targeted at the students themselves, some at other consumer groups. They will have developed some appreciation of the way advertisers relate products to particular lifestyles, present products as providing some sort of benefit to the consumer and to some extent demanding that the consumers value themselves sufficiently to purchase the product. This last feature is typified by the “Because you’re worth it” series of advertisements for hair and skin care products. The role of the teacher here is perhaps to enable the students to explore their existing knowledge and understanding of markets through the way they are advertised but also to challenge the view that designers can only design for consumer driven situations. The ‘Rat’ series of graffiti by the artist Banksy is a provocative way of doing this thus scaffolding the alignment of spontaneous and scientific concepts concerning users and markets (Banksy 2005).

Often in design & technology lessons the teacher makes the conceptual design decision for the student by deciding what sort of product the students will design. There are often good organisational and pedagogic reasons for this. If a class is designing a wide range of product types there might be difficulties in providing the variety of materials and components required leading to disaffection and de-motivation on the part of the students. If the products need to work in very different ways the students may not have the necessary technical knowledge to be successful. If the products require several different ways of making students may not have the necessary previous experience. Plus sometimes products are chosen because by designing and making them the students will cover particular parts of the syllabus. However, it is possible to engage relatively young students with conceptual design if the requirement to make the design is removed. This is the approach adopted by Young Foresight and is described in the next section.
Conditions for creativity and Young Foresight
The Nuffield Design & Technology Project and a government agency, QCA (the Qualifications and Curriculum Authority) responded to the Robinson Report. In 1999 QCA and the Nuffield Curriculum Centre invited 20 teachers to attend a full-day meeting at which they presented pupil's work in art & design and design & technology that they considered creative. This was followed by visits to a selection of schools to watch lessons in progress and a further full-day meeting in which teachers presented and discussed pupil's work.

From this overview it was possible to identify four features that had to be in place for students to act creatively in either subject.

- The activity had to be presented in a context to which the students could relate.
- The activity had to be supported by a significant stimulus which was often, but not exclusively, intensely visual.
- Focused teaching was necessary to provide knowledge, understanding and skills.
- An attitude of continuous reflection needed to be encouraged.

But the observations of lessons and the resulting work revealed that these four features alone do not ensure creative activity. The deciding factor is the way they are managed. This must be done so that students can handle uncertainty in exploring and developing outcomes. There must be some risk associated with the endeavour in terms of the "originality" of the activity as far as the individual student is concerned.

This is shown diagrammatically in Figure 2

![Diagram of Conditions for Creativity](image)

Young Foresight is a recent design & technology initiative in England. It challenges orthodox approaches to teaching design & technology in the following ways. Students design but do NOT make products and service for the future using new and emerging technologies in their design proposals. They write their own design briefs. They work in groups and are supported by mentors from industry. The students have to present their proposals to their peers, teachers and mentors and to adult audiences at innovation conferences.

Removal of the requirement to make what has been designed allows the student to conceive ideas for products that are not limited by their personal making skills and the tools, materials and equipment.
available in the school. It also enables them to consider applications of new and emerging technologies that are not accessible to schools. However the students are required to justify their design proposal in terms of four features; technical feasibility, being acceptable to the society in which the product will be used, meeting clearly identifiable needs and wants, and the nature of the market into which the product will be sold. (Barlex 1999). This is shown as a diagram in Figure 3.

![Diagram of Young Foresight tetrahedron]

Figure 3 The Young Foresight tetrahedron that facilitates conceptual design

If any one of the considerations is omitted it is likely that the resulting design concept will be flawed. The detail with which the students describe and justify their proposals indicates that they are products of worth and capable of manufacture albeit not by the students. This opportunity to be creative reflects the creativity of the designer in the world outside school where the designer is seldom required to manufacture her design proposal although of course she has to ensure that it can be manufactured.

In teaching Young Foresight teachers are able to meet the conditions for creativity. There are short TV programmes that introduce students to new and emerging technologies. This provides a stimulus and also some knowledge. Within the curriculum materials there is a toolkit of small tasks which can be used to teach a range of design strategies, presentation techniques plus key concepts concerning sustainability, future scenarios and new technologies. This provides relevant knowledge and skills and enables the students to decide on the context of their designing for themselves. Requiring the students to visit each ‘vertex’ of the tetrahedron as they develop and justify their overall design idea promotes reflection. The most common ‘risk’ in the conventional designing and making approach to design & technology is in students conceiving a design that takes too long, or is too difficult, to make. This risk is removed from Young Foresight as the design does not have to be made. The risks are intellectual risks in terms of the validity of the idea. The teacher is able to support the students in taking the intellectual risks by scaffolding their attempts to justify their ideas as they ‘move around’ the Young Foresight tetrahedron.

**Creativity, collaboration and pedagogy**

Conceptual designs from groups of students using the Young Foresight approach show imagination, the pursuit of purpose, originality and value—the four features of creativity identified by the Robinson Report. (Trebell and Barlex 2007). In making presentations about their ideas it is the students
themselves, supported by teachers, who make the judgements as to the creativity of their concepts. Csikszentmihalyi (1999) an acknowledged expert on creativity notes the importance of these judges or peers in recognizing creativity and makes a strong case for building communities that nurture creative genius as opposed to developing highly gifted individuals.

If these conclusions are accepted, then it follows that the occurrence of creativity is not simply a function of how many gifted individuals there are, but also how accessible the various symbolic systems are and how responsive the social system is to novel ideas. Instead of focusing exclusively on individuals, it will make more sense to focus on communities that may or may not nurture genius. In the last analysis, it is the community and not the individual who makes creativity manifest (p. 333).

Collaboration between students in being creative lies at the heart of Young Foresight. Vera John-Steiner (2000) has identified several models for creative collaboration and the family’s pattern for creative collaboration - dynamic integration of expertise achieved through a fluidity of roles fuelled by a common vision and underpinned by trust – seems the most appropriate for conceptual design. John-Steiner notes that those taking part in such collaborations will need to take the bold step of becoming dependent on one another. This dependence is not a sign of weakness, but of strength. It is a dependence that will allow individuals to make substantial growth through partnership. Above all it is a dignified interdependence through which those working together have mutual respect and can forge achievements far beyond their individual, isolated capacities. In the current climate of meeting performance targets as opposed to achieving learning it requires a break with hegemonic approaches to teaching to support creativity in the design & technology classroom. Patricia Murphy (2003) in her evaluation of Young Foresight has identified the pedagogic stance required to support students’ creativity as follows:

- Tasks need to be culturally authentic
- Students share responsibility for learning with teachers
- Students are motivated by dilemmas to which they are emotionally committed
- Learners construct rather than receive meaning
- Intellectual abilities are socially and culturally developed
- Prior knowledge and cultural perspectives shape new learning

Without such pedagogy, one that values what the students bring into the classroom from outside school as well as what is formally taught in school, it is almost impossible to develop the relationships needed for collaboration or the creative community that nurture creativity in the classroom.

**Tools to probe the interaction between technology and society.**
The Young Foresight tetrahedron provides a framework with which students can use their creativity to develop conceptual designs. The same framework can be used to interrogate existing products. Placing a product at the centre of the tetrahedron students can ask the following questions as they visit each vertex.

Concerning the technology
- What technologies are utilised in the product?
- What alternatives might there be?
- What would be the advantages and disadvantages of these alternatives?

Concerning peoples’ needs and wants
- What needs or wants does the product meet?
- Is meeting these needs or wants significant in promoting the health and happiness of people using the product?

Concerning society
- To what extent is the product acceptable in our society?
- Are there any indications that it will become less acceptable as time goes by?
Concerning the market
• What market or markets are relevant to the product?
• Are these markets likely to grow or diminish as time goes by?

The design decision pentagon can be used in a similar way. The product can be placed at the centre and interrogated as follows.

• Does the concept have worth?
• How does it work?
• Why did the designer choose this way of working rather than another?
• Why did the designer choose on this particular appearance?
• How was the product manufactured?
• For what market or consumer group is the product intended?

The interrogations of products by either the Young Foresight tetrahedron or the design decision pentagon can be extended by asking three very important supplementary questions

• What is the social impact of the product?
• What is the economic impact of the product?
• What is the environmental impact of the product?

It is essential that these interrogations be carried out in a spirit of free enquiry in which the students’ views are paramount. It is not a question of teaching so that the students can recall ‘right answers’. In this way the intellectual tools and associated pedagogy used to develop creativity through designing can also be used as analytical tools to evaluate products and their effects on the way we live i.e. to enhance pupils understanding of the relationship between technology and society.

Conclusion
Technology education is subject to the influence of a variety of stakeholders including ‘economic instrumentalists’, ‘professional technologists’, ‘sustainable developers’ and ‘defenders of participatory democracy’. (Layton 1994). The broad vision of technology education as described in the aspirational statement in the National Curriculum for England (QCA 1999) can become compromised in practice. This has led in some cases to a narrow interpretation of technology education in the classroom in which the moral issues are not confronted (Layton 1995)

“Morality, it seemed, had been jettisoned: providing the thumbscrew, the gas chamber, or the bug worked well, we were dealing with high quality D and T.” (p. 108)

Hence it may be difficult to achieve technological literacy within the taught subject technology with a major, if not exclusive, focus on designing and making products, as is the case in design & technology in England. However by aligning the subject with the ‘creativity in education’ agenda it is possible to use tools developed primarily to enable pupils to be creative through designing as the means to critique existing products and the uses of technology. This widens the scope of the taught subject without necessarily having to spend large amounts of time developing new conceptual tools for students to use. This will enable the teaching of the school subject design & technology to engage more fully with achieving technological literacy. It will of course be necessary for teachers to adopt a pedagogy that engages with, and takes heed of, the student voice, with special reference to that which has been learnt ‘spontaneously’ in the world outside school.

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Technological Literacy in New Zealand: Two paradigms a swing apart.

John Gawith, Gary O’Sullivan, Nigel Grigg, Massey University. New Zealand.
Email: J.A.Gawith@massey.ac.nz

Introduction:
Technology education is both an old and a new subject. As an old subject it is associated with notions of craft and vocational preparation. As a new subject a greater emphasis is being placed on technology in a critical social context. Technical education was introduced in 1890 with separate subjects for boys and girls. Since that inception its development has been seen by many as vocational and skill based (Burns, 1992). This paper will highlight concerns by current technology teachers in New Zealand that the pendulum has swung and seems stuck too far away from those roots towards an increasingly academic technological social studies. These two paradigms form the ends of a pendulum swing that is causing consternation for teachers who have a tradition of teaching particular craft and skill sets. Are these concerns justified or are they expressions of dissatisfaction from teachers unwilling to change? Furthermore, are these practical skills important in forming technological expertise?

Chi (2006) defined expertise as “the manifestation of skills and understanding resulting from the accumulation of a large body of knowledge” (p.167). It could be argued that aspiring for technological expertise within a school subject is unrealistic and unobtainable. However, few would argue that a foundation for that expertise should be established by the learning area in schools. The
question then becomes; What does this foundation consist of and how do students acquire it? The maturing area of research into expertise and expert performance provides a fertile starting point. This research area is not just concerned with the ultimate limits of expert performance but significantly for this discussion, “the earlier stages of development through which every future performer needs to pass” (Feltovich, Prietula & Ericsson, 2006 p.62)

Kuhn (1962) argued that paradigm shifts occur in discontinuous revolutionary breaks. Kuhn seems to have described what we are experiencing in New Zealand with the current curriculum review. The vision of academics may need tempering by the reality of the classroom. Olsen (1997) described this duality of old and new as the curse of technology education. Olsen also signalled the revolution that we may now be facing in New Zealand schools:

The future of technology education will depend on policies that are sharpened by the hard edge of school reality, and thus there is a vast challenge given to curriculum research by many emerging visions of technology in schools (Olsen, 1997, p.383).

Finland, a country not dissimilar in population to New Zealand, has a highly practical technology education to credit for its innovations in mobile telecommunications (Autio & Hansen, 2002). These authors argued that outcomes from learning in this area include individual responsibility, creativity, perseverance, initiative and a positive picture of oneself. They took their argument further by suggesting that self-esteem is built on practical rather than academic achievement. One could and perhaps should argue that self esteem comes from a number of sources. However, their point is relevant in the context of this paper.

Autio and Hansen’s report also noted that Finland’s focus on craft flew in the face of many contemporary technology education curricula being implemented. For example Olsen (1997) stated that general education is perceived to be more valuable. He associated it with abstract propositional knowledge - thinking rather than making. The findings of this paper challenge the perception that academic is more important than practical.

The focus of recent curriculum development in New Zealand has been towards developing technological literacy. The New Zealand Curriculum Draft for Consultation states, “The aim is for students to develop a broad technological literacy that will equip them to participate in society as informed citizens (Ministry of Education, 2006), a lofty and worthy goal with which few can argue.

What is meant by a broad technological literacy? The learning area is structured with three strands: Technological Practice, Nature of Technology and Technological Knowledge. The Practice strand includes provision and guidelines for students undertaking technological practice and the opportunity to critique the practice of others. The Nature of Technology strand includes developing a philosophical understanding which should lead to a critical awareness of technology. The Technological Knowledge Strand provides an opportunity for students to develop a generic knowledge base.

An increased emphasis on the history, philosophy and sociology of technology exacerbates the swing away from the practical paradigm. Olsen (1997) made a number of observations that may be beneficial to the New Zealand context. Firstly, how can technology teachers be expected to tackle critiquing issues which few other teachers could handle? Secondly, this is a significant shift from their previous focus, one of developing practical expertise. Thirdly, despite all the policy debate in technology education, there is little research on how teachers have coped with the changes.

Discussions surrounding technological literacy, including fitness for purpose or fitness of purpose, should have making or doing at their core, a view Olsen (1997) supported:
The point is that things are made for a purpose, and, when well made, are beautiful. The question of fitness for purpose and fitness of the purpose arises as part of making (p. 385).

Olsen’s (1997) work supported the inclusion of the morals of making things within technology education, a position the authors of this paper uphold. To ignore these issues and/or suggest they belong elsewhere is not desirable or advocated. However, Olsen also noted that research in the area of technology education must consider the viewpoints of the classroom teacher. It could be argued that current curriculum developers place an overemphasis on fitness of purpose to the detriment of fitness for purpose, in other words a swing to an academic technological social studies paradigm.

This paper highlights the viewpoints of teachers and suggests an inclusive construct of technological literacy that will allow the development of technological expertise, not just the ability to critique. An inclusive construct of technological literacy can be developed through experiences that include the development of expertise, but without the dramatic swings we have seen in the past. The model we propose sees the pendulum swinging freely, with the arc growing in both paradigms.

Figure 2.

Technology Education
A model of growth

Practical                Academic

Growth in expertise = a greater exposure in both paradigms.

Method

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The researchers conducted a postal survey of secondary school technology teachers in New Zealand. The survey was designed to explore technology teacher satisfaction with the development and implementation of the curriculum. The questionnaire was constructed to be easy to complete, while providing opportunities for teachers to write comments. It consisted of seven questions, five of which concentrated on respondents' involvement in curriculum implementation and two on the way technology education is currently developing. As a content validity measure, the questionnaire was scrutinised by two external experts, and minor changes made before being posted to schools.

Questionnaires were sent to the Head of the Technology Department of each of the 332 secondary schools in New Zealand. The Heads of Department were asked to distribute them within their department and, if necessary, make further copies. Each questionnaire was individually numbered and recorded against the school name.

Responses were received from teachers in 130 identified schools. An additional 30 questionnaires were received electronically that were not identified with specific schools. This represents a response rate of approximately 42%. This return rate indicates the interest and the strength of feeling about the questions. The total number of completed questionnaires received was 355 spread throughout the country.

Data Analysis

This paper presents the analyses to the questions relevant to its title:

Question 1: Teacher satisfaction with the technology Curriculum in two areas, development and implementation over the past ten years.

Question 4: Teacher identification of positive aspects and concerns relating to the development of technology education for their pupils.

Question 7: Teachers satisfaction with the way Technology Education is currently developing.

Numerical responses were analysed using SPSS version 14.0 software to produce the various frequency distributions, cross tabulations and summary statistics, and perform hypothesis tests including t-test and chi-square test of association.

Analysis and Results

To determine the influence of experience level on the responses given, respondents were divided into two groups: Those with less than ten years experience, and those with ten or more years’ experience. This categorisation is based upon the introduction of the new curriculum. Those teachers with more than ten years’ experience of technology education would have been teaching workshop and design when the technology curriculum was introduced, while those with less than ten years experience would have started teaching technology since the introduction of the new curriculum.

1. Teacher satisfaction with the technology Curriculum in three areas

Teachers' level of satisfaction with the Technology curriculum was assessed via a five-point Likert scale ranging from 1=Not at all satisfied to 5=Very satisfied. Findings are discussed below in relation to the two areas.

A frequency distribution of responses was first obtained in order to determine the pattern of responses given by the entire sample group. Summary statistics were obtained for these distributions, consisting of score mean, mode and standard deviation. Responses to the questions were then cross-tabulated against experience level to determine the extent to which differences exist in the distribution of responses for the two groups, and finally a t-test was conducted to determine whether or not a
significant difference existed between the mean (average) scores given by each group (shown in table 1).

a) Development of the curriculum.
Figure 3 shows the frequency distribution of responses in relation to development of the curriculum. As the diagram shows, there is more dissatisfaction than satisfaction: 50.5% of respondents are in categories 1 or 2 (dissatisfied); 16.4% are in categories 4 or 5 (satisfied); and the remaining 33.1% are in category 3 (neutral). The mean rating is 2.48 towards the dissatisfaction end of the scale, while the modal response category is 3, which is a neutral response.

Table 1 shows the cross tabulation of responses by experience level (<10 or ≥10 years) and shows the results of the t-test for difference in mean response score for the two groups. These analyses reveal no significant difference between the two groups in relation to their responses.

Table 1

<table>
<thead>
<tr>
<th>Question</th>
<th>Years experience</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>T value</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Satisfaction with Development of curriculum</td>
<td>Under 10 years</td>
<td>169</td>
<td>2.56</td>
<td>1.034</td>
<td>1.235</td>
<td>.218</td>
</tr>
<tr>
<td></td>
<td>10 years or more</td>
<td>142</td>
<td>2.42</td>
<td>1.053</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2 Satisfaction with Implementation</td>
<td>Under 10 years</td>
<td>168</td>
<td>2.34</td>
<td>.965</td>
<td>1.842</td>
<td>.066</td>
</tr>
<tr>
<td></td>
<td>10 years or more</td>
<td>141</td>
<td>2.13</td>
<td>.980</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) Implementation.
The bar chart in figure 5 shows the frequency distribution of responses in relation to implementation of the curriculum. As the diagram shows, there is far more dissatisfaction than satisfaction: 62.6% of respondents are in categories 1 or 2 (dissatisfied); 9% are in categories 4 or 5 (satisfied); and the remaining 28.4% are in category 3 (neutral). The mean rating is 2.23 towards the dissatisfaction end of the scale, while the modal response category is 2, which is a dissatisfied response.

Figure 6 shows the cross tabulation of responses by experience level (<10 or ≥10 years), and table 1 shows the results of the t-test for difference in mean response score for the two groups. These analyses reveal no significant difference between the two groups in relation to their responses.
2. Teachers feeling of happiness or disappointment with the way technology education is currently developing

Figure 9 shows a bar chart of the frequency distribution of responses to the question of how happy the respondent is with "the way technology education is currently developing". As the diagram shows, the majority of respondents (approximately 70% of those expressing a view), are either unhappy with, or disappointed with developments.

Figure 9

Responses were then cross tabulated against experience level to determine the extent to which differences exist in the distribution of responses for the two groups (represented in figure 10), and a chi-square test of association was carried out to determine whether distributional differences existed between the two groups. These analyses reveal no significant difference between the responses given by two groups.

Figure 10
3. **The positive aspects for pupils and concerns for pupils of the many developments in technology education over the last ten year period.**

Respondents were asked to write down what they saw as positive aspects for pupils and concerns for their pupils. 326 respondents took the time to write detailed comments, many writing three or more different comments for each. These comments were coded into seven concern categories and four positive aspect categories. Interpreting and coding the comments was done in three steps:

1. A random sample was analysed to identify initial categories of response
2. Each comment was read and assigned to one of the identified categories
3. Analysis of these initial categories was carried out using SPSS software, and the results used to further subdivide the responses. Initial categories that contained a high percentage of the comments were further subdivided so as to elicit greater detail, and categories with few comments were amalgamated.

The seven 'concern' categories that emerged from the raw data were:

A. Academic versus practical
B. Work load for students
C. Student abilities
D. Overemphasis on prescribed process
E. Industry needs
F. Gender issues
G. Ministry of Education related concerns

Concerns A to D, will be analysed in this paper as they relate to the two paradigms being discussed.

The four 'positive aspect' categories were:

1. Encourages students to think widely, express ideas and plan for projects
2. Encourages creativity and enterprise by giving students project ownership.
3. Wider exposure to a variety of materials and technologies within the organized curriculum.
4. Clear pathway to university study
Concerns over the new curriculum

Figure 11 shows the distribution of responses relating to the concerns that respondents had for their pupils:

These concerns, and the number and approximate % of respondents expressing each concern are summarised in the following tables:

<table>
<thead>
<tr>
<th>Table 2. Academic versus practical: 209 (59% of) respondents.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Concerns</strong></td>
</tr>
<tr>
<td>The curriculum overemphasized academic/theoretical knowledge, and underemphasized the importance of practical knowledge.</td>
</tr>
<tr>
<td>The undervaluing of practical knowledge was leading to loss of practical skills and the ability to develop practical solutions.</td>
</tr>
<tr>
<td>There was a wide variation in students’ practical knowledge and abilities between schools.</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
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</tbody>
</table>
Performing a cross tabulation by length of experience (pre and post-new curriculum) again revealed no significant difference in responses. Figure 12 shows the cross tabulation.

Figure 12
Positive aspects of the new curriculum

Figure 13 shows results in relation to the positive aspects that respondents saw for their pupils as a result of the curriculum change.

Figure 13

These positive aspects, and the number and approximate percentage reporting, are summarised as follows:

**Table 6: Extended student thinking; 113 (32% of) respondents**

<table>
<thead>
<tr>
<th>Positive aspect</th>
<th>Teacher comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourages students to think widely, express ideas and plan for projects</td>
<td>T137. They make students think outside of the square. It challenges the way students go about problem solving and makes them think about sustainable design. T85. Technology offers a good opportunity to explore and develop around a problem solving skills and develop a great awareness of good practice which is not self-centred. The development of critical thinking is important. T187. The ‘process’ is a lifetime valuable approach to ensuring a good outcome, i.e. Consulting stakeholders, planning etc. T249. Students able to learn within authentic contexts, developing solutions to real problems as individuals.</td>
</tr>
</tbody>
</table>

**Table 7: Encouraged Creativity; 79 (22% of) respondents**

<table>
<thead>
<tr>
<th>Positive aspect</th>
<th>Teacher comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourages creativity and enterprise by giving students project ownership</td>
<td>T72. [Students] Given the ability to take on individual challenges. T128. For the creative, intelligent student who can work independently it allows them the opportunity to explore variables. T201. The graphical element of technology is an excellent tool to allow students to develop their own personal design skills. Allows them to be creative and express their ideas. T201. They can become individual and work to their own strengths. They can take ownership of their work.</td>
</tr>
</tbody>
</table>
Teachers in the survey made considerable effort to answer this question in detail, writing 6,700 words. The survey results highlight that there is significant dissatisfaction with the direction of the technology curriculum and that teachers are concerned about the loss of practical activities and skills. It was also clear that teachers who started teaching technology after the introduction of the existing curriculum had the same levels of dissatisfaction and concerns as those who were teaching workshop and design before the introduction of the technology curriculum. Therefore, a simple dismissal of teachers responses based on those who began their teaching career within the craft paradigm is unsupported.

Discussion
This survey clearly identifies technology teacher concern at the loss of practical skills and knowledge irrespective of length of service. The authors of this paper share this concern and argue that practical skills are part of the foundation for expert performance in technology. Expert performance research describes experts as organising their knowledge and skills into chunks: “A chunk is a perceptual or memory structure that bonds a number of more elementary units into a larger organisation” (Feltovich, Prietula, & Ericsson, 2006, p.49). An example of an elementary unit is the cutting of materials. This action requires eye-hand coordination, but also understandings such as the selection of material and tools to use, the finish after cutting, costs involved, environmental implications and potential health and safety issues. As their expertise develops, students can add more techniques and knowledge to their repertoire of cutting. These basic elements are the beginnings for a chunk of knowledge focussed on cutting that technological experts use.

A quick look at some leading technology text books at the tertiary level indicate how the community of practice organises its knowledge chunks. Manufacturing texts are organised into chapters on cutting, forming, casting, extruding, joining and finishing (Edwards & Endean, 1995; Ostwald & Muñoz, 1997; DeGarmo, Black, Kohser & Klamecki, 2003). Process technology texts are organised around unit operations such as separation, mixing, size reduction, heat transfer, fermentation and transport/fluid flow (Barbosa-Cánovas & Ibarz, 2003; McKetta, 1993; Smith, McCabe & Harriott, 2004).
Responses from teachers in this survey suggest that they see a devaluing of practical skill and associated knowledge chunks within the technology curriculum. We do not advocate for these basic elements to be taught in isolation, but rather, within the context of developing exciting technological solutions. Again, from research on expert performance: “Deliberate practice is the basis of expertise, which in turn, is responsible for consistent superior performance that is creative” (Weisberg, 2006, p.768).

Conclusion

There is a justification based on these findings for a reconsideration of the two paradigms and their importance in the development of technological literacy. We have argued that replacing one paradigm with the other will be unsuccessful. We advocate a balanced curriculum that swings to accommodate and develop both. Perhaps recognising and incorporating research on expert performance will allow the valuing of knowledge and skills from both paradigms, providing a possible structure for a way forward.

References:
Thinking in Time: Affecting Technological Literacy through Oral History Research

Jenny Daugherty, University of Illinois and Michael Daugherty, University of Arkansas, USA
Email: jdaughe2@uiuc.edu mkd03@uark.edu

Abstract

Technological literacy implies more than just the ability to create tangible objects. It implies an understanding of the historical, social and cultural context within which a technology was envisioned, created, and used. With technology playing an increasingly important role, it is vital that students be exposed to the interdisciplinary nature of technological literacy and the complex interaction between technology and society. This paper investigates methods of improving student's technological literacy by using oral histories to better engage learners in the exploration of the historical, social, and cultural context surrounding technology. This paper concludes with evidence from a study in which oral history projects were designed and implemented to engage students in exploring the relationship between technology and society.

Bringing Technology Home

In the broadest sense, technology is the modification of the natural world to satisfy human wants and needs (Garmire & Pearson, 2006). Although people tend to focus only on artifacts like the computer and cell phone, technology also includes written languages, systems for calculating time and location, and other less tangible technological systems. Virtually everyone in modern society is profoundly influenced by technology (Garmire & Pearson). Technological adaptation and proliferation affects societies and cultures in multiple ways. Technology, among other impacts, increases individual options and alternatives, creates social problems that require action, and alters human interaction patterns and cultural norms. Because technology is so pervasive in our world, it is vitally important that people understand what technology is, how it works, how it is created, how it shapes society, and what factors influence technological development (Garmire & Pearson, p. 19). This paper will focus on these latter two purposes in examining how to better develop an understanding of the societal and contextual factors that influence technology.

Striking changes in teacher perceptions of technology education have taken place in the past two decades, specifically in the United States (Garmire & Pearson, 2006). Whereas the technology education discipline was once equated primarily with long-term laboratory projects and the construction of tangible products, it is increasingly seen as a more complex field that also offers instruction related to technology and society, and the relationships between technology and other domains. The publication of Standards for Technological Literacy: Content for the Study of Technology (ITEA, 2000) cemented this increased role for technology education. In fact, the Standards for Technological Literacy outline four standards directly related to technology and society (ITEA). These standards offer content suggestions related to how the use of technology affects society and the environment, as well as how society influences the development of technology, and how technology has changed and evolved over the course of human history.

At the same time, however, a clear view of the avenues for implementing learning experiences and curriculum related to technology and society has come more slowly. Many educators have expressed concern that the existing curricular practices are too heavily focused on artifact development to adequately present content focused on lessons on technology and society (Dakers, 2006a). What seems to be required is a curricular approach that promotes conceptual learning and activities that engage students in understanding the complex relationships that exist between technology and society. This
Oral Histories and Technology Education
The historical and societal relevancy of technology has not been a traditional point of concern for teachers in technology education classes. As one of few disciplines where students actually have the opportunity to develop and practice psychomotor learning and skills, technology education has generally focused on the vocational aspect of technology in the preparation of adolescents for the industrial, technical workforce. As technology teachers have begun to venture out from the singular preoccupation with the creation of artifacts, into the uncharted territory of technology and society, many have struggled to find an appropriate instructional approach. Long used in other disciplines, oral history studies may provide an appropriate teaching tool for examining the intersections between technology and society, while generating student engagement with a given topic.

Oral History can be defined as the interviewing of eye-witness participants to past events for the purposes of historical reconstruction. According to Starr (1977/1996), oral history is “primary source material obtained by recording the spoken words—generally by means of planned, tape-recorded interviews—of persons deemed to harbor hitherto unavailable information worth preserving” (p. 40). Hoopes (1979/1996) offered a broader definition of oral history, stating that it is “based on documents that are spoken” (p. 5). These documents include folklore, legend, songs, speeches, interviews, and formal and informal conversations. Often oral history is used to refer to the collecting of an individual’s spoken memories of his or her life. As an organized activity, the roots of oral history lie in the launching of “The Oral History Project” at Columbia University under the guidance of Allan Nevins. Oral history is often referred to as a method or tool of the historian but it certainly has multi-disciplinary applications.

A contribution that oral history offers is that it can “capture and preserve life stories that would otherwise be lost” (Starr, p. 40). As Hoffman (1974/1996) pointed out, oral history “facilitates a new kind of history—a history not of captains, kings, and presidents but of farmers, workers, immigrants, and the like” (Hoffman, p. 92). In addition, oral interviews often contain a level of “freshness and candor” (Hoffman, p. 92) not achieved in the historical record. Although oral history is based on the recall and memory of the interviewee, the resulting data has the potential for being more intimate and reflective, especially when the questioner delves deeper into the events and stories of the interviewee’s life (Starr).

Intersection of Oral History and Technology
The development of oral history as a tool for collecting primary source material has both been dependent on and necessitated by technology. As Nevins (1966) argued, oral history was “born of modern invention and technology” (p. 30). The reconstruction of the historical record has depended largely on the existence of a written record to be analyzed by future generations. However, letter writing and other forms of written communication have been largely replaced by the telephone and, with improved transportation technologies, in-person visits. As Hoopes stated, with the development of these technologies and sound recording technologies, “memory in literate societies is exercised even less frequently than only a few years ago” (p. 7), when the preservation of spoken words depended on memory and written form. The lack of a written historical record has necessitated the use of oral documentation. At the same time, the development of sound recording technologies has enabled the ease and accuracy of documenting interviews. Starr even argued that the development of oral history could be perceived as a “conscious effort to utilize technology…to counter the inroads of technology that Nevins deplored” (Starr, p. 41). As Hoopes argued, “what the communications revolution has taken away it has also restored, in the form of tape-recorded interviews” (p. 9).

Oral Family History
Imagine listening to an elderly relative tell of her journey to America as an immigrant, her arrival at Ellis Island, and her first job in a clothing factory. Or imagine a family member describing how he worked on the family farm, learned to read in a one-room school house, and courted his wife at church socials. Such are the opportunities available to the family historian who draws upon the method of oral history (Shopes, p. 232).

The development of oral history has resulted in its use in many other disciplines and pursuits. Shopes (1980/1996) discussed in depth the use of oral history to construct and document a person’s family history. Different from genealogy, which is focused on the construction of a family tree, primarily using documents such as birth and death records, the construction of a family history is dependent on oral interviews, along with other primary source material. Also, different from traditional oral history, with family history, the interviewer and interviewee are tied more closely together. By investigating the interviewee’s personal story and trying to understand that person’s life in relation to a specific social and historical context, the interviewer can “gain perspective on the context of their own lives” (Shopes, p. 232). More intimate connections and understandings of the past can be made by the interviewer when personalized and remembered by a family member.

This issue of context is explored further by Wineburg and Fournier (1994), in relation to presentism or the judging of past actors by present standards. Presentism often occurs when the context in which the actors lived is ignored or replaced by the present context. Their actions and beliefs are judged, usually in harsh terms, according to current ways of thinking. Wineburg and Fournier argued that presentism “must be overcome before one achieves true historical understanding” (p. 286). Students should be encouraged to “think about the past on its own terms” (p. 286), developing contextualized thinking skills. Contextualized thinking, however, can be a complicated and difficult ability for students to acquire. Oral history can be a way for students to weave their family member’s history into the broader context of the social and historical events of their time. In so doing, students can develop the ability to “think in time” (p. 286), an important aspect of contextualized thinking.

Oral History as an Instructional Tool
As an instructional method, oral history has been offered primarily in the teaching of history. However, Neuenschwander (1976) argued that “oral history can be successfully adapted to the resources and time dimensions of virtually any teaching situation” (p. 9). An important pedagogical contribution that oral history offers teachers is that illustrative examples used to facilitate comprehension, typically the responsibility of teachers, can be gained by the students themselves. When used to explore the role that technology has played in the shaping of a society or culture, for example, oral history can reveal how the infusion of new technologies shaped family member’s lives. This understanding can lead to an expanded historical consciousness and a better perception of the student’s own life in relation to the larger technological, social and historical context.

Oral history turns “local human resources into course materials” (p. 37), engaging students’ imaginations and relating their personal worlds to local surroundings and society at large. Heurta and Flemmer (2000) also argued that oral history projects in the secondary classroom help maintain student interest because students “go beyond the role of passive learner to active researcher” (p. 106). Through oral history projects, students “explore community life, analyze social problems, and consider possible solutions” (p. 105). Whitman (2000) also discussed the success of oral history projects in secondary school courses. He indicated that students feel empowered by the opportunity “to directly engage with those individuals who were makers or part of history, rather than spend the year reading about voiceless men and women in textbooks” (p. 469-470). By making a connection with the past, oral history is an accessible approach across all disciplines because of the flexibility in which it can be introduced into the curriculum, and the “wide range of skills and multiple intelligences that must be deployed to effectively complete it” (p. 473).
Whitman also suggested several resources to aid the teacher in facilitating an oral history project. For example, *Talking Gumbo: A Teacher's Guide to Using Oral History in the Classroom* by Dean, Daspit, and Munro is a resource available through the T. Harry Williams Center for Oral History. Another resource available through the same center is a thirty minute video called *You've Got to Hear this Story* that explains the how-to's in conducting oral history. In addition, the Association of Oral History Educators publishes *The Oral History Educator*, a resource for teachers incorporating oral history projects into their courses. As well as numerous internet sites that offer resources and illustrations of oral history projects.

### Technology Education and Oral History

Dakers (2006a) argued that the artifact-driven nature of technology education can be attributed to its technical, rule-driven focus on procedural knowledge. In this epistemological framework, technology education is seen as a vocational subject that is a training ground for the future industrial workforce. With much of the artifact-focused technology education, students are less aware of the “idea that technology also comprises knowledge, and that technology is something one can study” (de Vries, 2006, p. 29).

Arguments have increasingly been offered against this framework, centering on the belief that “these situated skills are no longer sustainable in today’s modern technologically driven world” (Dakers, 2006b, p. 152). Another framework or paradigm has been offered that is rooted in social constructivist theories and sees learning as “culturally influenced and set within a socio-historical context” (p. 154). In this framework, students are encouraged to construct meaning through directly experiencing the natural, fabricated, social, and cultural world. This academic subject paradigm puts forth the notion that students need to grasp the contextually relevant aspects of an artifact in addition to its fabrication and specific features. Dakers offered a synthesis of the two frameworks as a way to achieving technological literacy. He argued that technology education “should have a ‘relationship’ with industry, but not a subservient one” (p. 156), but that a discourse “regarding the very essence of technology, the way technology affects our cultural development and our participation in a global society must become embedded into technology education” (p. 157).

According to de Vries, technology educators should also take into account the different type of knowledge (procedural and conceptual) in trying to teach technology procedures and knowledge. In addition, the normative dimension of technology should also be taken into account. Students should be made aware that “knowledge in technology is often about what should be, not about what is” (p. 29), meaning that knowledge in technology is often a matter of decisions and preferences. Values are an important aspect of technology that is not made apparent when focused merely on the artifact.

This move away from merely focusing on the procedural aspect of technology to incorporating conceptual, social, and cultural dimensions can be spurred by incorporating a historical perspective. Through discussions about the decisions and preferences that have led to the development and continued use of a particular technology, conceptual knowledge of technology can be made more apparent to students. As well as, the values embedded or that have contributed to that technology can be better explored through historical analysis.

In particular, through oral history projects of family members, the contextual understanding of technology can be made more apparent. Contextual understanding is an important aspect of conceptual knowledge. By understanding that technology has a history with both intended and unintended consequences, students are encouraged to better understand that technology is more than about the artifact itself. Students can better grasp that technology is something that “one can study” (de Vries, p. 29). Oral history can also be a way for students to weave their family member’s history into the broader context of the social and historical context surrounding technology. In so doing, students can develop the ability to “‘think in time’” (Wineburg and Fournier, p. 286), an important aspect of contextualized thinking, and develop a deeper level of conceptual understanding of technology.
An Oral History Experiment in Technology Education

As discussed above, students have a tendency to perceive technology in terms of its artifacts or as computers. Often students are unable to “see technology in terms of the knowledge and processes that create these artifacts, nor, in particular, are they aware of the various implications for society, that result from the existence of these technologies” (Dakers, 2006a, p. 1). Additionally, students have a tendency to display presentism and judge historical events and historical figures by present standards. In an effort to explore the affect that studies of oral histories can have on student technological understanding, an exploratory study was conducted in a university undergraduate course titled, Living in a Technological World, over a 3-year period.

Living in a Technological World was a general education course for undergraduate students who were not pursuing degrees in technology. During a unit of study within the course, an examination of the complex relationship between technology, society, and culture, the oral history project was implemented. In general terms, the project required students to conduct an interview with an aging relative over 70 years old and develop a written account of the interview for classroom discussion. To focus the interview on the relationship between technology, society, and culture, a questionnaire was developed that included a series of guiding questions. Students were instructed to collect data about the family member prior to the interview to establish a general understanding of the historical context in which he or she lived. Additionally, the students were made aware that asking a family member to recall the past may lead to certain problems. For example, the family member may have difficulty understanding that their story is of interest or value and may show a lack of enthusiasm. Some may be unwilling to speak candidly about what they feel is personal and private. By recalling past events, feelings long buried may resurface and may be difficult to discuss or negotiate for both the family member and the interviewing student. Students were instructed to use tact, persistence, and a sensitivity to conduct the interview and to use the questionnaire to frame the conversation.

In general, the questionnaire prompted the students to ask questions about their aged family member’s childhood. These questions ranged from where they lived (i.e., city, suburbia, rural areas, small towns), familial relationships, the existence of extended families in the home, parental occupations, social and eating habits, the availability of electrical, sewer, and water services, participation in religious, entertainment, or social events, etc. Additionally, students were encouraged to discuss the role that technology played in the household of the relative when he or she was a child. For example, did the aging relative recall a major event driven by technological development that occurred while they were a child (i.e., first electric radio in the neighborhood).

After students had conducted the oral history interviews and drafted a written account, the combined results of the interviews were tabulated and shared with the class as a starting point for a discussion on the impact of technology on society and culture. Over a 3-year period, 91 aging family members were interviewed. These respondents ranged in age from 65 to 93 years of age. The majority of the respondents (72%) lived on farms or in small towns at the time of their childhood, contrary to the students, 68% of whom lived in large cities or suburbs. Similarly, 93% of the respondents indicated that both parents resided in the family home during their childhood and 88% of their mothers had no employment outside the home. Again, these results did not reflect the circumstances of most of the students. When asked the occupation of their father, many of the respondents (28%) indicated that their father was a farmer. During the 3-year period of the experiment, only three members of the class indicated that their own fathers were farmers—less than 2%.

The results of the oral history interviews provided immeasurable material for classroom discussion on the role of technology in cultural and social change and created an unparalleled level of student engagement. For example, over 43% of the respondents indicated that they did not have indoor plumbing in their home as a child and almost 30% indicated that they did not have electricity. An astounding 93% of respondents indicated that their homes were heated with coal or wood fires as a
child and 100% lived in homes without cooling systems. Equally significant was the fact that 78% of the respondents indicated that their families grew much of their own food during their childhood, something completely foreign to members of the class. Not surprisingly, all of these results spurred lively conversation and debate about how much technology has changed the way people live in the United States and whether those changes were always for the better. Further, these conversations provided an opportunity to discuss the fact that a great deal of the Earth’s population continue to do without many of the technologies modern societies take for granted.

The cumulative data generated through the use of oral history projects in these technology education classes and the resulting discussions expanded student perspectives on technology and allowed them to examine the impacts of technological proliferation in a very personal way. The experience also engaged students in lines of inquiry that extended from the personal level to the societal level. For example, the degree to which technological proliferation: 1) changed standards of living and lifestyles; 2) changed levels of physical fitness; 3) changed personal and societal expectations; 4) reduced personal and societal control; 5) caused technology to become more indispensable; 6) allowed certain technologies to become larger threats; and 7) caused society to relinquish personal control of our lives to technology. Ultimately, the use of oral histories brought personal relevance to the study of technology and society, while at the same time broadening the understanding and perspective of the students. Oral history research has the potential to engage students in the broader context of technology and allow students to explore the social and cultural constructs surrounding technology. In doing so, the research tool may become a very important instructional methodology for the technology education discipline and allow instructors to reach students in a very profound way.

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Examining teachers’ pedagogical content knowledge of technology with a multiple choice test

Ellen J. Rohaan¹, Ruurd Taconis, Wim M.G. Jochems. Eindhoven University of Technology, The Netherlands
Email: e.rohaan@tue.nl.

Abstract
Pedagogical Content Knowledge (PCK) is a vital element of the knowledge base for teaching. It is associated with increased student learning in technology education, and increased motivation and interest in technology. In most studies on PCK, only teachers’ actions and their reasons for those actions (usually reflections on classroom behaviour) are examined, whereas the cognitive aspect of PCK (what a teacher knows) is rarely measured. The remaining challenge in examining PCK is to construct an instrument that measures the cognitive component in a time and labour-efficient way and makes it possible to investigate large sample sizes. This paper illustrates how teachers’ PCK could be examined with a multiple choice test. The advantages and disadvantages of this methodological approach, the procedure of test item construction, preliminary results, and possible implications of the test are discussed.

Introduction
Technology is strongly interwoven in today’s society. It has become vital to human welfare and economic prosperity and will be even more vital in the future. Education needs to adapt to this growing importance of technology. New educational programmes should be aimed at making pupils more technological literate (Technological Literacy for All, 2006).

In studies on pupils’ attitude towards technology, it is found that a realistic and complete view of technology is often related with a positive attitude towards technology (De Vries, 2000). In turn, this positive attitude could result in a larger number of students choosing technical studies and careers. A larger number of these students are necessary, because in the last 15 years the numbers of science and technology students in the OECD (Organisation for Economic Co-operation and Development) countries have been relatively decreasing. Clearly, this trend is worrying with regard to the continuing transition to a more technology-intensive economy (Evolution of Student Interest, 2006).

It is of great importance that teachers know what and how they should teach in the field of technology education. Teachers need to have sufficient knowledge of technology and technology education, because teacher knowledge affects teaching and, in turn, positively affects pupils’ concept of and interest in technology (Rohaan, Taconis, & Jochems, submitted).

This paper illustrates how PCK, the central aspect of teacher knowledge, could be examined using a multiple choice test as measurement instrument. First, the construct of PCK is conceptualized and common ways of examining PCK are presented. Subsequently, two promising initiatives of measuring PCK with a multiple choice instrument are discussed. Thereafter, the procedure of test item construction, including the preliminary validation results of the first test version, is described. Finally, a reflection on these results and further implications are discussed in the concluding section.

Conceptualizing Pedagogical Content Knowledge

¹ Corresponding author. Mail to: e.rohaan@tue.nl. Telephone: +31 6 41402858.
What are the sources of the knowledge base of teaching? In what terms can these sources be conceptualized? These questions were asked by the American educationalist Lee Shulman, who introduced the term ‘Pedagogical Content Knowledge’ when investigating the knowledge base of teachers. He defined it as “a special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding” (p. 8). He stated that effective teachers need PCK rather than just the knowledge of a particular subject matter (Shulman, 1987).

In order to clarify the concept of teacher knowledge, Grossman (1990) designed a model of teacher knowledge by summarizing the most important investigations in this field. The model consists of four general domains of teacher knowledge, which can be seen as the cornerstones of teacher knowledge. PCK is presented as an unique, central domain that is influenced by other teacher knowledge domains, and includes four central components: (1) knowledge and beliefs about the goals for teaching a subject at different grade levels, (2) knowledge of pupils’ understanding and (mis)conceptions of particular topics in a subject matter, (3) curricular knowledge, i.e. knowledge about the content of the courses within one field and about the available materials, and (4) knowledge of instructional strategies and representations for teaching particular topics (Grossman, 1990).

Van Driel et al. (1998) compared conceptualizations of PCK by different researchers. They showed that there is no universally accepted conceptualization, but that all researchers seem to agree on two essential elements: 1) understanding of students’ specific learning difficulties, and 2) knowledge of representations of the subject matter to overcome these difficulties. Furthermore, they illustrated that researchers assumed subject matter knowledge to be a prerequisite for the development of PCK.

Some researchers argue that it is impossible to clearly mark off PCK from other knowledge components. Van Driel et al. comment that PCK can be seen as a separate knowledge component when defined as practical teacher knowledge of pupils’ learning difficulties and of instructional strategies with regard to particular topics in a subject matter. They underline that research on PCK is valuable, because it can provide insights into the instruction process, i.e. how teachers transform subject matter knowledge into meaningful student learning. PCK is considered as a vital component of the knowledge base for teaching (Van Driel, Verloop, & De Vos, 1998).

Magnusson et al. (1999) presented two important ideas about PCK. First, within each PCK element teachers need to have specific knowledge differentiated by topic. Effective teachers need to develop knowledge regarding all elements of PCK and regarding all topics they teach. Second, the elements of PCK function as a whole. Consequently, a lack of coherence between the elements is problematic and a teacher’s knowledge of one particular element may not be predictive for the teacher’s teaching practice (Magnusson, Krajcik, & Borko, 1999).

**Research on PCK in technology education**

The New Zealand researchers Jones and Moreland (2004) investigated PCK in the context of technology education. They found that in particular teachers’ understanding of the nature and purpose of the subject strongly influenced teachers’ PCK. Moreover, they found that enhanced PCK is associated with increased student learning in technology education, and increased motivation and interest in technology (Jones & Moreland, 2004).

In our theoretical review on teacher knowledge in technology education, three elements of PCK, which are vital for effective technology education, were derived from the reviewed literature. These elements are: 1) knowledge of pupils’ concept of technology, and knowledge of pupils’ pre and misconceptions related to technology, 2) knowledge of pedagogical approaches and teaching strategies for technology education, and 3) knowledge about the nature and purpose of technology education. In addition, two elements of subject matter knowledge, general subject matter knowledge and concept of technology, were supposed to be important for technology teaching (Rohaan, Taconis, & Jochems, submitted).
Comparing our findings with the theoretical conceptualization of PCK by Magnusson et al. (1999), many similarities can be found. However, this analogy only counts at a general level. Mentioned earlier, as the first important idea presented by Magnusson et al. (1999), within each element teachers have specific PCK differentiated by subject or topic. For example, the PCK required to coach a design task in the context of technology education is different from PCK required to coach a task in the context of science education. Tasks in technology education tend to have a more open-ended character, while tasks in technology education are aimed at discovering established, scientific laws. In the words of Banks et al. (2004): “[c]ompared with other subjects, such as science and mathematics, perhaps a teacher of technology is less in a position of being a ‘fount of all wisdom’ but rather a guide to help a pupil (…)” (p. 144). The difficulties in comparing PCK among subjects and topics are related to the heterogeneous nature of PCK, that is, PCK is composed of widely dissimilar elements at different levels. This might also be an explanation for the few concrete examples of PCK in literature.

Examining PCK
To examine PCK researchers have developed an accumulation of methodologies and techniques. Baxter and Lederman (1999) reviewed methodologies and techniques that have been used to assess teachers’ PCK in the context of science teaching. Most researchers in science education that study PCK build upon Shulman’s definition of PCK. The methods of examining PCK can be categorized into three groups: concept mapping techniques, multi-method evaluations, and selected-response instruments (for instance, multiple choice tests).

Concept mapping techniques are used to chart knowledge structures represented by key terms and relationships among those terms. Often, the subjects are asked to draw pictures or maps that illustrate the key terms and their associations. The underlying assumption, which is highly criticized, is that concept maps reflect the organization of information as it is in long term memory. Concept mapping techniques are mostly used to measure short-term changes rather than long-term changes in knowledge. They are particularly useful tools in teacher education, because they evoke reflection and provide pre-service teachers with valuable feedback (Baxter & Lederman, 1999).

Most studies of PCK use multiple method evaluations (i.e. a variety of techniques which includes structured, semi-structured and stimulated recall interviews, observations, and concept mapping) and triangulate the data of these different sources. The result is usually a general profile of a teacher’s PCK (Baxter & Lederman, 1999). Multi method evaluations are complicated and difficult to replicate. The data collection and analysis is time and labour-intensive. Besides, teachers are often influenced by participating in the study. For that reason, multi method evaluations might be particularly valuable for the professional development of teachers.

Most problematic aspects of assessing teacher cognition (in the broad sense) also apply to the assessment of PCK. Firstly, PCK is difficult to assess directly, because teacher’s cognition is often held unconsciously. Moreover, teachers cannot always verbalize their thoughts and beliefs or may refrain from expressing unpopular ideas. In addition, beliefs appear to be highly depended on the context. Secondly, PCK is by definition partly an internal construct. For that reason, we cannot rely exclusively on observational data. Teachers may use only a small portion of their PCK in the observed situations. Furthermore, observations will not reveal why teachers act as they do. Thirdly, PCK methodologies are time-consuming, because audiotapes need to be transcribed and the content often needs to be analyzed qualitatively. A related problem is generalization, which seems risky because groups sizes rarely exceed 10 and because the results are very content and teacher specific. Finally, making judgments about teachers’ cognitions is problematic, because it is highly debatable what the standards for good (high-quality) PCK are. In other words, it remains the question what constitutes good PCK (Baxter & Lederman, 1999; Kagan, 1990).
As mentioned above, PCK is by definition both an external and internal construct. It is constituted by what a teacher knows, what a teacher does, and the reasons for a teacher’s actions. The translation of teachers’ knowledge into classroom practice is a critical aspect of PCK and obligates to observe actual teaching practice. However, research that relies only on teachers’ actions to assess knowledge is problematic. An overemphasis on classroom behaviour presents a distorted view of teachers’ PCK, just as a narrow focus on cognition limits this view. In the words of Verloop et al. (2001): “[t]he basic idea is that a reciprocity exists between the whole of teachers’ cognition (in the broad sense) and their activities and that, consequently, it makes sense to investigate teachers’ knowledge” (p. 445).

In most studies on PCK only teachers’ actions and their reasons for that actions are examined, whereas the cognitive aspect of PCK (what a teacher knows) is rarely measured. Hence, the remaining challenge in examining PCK is to construct an instrument that measures the cognitive component in a time and labour-efficient way and makes it possible to investigate large sample sizes. One way to achieve this is to construct a selected-response instrument.

**Examining PCK with a selected-response instrument**

Selected-response instruments need predetermined descriptions of desirable teacher knowledge and beliefs as critical standards. But what are the predetermined descriptions of PCK? How to construct a selected response instrument that can measure teacher’s PCK? In this section two promising initiatives to develop such an instrument are discussed.

In his article on assessing teachers’ PCK, Carlson (1990) discusses three issues related to the development of multiple choice test items to assess PCK for a primary teacher licensure test. The first issue concerns the level of the test. It has to be clear what the aims of the test are. For example, a certification test asks for other item types than a licensure test. The second issue concerns the blending of pedagogical and content knowledge in test items in such a way that PCK is assessed, rather than simply testing pedagogical and content knowledge separately. Items in which the correct answer embodied both good pedagogy and correct content knowledge do not represent a blending of content and pedagogy. Instead, test items that require the application of pedagogical knowledge to specific content areas need to be constructed. The examinee will need to have knowledge of the subject or topic in order to recognize the correct application of the pedagogical principle. The problem that arises is that these applications need to be clearly correct, that is, they need to be empirically supported. A complicating factor is the limited consensus about the best ways to organize and present content in different subjects. The third issue concerns the credibility of items. Although Carlson used two criteria for correctness, i.e. empirical support and professional consensus, it was found difficult to write items with correct and convincing answers. As a solution, Carlson developed best-answer in stead of correct-answer items.

A second initiative to construct multiple choice test items to measure PCK was taken by Kromrey and Renfrow (1991). Their aim was to increase the practical value of teacher tests by constructing so-called ‘content-specific pedagogical knowledge (C-P)’ items. In line with Carlson (1990), Kromrey and Renfrow stated that the ability to answer a C-P item should require knowledge of subject content combined with general pedagogical knowledge and knowledge of specific pedagogical techniques. Their working definition is: “The class of C-P items includes those items for which the examinee’s determination of the correct response depends upon knowledge of the treatment of content in educational situations” (p. 5).

Kromrey and Renfrow discussed several practical issues that are related to the development of C-P items. They experienced that C-P items require more planning, writing and editing than for examples content items. An explanation might be that C-P items demand a metacognitive awareness of the teaching process. Besides, there are many reasonably correct answers to choose from. They advocated field testing as an important way to provide critical and valuable feedback for the revision of items.
Besides, more research is needed concerning the statistical properties of C-P items. Unfortunately, the work of Kromrey and Renfrow is not continued, but it could definitely serve as a good starting point. Critics of the use of selected-response instruments to measure PCK comment that a set of right answers do not exist, because of the specific content and context in which teaching and learning occurs. Consequently, a PCK item scenario needs to be described in great detail (Baxter & Lederman, 1999). An additional problem is the broad definition of PCK, or the unclear nature of the concept, which complicates the design of solid methods to examine PCK.

**Procedure**

With the complications of PCK measurement in mind, we needed to find a construction method that fits the current position of PCK in primary technology education. Oosterveld and Vorst (1996) made an overview of test construction strategies in the social sciences. Six basic construction methods, which focus on different psychometric criteria, were presented: the rational, prototypical, internal, external, construct, and facet method.

In our view, the prescribed conditions of the rational method match best with the current position of PCK in primary technology education. This method is classified as ‘intuitive’ and focuses on optimizing face validity. Personality tests, for instance, are often constructed according to this strategy. Rather than empirical data, judgments of experts are of particular importance for the specification and construction of items. This method is found to be especially useful if the central concept is conceptualized insufficiently and if empirical data is scarce. Both features apply to PCK in primary technology education, which makes the choice for this method of test construction a valid choice.

In general, the total period of test construction can be synchronically divided in seven phases: 1) specification of the theoretical framework, 2) construct analysis, 3) specification of item characteristics, 4) production of items, 5) judgement of items, 6) construction of the scale/instrument, and 7) validation of the instrument. Following the rational method, specifying the theoretical framework means forming a general, shared view of the construct, this is characterized as a working definition. The construct is analysed by describing typical phenomena or situations. It is of particular importance that the experts agree on the construct analysis. With the production of items, descriptions of typical situations are often used as item scenarios or contexts. The items are judged by the experts and their judgements form the foundation of the test/scale construction. The test is validated by comparing the results with the experts’ judgements (Oosterveld & Vorst, 1998).

Our expert team consisted of 7 members: 1 employee of the ministry of education in Belgium (specialized in primary technology education and a former primary school teacher), 1 primary school teacher (with a special task as technology education coordinator), 1 senior researcher in science and technology education (at the Eindhoven University of Technology), 1 retired science and technology teacher (at a primary teacher training college), and 3 science and technology teachers at three different primary teacher training colleges throughout the Netherlands.

The expert team had four successive meetings (each meeting lasting approximately 4 hours), which were led by the test constructor. A website was set up and used to share information, exchange documents, discuss and make announcements. The first meeting concerned an introduction to the research project, a specification of the theoretical framework, and a first analysis of the construct. Beforehand, the experts were asked to think of possible examples of PCK from their own experience and practice, which were shared and discussed with the group. In the second meeting the construct analysis was continued and complemented with a specification of the item characteristics. In this meeting a working definition of PCK was formulated: “PCK is the knowledge that a teacher needs in order to make the transition from his/her own content knowledge to the learning of pupils. In other words, PCK is the knowledge a teacher needs in order to relate his/her own knowledge to pupils’ knowledge.” The central aim of the third meeting was producing and rewriting PCK items. Prior to the
third meeting the experts were asked to write PCK items (at least 10 items per expert) following standard rules, collectively created item specifications and using an item template. It was found specifically difficult to formulate plausible distracters. Besides, a lot of discussion arose about the correctness of the best answer, which was supposed to be chosen by teachers with a lot of PCK. In general, the experts struggled with creating answers that reflected a correct fusion between content knowledge and pedagogical knowledge (i.e. PCK). In the fourth, and last, meeting all the produced items were judged by the experts and, if necessary, rewritten for a final time. With the use of a list of judgement criteria, pairs of experts judged the items produced by other experts. From the 52 judged items 40 items were selected for admittance in the first version of the PCK test.

After the last meeting, the test constructor compiled the first complete instrument, called the ‘Technology Didactics Test (TDT)’. Because 40 items in one test would make the test too long, two versions of the test (scale A and B) were constructed (2x20 items). The constructor had to take care of the similarity in difficulty and length of the two versions. Furthermore, in both versions, the entire construct of PCK should be covered, the items should involve different phases of a technology class (preparation, instruction/communication, and assessment) and the (technology) content of the items should vary. Meeting as much of these conditions as possible, the first TDT came into being.

Preliminary results

The 2 scales (A and B) were administered to most primary schools in the Province of Limburg (The Netherlands) that were involved in a governmental project on technology education. The distribution of the tests was done by e-mail. In total, 30 subjects filled out and returned the test. All subjects were primary school teachers in (Dutch) grade 6, 7 or 8 (pupils’ age 9-12 years). Scale A was made by 19 teachers (13 male and 6 female) and scale B by 11 teachers (6 male and 5 female). The mean age of the teachers was 43.3 years and their mean years of teaching experience 20.3. No significant group differences were found between teachers that made scale A and the ones that made scale B. After a first descriptive analysis of the items, three items (1 of scale A and 2 of scale B) were excluded for further analysis based on their absence of variance in responses, that is, (almost) all subjects chose the same alternative.

To detect meaningful underlying dimensions of the response alternatives of the items, Multidimensional Scaling (MDS) analysis was used. This was done because of the meaningfulness of rank-ordering the response alternatives of the items (from ‘no’ to ‘high’ PCK). Beforehand these alternatives were characterized as representing ‘high’ PCK, ‘low’ PCK, pedagogical knowledge or content knowledge. Furthermore, MDS provides more readable and interpretable results than other data reduction methods.

At a first glance, the MDS analysis of scale A showed that in a 2 dimensional model the pattern of variables (i.e. response alternatives) in the scatter plot is interpretable in a useful manner (Kruskal’s stress = 0.25). It seems that a cluster of ‘high’ PCK answers, and a cluster of ‘no’ together with ‘low’ PCK is formed along the two dimensions in the plot. Based on the 2-dimensional scatter plot, 6 items were excluded for further (exploratory) analysis. Removal of these items did not change the stress value (Kruskal’s stress was still 0.25), but did improve the interpretability of the scatter plot.

The MDS analysis of scale B showed a rather similar pattern compared with scale A (Kruskal’s stress = 0.26). The scatter plot of the 2-dimensional model could again be interpreted as two clusters of answers (high and no/low PCK). From this scale 5 items were excluded for further analysis, which did improve the stress value (Kruskal’s stress = 0.24) this time, as well as the interpretability. The exclusion of the items based on the MDS analysis is not definitive. It is very likely that several response alternatives need reconsideration by the experts, and that afterwards, several alternatives could be recoded (i.e. another response alternatives becomes the ‘high PCK’ answer). In this exploratory analysis of the data, the items are excluded for practical reasons only.
For each subject a PCK score is computed simply by counting all the ‘high PCK’ alternatives that were chosen by the subject. For scale A the mean PCK score was 7.8 (min.=0, max.=13), for scale B this mean score was 7.1. No significant difference was found between male and female teachers. Finally, the scales A and B, with both 13 items, were analysed on reliability. For scale A Cronbach’s alpha was 0.55 without deleting anymore items. For scale B Cronbach’s alpha was 0.60 only after deleting one more item. Although these results are acceptable for a first validation, the items obviously need revision in order to make the scales more reliable.

More profound statistical analysis is needed before any solid conclusions can be drawn. The data needs to be compared with other methods or instruments, which aim to measure PCK, and with control variables, for instance (technology) teaching experience, to guarantee external validity. In the nearby future the test will also be externally validated by correlating the test data with observation and interview data on PCK.

Conclusions and implications
Our multiple choice test for the examination of PCK in primary technology education is expected to have both scientific and practical implications. First, this new way of PCK measurement, with a focus on the cognitive part of PCK, sheds a new light on the concept of PCK and contributes to the conceptualization of the construct. Moreover, it allows researchers to easily examine larger sample sizes. In educational practice this test could be used as an assessment tool in primary teacher education and in relation to the professional development of primary school teachers.

References


Consideration of Teaching Method for Technology Teacher Training in the Technology Education Course of Education Faculty

Sumiyoshi MITA, Gunma University and Toshiki MATSUDA, Tokyo Institute of Technology, Japan
E-mail:sumita@edu.gunma-u.ac.jp

Introduction
We report the present condition of technology teacher training for a junior high school in Japan: the curriculum for technology teacher training, students' learning conditions, and a developed e-learning teaching material for improving the teaching method. This paper describes a teaching method for training technology teachers.

Technology teachers are trained in the technology course of the education faculty. However, most students of the technology course complete a liberal course of senior high school and have little 'manufacturing' experience. They typically acquire an elementary school teacher's license simultaneously with the junior high school teacher's license. The number of credits of subjects related to technology that those students take is limited in such cases. For those reasons, an effective and efficient teacher training method is necessary. One way of improving training methods is the application of e-learning teaching materials.

It is important to know how to solve technical design subjects through application of the knowledge of science and technology and learning essential principles of ‘manufacturing’. We have developed e-learning teaching materials for designing a car model to clarify this. We practiced application of the developed teaching material for students of the technology course and analyzed the learning effects from the viewpoint of the relation between the design ability and the learning conditions of fundamental knowledge about science and technology. We clarify the subject of the technology teacher education from the viewpoint of the teaching method.

A Technology Teacher Education Curriculum
The total learning time of technology and domestic science in junior high school is 175 unit times during 3 years: 70 unit hours in the 1st grade, 70 unit hours in the 2nd grade, and 35 unit hours in the 3rd grade, where one unit hour is 50 min. The school hours of technology and domestic science are shared equally.

The technology area comprises the two fields of 'technology and manufacturing' and 'information and computers'.

Technology and Manufacturing
• The role of technology in life and industry
• Product design
• Way of using tools, machines and processing technology
• Structure of machines used for production and maintenance
• Design and manufacture of products that apply energy conversion technology
• Crop cultivation
• Technology related to woodwork, metalwork, machinery, electricity and cultivation as necessary for manufacturing.

Information and Computers
Many subjects are prepared by the program of technology education course in the Department of Education in accordance with these above contents. Numerical values inside the parentheses show the numbers of credits.

**Learning Conditions of Students in the Technology Course**
Students do not learn technology systematically to choose subjects of the curriculum independently. Particularly, students who want to be elementary school teachers do not learn technology systematically because they learn only the smallest number of subjects.

Moreover, many students have learned chemistry and biology in sciences at senior high school, and most students of the technology course have not learned physics as the foundation of physical manufacturing. Furthermore, technology education as part of a liberal education in Japan typically includes only technology and domestic science in junior high school. Students in many cases learn only the subject ‘information’ and not manufacturing technology in senior high school.

**Teaching Material of E-learning based on the Relation between Science and Technology**
We have developed a design learning support system of a car model using a simulation and gaming system developed by Dr. Matsuda (Matsuda, 2003).

The concrete design subject is designing a car model that can raise a 150-g mass. This design subject includes knowledge of dynamics and technology: force, moment of force, friction, centre of gravity, motors, and gears.

Text information concerning basic knowledge and theory, image information concerning the design subject and elements, analysis models based on dynamics, experiments concerning dynamics, and simulation based on dynamics are all developed as teaching materials.

Results of practice using this system clarified that it is necessary to help students to learn the basis of dynamics (Mita, Matsuda, Iwaki and Furuta, 2006). Furthermore, it is difficult to do learning on the Web and actual ‘manufacturing’ work in parallel.

The following functions were developed using Java Applets and were added to the system for solving these subjects.

Function 1: Forces working between elements: gravity, normal force, frictional force, tension and so on, are presented visually to students as feedback information, and students can understand the basis of dynamics.

Function 2: Students can experiment to verify design results on the Web.

Two simulators are developed to verify whether the design of the mass and the centre of gravity of the model car are correct or not and whether the model car can raise the weight or not.
Dynamics: The name and the vector indication of forces; Force Balance; Frictional Force and Frictional Coefficient; The moment of force; The balance of the moment of force; The centre of gravity; Work, Power; Power Transmission

Technological Design: Gears

Therefore, the developed teaching material includes the two teaching materials of dynamics and technological design.

Teaching materials of dynamics:
Step 1: Introduction – The need to learn dynamics.
Function 1 is included to help students to solve problems.

Teaching materials of technological design:
Step 2: Students design the model car and produce a design sheet.
Step 3: Check of the design sheet using the teaching material. The gear mechanism design: The required pulling force. Design of the mass and the centre of gravity of the model car: the required frictional force
Step 4: Assembling a car model and performance test.
Function 2 is included to help students to verify the design result.

The following knowledge is included to support students' design activities: Specifications of motors, gear reduction and spur gears. Gear trains and their output torque
Analytical Model of friction force acting between the tire and road
Analytical Model of force acting on a car model
Analytical Model of force transmission in the gear train
Method of measuring a centre of gravity

Assessment of Teaching Material and Teaching Program
We verify the following teaching methods of the basis of physics related to physical manufacturing and the practical learning of manufacturing using the developed teaching material.
Teaching Method A: Students learn the basis of physics related to manufacturing after solving a problem related to manufacturing.
Teaching Method B: Students grapple with solving a problem related to manufacturing after learning the basis of physics related to manufacturing.
Teaching Method C: Students learn the basis of physics related to manufacturing by solving problem related to manufacturing.

The subjects of the evaluation experiment are 11 students of the technology course of education faculty: four second-grade students and seven fourth-grade students. About half of these students had not learned physics in senior high school, and most students do not learn technology systematically based on the curriculum. Therefore, many students do not satisfy the precondition of development of the teaching material.

Students' basic scholarship was confirmed before the evaluation test.
Students were separated into two groups: group A included the second-grade students and group B included the fourth-grade students. Students of group A grapple with learning dynamics and designing the model car through the developed teaching material after assembling the model car and performance-testing it. Students of group B grapple with assembling the model car and performance test after learning dynamics and designing the model car through the developed teaching material.
The advanced design subject of designing "a car model to climb the slope of 30°" was assigned to
students; students produced a design sheet of the advanced design subject and reported it.
The developed teaching materials were evaluated based on the evaluation result of the pre-test and the
post-test of dynamics and the design sheet of the advanced design subject.
The design sheet of the advanced design subject was evaluated based on the following items. A perfect
score is five points.

Items for evaluation: Composition of the design sheet; The frictional angle; Examination of the
frictional coefficient; Components of the car model and the centre of gravity of the body; The
normal force acting on the driving wheel; The frictional force acting on the driving wheel; The
forces acting on the object put on the slope and the power; The transmission ratio; The force acting
between the driving wheel and the road surface

Program for Evaluating the Developed Teaching Material:

Group A (2nd grade)
Production and Performance Test of Model Car
Learning Using the Teaching Material of Dynamics
Pre-Test
Designing Model
Car Using the Design Support System of the Model Car
Design of the Advanced Design Subject
(Design of Car Model that can climb a slope of 30°)
Post-Test
Group B (4th grade)
Learning Using the Teaching Material of Dynamics
Pre-Test
Designing Model Car Using the Design Support System of the Model Car
Production and Performance Test of Model Car
Design of the Advanced Design Subject
(Design of Car Model that can climb a slope of 30°)
Post-Test

Results of the assessment
The required time for solving a problem
The required mean time for solving problems of basic dynamics
Force Balance of Gravity, Normal Force and Friction Force: 26.8 min
Moment Balance of Gravity and Normal Force and Centre of Gravity: 30.1 min
Moment Balance of Gravity and Normal Force and Centre of Gravity: 17.5 min
The Integrated Problem related to Balance of Force and The Moment of Force: 18.1 min
Total Mean Time: 92.5 min
The required mean time for decision-making related to the design value in designing the model car
Friction Force and Friction Coefficient: 10.3 min
Traction Force: 28.5 min
Design Check: 59.1 min
Total Mean Time: 97.9 min
The respective mean times for solving problems of basic dynamics and designing the model car are
about 90 min

Results of Evaluation Test (Percentage of correct answers)
Pre-Test Group A: Mean 43, S.D. 9 Group B: Mean 61, S.D. 14
Post-Test Group A: Mean 83, S.D. 5 Group B: Mean 88, S.D. 11
No significant difference was revealed by the post-test, but a difference was apparent between group
A and group B by the pre-test from results of the evaluation test. Furthermore, the basic scholarship
of all students of groups A and B was improved.

Evaluation Results of the Design Sheet concerning the Advanced Design Subject
The design sheet of the advanced design subject is evaluated using the following criteria.

Composition of the design sheet: 6.2 (10 points = perfect score)
Consideration of the friction angle: 3.6 (5 points = perfect score)
Consideration of the friction coefficient: 4.9 (5 points = perfect score)
Determination of the centre of gravity of the car, including parts and body: 4.4 (5 points = perfect score)
Determination of the normal force acting on the driving wheel: 4.5 (5 points = perfect score)
Determination of the frictional force acting on the driving wheel: 4.7 (5 points = perfect score)
Determination of forces acting on an object put on the slope: 4.7 (5 points = perfect score)
Determination of the transmission ratio of the gear train: 3.1 (5 points = perfect score)
Determination of the force that the tire exerts on the road surface: 4.8 (5 points = perfect score)
The total points of these evaluation points are divided by 10. A perfect score of the design sheet is 5.
Group A: Mean 4.3, S.D. 0.4  Group B: Mean 4.0, S.D. 0.4
No significant difference was found between group A and group B from the evaluation results of the design sheet.

The coefficient of correlation between the pre-test and the post-test is 0.33. The coefficient of correlation between the post-test and the required time for learning through this teaching material is 0.07. The learning achievement does not depend upon the learning time, but it depends upon learning deeply.

The basic scholarship and the application ability of students of both groups A and B were improved when the learning effect through the developed teaching material was evaluated synthetically from results of the test and the design sheet.

The results described above show that students can master basic scholarship independent of their personal learning history by forming the basic learning and practical learning skills.
Students can master basic knowledge and practical abilities effectively and efficiently using the developed teaching materials.

Students’ Responses
Students completed the following questionnaire.
Learning Experiences:
Have you ever learned about dynamics?  Yes: 100%  No: 0%
Have you ever learned about gears?  Yes: 64%  No: 36%
Have you ever learned about machine design?  Yes: 55%  No: 45%
Have you ever made a thing that moves?  Yes: 82%  No: 18%

The subject and its difficulty: The design, production and performance test of the model car
Were you interested in this subject?  Mean 4.5 (5 points = perfect score)
Did you think that the subject was difficult?  Mean 2.5 (5 points = perfect score)
Did you think that this subject was easy before you attempted it?  Mean 1.6 (5 points = perfect score)

Learning through this teaching material:
Did you learn the basis of dynamics through this dynamics teaching material?  4.5 (5 points = perfect score)
Was this teaching material of the car model design easy for you to use?  4.3 (5 points = perfect score)
Was this teaching material useful to design a car model?  4.7 (5 points = perfect score)
How to use this teaching material:
Teaching plan A – learning is better using this teaching material after production and performance tests of the car model.  Agree: 27%
Teaching plan B – learning is better using production and performance testing of a car model after learning using this teaching material.  Agree: 64%
Teaching plan C – learning is better using learning with this teaching material and production of the car model at the same time. Agree: 9%

Although this teaching material was difficult for students, they were interested in and grappled with this subject. They solved this design subject using the teaching material. Moreover, they answered that teaching plan B is better as the teaching method.

Conclusion
E-learning teaching materials of dynamics and design were developed. Students of the technology course in education faculty learned dynamics and design through the use of this teaching material. Results of practice using the developed teaching material clarified that students can master basic ability and practical ability without depending upon their personal learning history. The developed e-learning teaching material integrated the basis and the application is a useful teaching method for training technology teachers within the limited number of credits.

References
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Exploring Creativity and Progression in transition through “Assessment is for learning”

S.V. McLaren, University of Strathclyde, Glasgow, Prof. K. Stables and J. Bain, University of London, UK.
Email: s.v.mclaren@strath.ac.uk  k.stables@gold.ac.uk

Outline
This paper provides an overview of the aims, methods and findings of the Capability and Progression in Transition through Assessment for Learning in Design and Technology (CAPITITAL-DT) project. This project, funded by Determined to Succeed Scotland, aimed to identify useful approaches to aid progression in creativity through the current initiative entitled ‘Assessment is for learning’ (AifL, SEED, 2002). AifL encourages learners and teachers to engage with assessment for, as, and of learning and adopt a range of strategies and ideas. The project team gathered baseline and follow up data from teachers and learners using questionnaires to gauge attitudes towards creativity, structured conceptual design activities to assess performance, learner evaluations and teacher interviews. The team concludes that there is scope for adopting the tools explored to support formative and sustainable assessment strategies and approaches to gathering meaningful indicators that can be embedded into enterprising teaching and learning for Design and Technology Education.

Introduction/ Background

The National Guidelines for 5-14 Environmental Studies (1993) described for the first time the required learning for Science, Social Subjects, Technology Education, Health Education and Information Communications Technology for children aged from 5 years to 14 years old in Scotland. Problems with the implementation in schools, both primary and secondary, led to a review and revision of the guidelines. The revised guidelines Environmental Studies: Society, Science and Technology (LTS, 2000) simplified the language, terminology and clarified the intended purpose of technology education.

Standards and Quality in Primary and Secondary Schools: 1998-2001 (HMI 2002) identified weaknesses in technology, the majority of schools achieving only ‘fair’ or ‘unsatisfactory’. Only a minority of learners’ were found to be skilful in designing and making and had a good understanding of the impact of technology on society. Limited understanding of technological capability (SCC, 1996) had resulted in a tendency for the teacher to focus on the production of a product rather than the thinking skills, creativity, processes, exploration of issues and key learning involved.

Jones & Compton (1998) concluded that embedded and informed practice requires teachers to develop a personal technological knowledge base through practice. Teachers should also be able to reflect on and critically analyse the rationale, purpose and worth of such learning for their learners (Fox-Turnbull, 2006). In order to help teachers identify pupil’s learning, strengths and areas for development, teachers require useful and meaningful tools to help them and their learners form judgements on progress and identify ways forward to develop technological capability.

Two current initiatives in Scotland ‘Assessment is for learning’ (SEED, 2002) and ‘A Curriculum for Excellence’ (SEED, 2004) contribute towards ‘Ambitious Excellent Schools’ (SEED, 2004) and aim to improve the educational experience and achievement of youngsters. The development of technological capability has a significant role to play within these developments (HMIE, 2004). But there is concern that due to historical reluctance to change and adapt, the potential Technology Education offers learners may not be exploited. (Dakers, 2005)
To date, learning, teaching and assessment methods have all too often distorted the very nature of creativity and innovation and resulted in students ‘jumping through hoops’, taking a highly strategic approach to their work. Hayward, Kane, Cogan (2000) caution against creating assessments that dominate and encourage strategic learning. An example of this in Design and Technology Education is where a ‘design folio’ becomes a product in itself rather than a record of the journey involved in the design thinking (Kimbell et al., 2002). There is evidence (e.g. Atkinson, 2000; Barlex and Welch, 2004; Kimbell, 2002; McCormick and Murphy, 1996; McLaren, 2003) that learners are being asked to follow a template or formulaic approach to designing. This reduces design activity to a series of steps that limit thinking, risk taking, spark generation, development and collaboration and therefore limits learning and rewards ‘playing safe’, leading to what Lave (1988) calls a ‘veneer of accomplishment.’ It also may result in a dependency culture and does not empower learners with sustainable assessment strategies that involve them directly in their own progress. (Black and Wiliam, 1998)

Purpose of the research study
This study aimed specifically at supporting the development of learning and teaching in technology education through focusing on assessment for learning with an emphasis on creativity, targeting learning and teaching at the transition between primary and secondary schools (McLaren et al., 2006; Bain and McLaren 2006; Stables, 2006). The approaches developed, data gathered and subsequent analysis aimed to inform recording and monitoring methods by providing an informative record of performance for individuals and class groups, whilst encouraging a related, reflective personal learning planning process.

The questions framing the exploration were grouped into four aspects:

- Value and attitudes towards Creativity (teachers and learners);
- Self and peer evaluation;
- Learner progress;
- Relationship between learner attitudes, evaluation and performance.

Research Design

Method
The study involved learners from 7 schools, in two different Scottish local authorities at a time of transition to new class or from primary to secondary. The participants (n=225) were in Primary 6 (10-11 years old), primary 7 (11-12 years old) and secondary 1 students (12-13 years old).

Three categories of research cohorts were created to take a quasi-experimental approach in the 9 month period between baseline and follow-up data collection:

- an intervention cohort, where teachers were given support in the development of technology education, creativity and assessment for learning practices;
- an in-the-know cohort, where no support was given, but where the teachers were present at all teacher meetings for discussion and explanation of the project;
- a control cohort, where teachers had no involvement with the project.

Survey Instruments
A dataset of 124 learners was created from those completing all aspects of the survey:

- a ‘Learner Attitudes Towards Creativity’ questionnaire;
- an ‘unpicked portfolio’ type performance activity (Stables & Kimbell, 2000; Kimbell et al., 2004);
- a ‘learner evaluation’ questionnaire.

The ‘Attitudes to Creativity’ questionnaire drew on methodology first developed through PATT research (Raat et al., 1987) and presented a set of statements about creativity (e.g. “Creative people
can improve other people’s lives”, “Being creative is difficult”) which required a response on a 4-point Likert scale. It also included a free response question - “in your own words write down what creativity, or being creative, means to you”. Teachers completed a parallel questionnaire.

A ‘Learner Evaluation’ questionnaire asked the learners to record their agreement / disagreement with statements (again on a 4-point scale) about why they liked/disliked the activity and what it had allowed them to demonstrate. To probe further they were asked to note three things they felt they had learned and three things they would like to get better at. Each participant was prompted by the following stem sentences:

- I was best at…
- The easiest thing was…
- The most difficult thing was…
- Today I learned…
- I want to get better at…

For both questionnaires the scaled responses were analysed quantitatively and the free response and stem sentences were analysed using derived content analysis.

The outcomes of the performance activities were assessed using a rubric that provided criteria for assessing holistic performance; performance of having ideas; growing ideas (though modelling); growing (optimising, developing, refining, dealing with complexity) and proving (testing, criticality, reflection and thoughtfulness). Each of the qualities was characterised by criteria organised on a four-point continuum, each point then subdivided into low, mid and high, providing a 12-point scale for each quality. The criteria for having ideas is given as an example.

Figure 1: Criteria for having ideas

<table>
<thead>
<tr>
<th>having ideas (sparkiness)</th>
<th>eg. explicitly choosing a risky task or expressing a risky idea; dicing on the edge; suspending reality; bending rules; courting failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>looking for starting points...</td>
<td>eg. suspends reality &amp; take on challenge; running with risky ideas towards unknown, but under cautious</td>
</tr>
<tr>
<td>risk/comfort zone getting outside conventional constraints</td>
<td>eg. plays at the edge of a safe task or idea; sets them on the path to achieve something new; dipping toes in</td>
</tr>
<tr>
<td></td>
<td>eg. plays safe; works within existing experience/reality repertoire; needs a ‘kick start’</td>
</tr>
</tbody>
</table>

The activity booklets also provided evidence of peer support in idea generation and concept development, peer and self-evaluation.

This paper focuses on the relationship between learner attitudes towards creativity, evaluation and performance.

**Findings**

The base-line and follow-up activities provided a variety of data. The assessment judgments allowed performance groupings to be created. These were:
Consistently high performers;
Consistently middle performers;
Consistently low performers;
Those who improved and those whose performance diminished.

Generally, the learners’ attitudes towards creativity did not shift to any significant degree over the 9 month duration of the project. The data indicates that although most learners thought that ‘being allowed to be creative is more fun’ only 50% of the sample group agreed that ‘projects where you have to follow instructions are boring’. The majority (94%) agreed that ‘you can learn to be creative’ and that ‘everybody can be creative in their own way’ (98%). However, a significant majority (71%) agreed that high marks can be obtained in technology education without being creative. This was echoed in the responses from the teacher survey. The teachers and learners were of differing opinions when considering whether creative people break rules. Initially only 19% of the learners thought creative people break rules, rising to 32% on follow up questionnaire to learners. Whereas 92% of the teacher sample indicated they believed creative people break rules.

However, further analysis indicated that there was a difference in thinking between the ‘high performers’ and the other learners in this, and a range of other, aspects, these ‘high performers’ often having similar responses of the teachers. (Stables, 2006)

**Illustrative samples of learner profiles**

The learners were required to record peer and self evaluation comments at specific stages during the activities. To identify trends and patterns in responses, comments were grouped and compared using the performance categories identified above.

Consistently low performers were typically limited in their comments to their peers and to themselves. Most frequently used phrases included, ‘I like what I have done’, ‘I thought it was good’, ‘It’s a good idea’, ‘ok’, ‘It was good it turned out well’, ‘I think I could do better…’ By contrast, high performers tended to relate comments to process, quality and design issues of function and intended market. For example, in Activity 1, learner no.07/02/45/7 identified the strengths ‘I think I have managed to make a rough idea of what it should look like. It looks cute and would not scare children and has a safety catch.’ The learner was also able to identify weaknesses and wrote, ‘I would try to improve its safety make it all the same colour scheme.’

![Figure 2](image.png)

**Figure 2.** Sample from Activity 1 booklet and accompanying learner evaluation

The comments of improved learners tend to show a deeper level of reflection on their own work and that of others in activity 2 and when compared to activity 1. This critique included issues of quality of their model; usability/practicality of the design idea; aspects of process of thinking, planning and...
taking action. For example, learner01/01/12 acknowledged the most difficult thing in activity 1 was ‘commenting on others’ and there was evidence that this learner attempted to improve the comments written to self and others in activity 2. This learner also changed in terms of their perception of creativity from something that gives ‘a better chance of passing test’ to meaning ‘thinking up and putting an idea forward’, and ‘making things out of your ideas.’

Likewise, learner 07/02/16/7 acknowledged the most difficult thing in activity 1 was ‘answering and commenting’. Improvement was evident in activity 2 where the comments to self and to others consider the idea in terms of the user and purpose of the design.

<table>
<thead>
<tr>
<th>Improved learner</th>
<th>+ strengths</th>
<th>- weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>To self 07/02/16/7</td>
<td>Act 1</td>
<td>I think it was an alright idea.</td>
</tr>
<tr>
<td></td>
<td>Act 2</td>
<td>It’s a good idea with the sticking to your jacket</td>
</tr>
<tr>
<td>07/02/16/7 to 07/02/45/7</td>
<td>Act 1</td>
<td>I like the way it won’t get in your way</td>
</tr>
</tbody>
</table>

Figure 4. Sample statements from Activity booklets 1 & 2 by improved learner

A sample profile of a learner who displayed a drop in performance is illustrated below (figure 5). As noted in the accompanying learner evaluation (activity 1) learner no. 4/02/19 wanted to get better at ‘evaluating’, and learned ‘how to help others and work as a team’. After activity 2, he acknowledges ‘I was not very good at coming up with ideas’ and ‘not very good at making models’. He thought he was best at ‘commenting on other people’s work’.

<table>
<thead>
<tr>
<th>Drop in performance</th>
<th>+ strengths</th>
<th>- weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>To self 4/02/19</td>
<td>Act 1</td>
<td>it is good how it recharges</td>
</tr>
<tr>
<td></td>
<td>Act 2</td>
<td>-----------</td>
</tr>
<tr>
<td>4/02/19 to 04/02/18</td>
<td>Act 2</td>
<td>great idea – it is a little too big</td>
</tr>
<tr>
<td>4/02/19 to 04/02/07</td>
<td>Act 2</td>
<td>I think it is great so far – it is nice and light for the running about,</td>
</tr>
</tbody>
</table>

Figure 5. Sample statements from Activity booklets 1 & 2 by learner

The post activity learner evaluations indicated similar trends in the focus of responses and in learners’ self-awareness.

Profiles of consistently high performers indicated these learners evaluate using a greater variety of factors than lower performers and have a higher awareness of their own strengths and weaknesses. Words such as ‘thinking’, ‘choosing’, ‘designing’, ‘planning’ feature more frequently in their learner evaluations. For example, learner 07/02/35/7 identifies that the most difficult aspect is ‘thinking about what to make’ (Activity 1) and again ‘thinking how you would make it’ (Activity 2). She has learned she ‘can think of good ideas’ (and indeed she scored a 7 in ‘having’ Activity 2) Her targets include ‘thinking up more things’ and ‘getting good ideas.’
This contrasts with consistently low performers who tend to be less aware of their own learning and set targets related to modeling rather than nuanced statements about quality, thinking, choosing and planning, for example. Typical low performer statements can be exemplified by ‘doing the modelling’; ‘using the glue gun’; ‘cutting the paper’; ‘cutting out’; ‘sticking’; ‘making’. Generally there was very little difference in any of their comments prompted by the evaluation i.e. best at, easiest, most difficult, learned and want to get better at.

For improving performers there is not much evidence to indicate a high level of maturity or self-awareness in the words recorded. However, the comments did display glimpses of reflection and becoming meta-cognitive, e.g. ‘thinking what I should do better’; ‘thinking up my ideas and planning them’; ‘thinking of ideas’; ‘sorting things out’. Interestingly learners in this performance group commonly wrote words that implied:

- caution and / or low self esteem e.g. ‘I am not very good at this’; ‘I am not very good at planning’; ‘difficult to think what to do’;
- surprise at what they had achieved or learned about themselves e.g. ‘I was good at making models’; ‘I can think up ideas’; ‘that you can have many good ideas but not know it’; ‘that sometimes I can be good at things’; ‘I can help other people with my idea’.

Learners whose performance dropped in Activity 2 tended to have made little effort to evaluate and record what they wanted to get better at, showed little interest and often indicted a level of low self esteem and lack of motivation. Target setting in terms of ‘I want to get better at...’ was related to making, if anything was noted at all. For example, Learner 06/01/25 in Activity 1 was best at ‘designing things’ and learned ‘how I enjoyed it so much’. This altered in Activity 2 where aspects of making, cutting, sticking and gluing became the focus for what she thought she was best at and what she had learner. The most difficult thing was the noted as being the same as that which she identified as wanting to get better at ‘trying not to get burned’.

It is important to note here that there was a strong school effect evident in the profiles of consistently high and consistently low performers, those who improved and those whose performance dropped. There were more consistently high performers and ‘improvers’ in the intervention groups and more consistently low performers and drops in performance in the control groups.

Discussion
This study illustrated that many learners, particularly the high achievers, are indeed aware of their own strengths and weaknesses. The target setting, ‘I want to get better at’ was completed by the majority of the learners relative to what they thought had been easy, best and most difficult and this is borne out as being highly relevant when examined in the context of their performance scores.

Low achievers seem far more unaware of their learning and as a result target setting remains very focussed on modelling related aspects. Whilst being less able to recognise the complexity of the various aspects involved in designing, many of the targets do show a continued willingness to learn and a desire to develop their skills. This ought to be exploited further and indicates potential in terms of achievement, if not attainment, to be recognised and celebrated as in keeping with the principles and capacities of ‘A Curriculum for Excellence’ (SEED, 2004).

At no time during the test activities, nor during any of the intervention sessions, did a learner ask what mark they were getting or how the work was being assessed by the teacher. There were many opportunities to make comments to self, to others, and to receive comments from others and this may have superseded the need for feedback from teacher at this time. Engagement in creativity appears to have a positive correlation with intrinsic motivation and the learners, particularly high and improving performers, displayed a good level of self efficacy. (Bandura, 1977; Lepper et al., 1973)
In addition to performance being judged holistically and in aspects of having, growing and proving, Design and Technology domain specific basic knowledge, domain specific design knowledge and general process knowledge/transferable knowledge and skills (Christiaans and Venselaar 2005) were tracked. This indicated further potential for the approach to allow both learners and teachers clearer insights into personal learning needs for progression that could be utilised in personal learning planning processes (LTS, 2004) and meaningful target setting.

Learner evaluation data reveals that the consistently higher performers and the improvers demonstrated a better understanding of technological capability while the lower performers focused on production of the product. Interestingly, this is in line with research into teachers identified earlier (e.g. Harlen et al, 1995 & 1997, Jones & Compton, 1998). A key feature of this study is that the performance data indicates that learners who were part of the intervention groups progressed more than those who were not. Learners who were in intervention groups were more likely to perform better and, through their learner evaluations, showed increased awareness of what contributed to improving their performance. The performance and learner evaluation responses indicate that the learning and teaching intervention strategies have, by incorporating aspects of teacher, self and peer assessment with a view to aiding progression, contributed to establishing a basis for students to undertake their own assessment activities in the future (Boud, 2000).

**In summary**

*The learners …*

The learners were generally motivated by the performance assessment activities and sustained engagement for the duration of the task. Comments offered by learners indicate an enthusiasm and the improvement in performance for the majority of the learners may be part due to novelty since ‘successful learning takes place when pupils are highly motivated, interest and curiosity is aroused’ (HMIE, 2000). The activities met a wide variety of learning preferences and styles through the range of approaches and sub-task types, and resources and yet were tightly structured through sub-task and time ‘milestones’ (Cross, et al.1996). The opportunity to engage with 3D sketch modeling was a key element to maintaining engagement.

*The teachers …*

The interviews with the teachers involved in the project revealed a willingness to adopt some of the underpinning concepts of the ‘unpickled portfolio’ approach. It was thought that the experience illustrated the potential to move away from a linear design approach ‘formula’ whilst providing a clear framework for design activity. The approach taken for the assessment of performance activities 1 and 2, and any intervention, contrasted with strategies more commonly used which are based on teacher demonstration with learners doing as teacher had shown.

Teacher no.01/01 was ‘surprised that the pupils didn’t question more’. Teacher no. 02/07 intends to ‘deviate from insisting everything should be written down’ and noted that the learners ‘loved all of it - they were very focussed and concentrated for long spells’. The experience has provided the confidence to allow her to let her pupils do D&T - especially 3D modelling.

Although some of the teachers were familiar with learner self evaluation of product outcomes, showing and inviting peer comment on initial design concepts and models at interim stages was a new strategy and was received positively. The teachers recognised that more work was needed to develop the vocabulary and skills of peer support related to design thinking and felt that this would be of value. Teachers acknowledged that their current assessment strategies, if indeed in existence, were more heavily weighted towards the practical outcome and less towards process and designing. The use of photos taken and logged at various junctures of the work as ongoing was also novel for the teachers and was an approach which most felt would be easily integrated and would be worthwhile. They recognised that the ‘unpickled portfolio’ has potential to be adapted and developed to create further learning opportunities.
Many personal qualities were demonstrated by the learners e.g. recognising the need for creativity and perseverance, supporting others, self-realisation of having achieved success and having a ‘can do’ attitude. Through the learner’s own attitudinal comments, this study illustrates that Design and Technology has the potential to foster personal qualities, attitudes and dispositions, particularly those pertaining to enterprising thinking and creativity which are valued as central to citizenship in the 21st century (Kimbell and Perry, 2001; SEED, S004).

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Abstract
This paper reports on a survey aimed to elicit students' understanding of technology. The survey was carried out with over 200 students of Grade 6 (11-14 years old) from schools in and around Mumbai, India. Two questionnaires: ‘technology-as-objects’ and ‘technology-as-activities’ were administered followed by interviews on a sub-sample. Analysis indicates that objects and activities related to communication and transport, especially modern gadgets used in urban areas were often considered technological. Objects presented along with humans were perceived more related to technology than objects alone. Most interviewed students had consistent reasons for associating objects and activities with technology. They believed that technology has existed in the recent past, has evolved and is ubiquitous now. Scientists and researchers were credited with creation of technology while others were mere users. The utilitarian and human-made nature of technological artefacts and its role in speeding work were emphasised as reasons for associating objects and activities with technology.

Introduction
Technology is embedded in culture and is reflected in a spectrum of artefacts and processes. The term is used variously to convey the modification of environment, design, and the social, cognitive, affective and material interactions involved in the process (Natarajan, 2004). It conjures up multiple meanings and images in differing contexts. The lay understanding of the word ‘technology’ is mostly associated with ‘hi-tech’ artefacts such as, computers, satellites, nuclear technology etc. (Rennie & Jarvis, 1995; de Klerk Wolters, 1989)

In schools where technology education is presented formally as a school subject, the curricula present technology as a problem solving activity that focuses on skills of investigation, designing, planning, evaluating and making or as STS – the science, technology and society approaches that focus on creating awareness of technology and emphasise its historical, social and philosophical dimensions (Kimbell et al, 1996). With these multiple approaches and views on technology, students and teachers may have difficulty in reconciling the lay views of technology with those presented by curricula. Besides, teachers need to know students’ conceptions in order to provide suitable learning environments (Driver et al, 1994).

Gender and experiences in school and at home (MacKenzie & Wajcman, 1999) as well as interactions with technological artefacts influence attitudes of individuals towards technology (Volk et al, 2003). To explore these aspects, there have been numerous PATT (Pupil’s Attitude Towards Technology) studies conducted across the globe (Bame et al; 1993, Correard, 2001).

A few efforts have been made in India at learning students’ ideas about technology (Rajput et al, 1990; Bhattacharyya, 2004). But there is a need for more in-depth studies. Indian schools do not have formal technology education and hence student’s ideas of technology are more likely to be influenced by factors other than school. This survey served as a precursor and input to the research and development of design and technology (D&T) units at the Homi Bhabha Centre for Science Education, Mumbai for introducing technology education at the middle school in India (Choksi et al, 2006; Khunyakari et al, 2007). We aimed to see how ideas about technology among Indian students from urban and rural areas, from different media (languages) of learning and girls and boys compared with those of students from other parts of the world.
Methodology

The survey questionnaires inspired by the PATT instrument aimed at measuring students’ attitudes towards technology. While attitude is a complex psychological concept having interrelated components of affect, behavior and cognition indicative of underlying belief or value (Shrigley et al, 1988), in this paper we have aimed at knowing the overall concept that students have of technology.

For our study we developed 2 pictorial questionnaires for use with Grade 6 (11-14 years) students. In both the questionnaires, students were given written and verbal instruction to circle the pictures that they felt had something to do with technology. One questionnaire focused on technology-as-objects (TAO) and the other on technology-as-activities (TAA). The questionnaires were initially prepared in English and later translated to Marathi (vernacular language of the State of Maharashtra) for use in Marathi medium schools.

The responses to the questionnaires suggested some patterns in students’ conceptions of technology. Interviews of some students followed the questionnaires and were aimed at a detailed exploration of the reasons for associating objects and activities to technology. The questions focused on aspects covered in the questionnaires, such as, users/creators of technology, temporal aspects of technology, locales of technology, gender and technology, what is ‘not technology’, and words, objects and activities associated with technology.

**Technology-as-objects (TAO):** This questionnaire consisted of 30 pictures of objects associated with ten categories: sports, agriculture, school, music, household, workplace, transport, communication, warfare and natural objects. Our selection of categories and the pictures in the categories was guided by the fact that our sample would have rural and urban students as well as girls and boys. In an earlier study involving students’ drawings of ‘image of science/technology’ we found that students often drew images of science or technology as related to communication, transport and warfare, in locations outside the classroom (Mehrotra et al, 2003). To focus on locations we included categories such as, school, household and workplace. For the rural context we included agriculture. Sports and music were included for their familiarity in both school and outside school contexts.

Each category had pictures that focused on aspects of ‘time’ or tradition/modernity. For example, in the transport category, there were pictures of bullock-cart, and airplane, while in the warfare category there were pictures of bow and arrow, tank and gun. Additionally, we had a category that could be termed ‘natural objects’ or ‘no technology’ (flower, sun) as we were interested in knowing how students would deal with this category of objects. The TAO sub-part was used in our earlier work with Grade 8 students and a reliability score 0.9 (alpha-coefficient) had been established (Khunyakari et al, 2003).

**Technology-as-activities (TAA):** This questionnaire depicted activities related to categories in the TAO questionnaire. Most pictures showed humans involved in an activity and there were a few pictures without humans (waterfall). Two alternate forms (A and B) were developed, with 24 pictures each. Both forms had some activities being done by males and some by females. If an activity in form A was shown as being done by a male then in the alternate form it was depicted as being done by a female. Students were asked to write “T”, if they thought that a picture was related to technology, and “N”, if they thought that the picture was not related to technology. This questionnaire was aimed at eliciting students’ ideas about technology in activities and gender stereotypes, if any. Test-retest reliability for TAA was 0.76.

Sample
The *TAO* questionnaire was administered to 343 students studying in Grade 6 from 8 schools in and around Mumbai, India. The details of the sample are given in Table 1. The two forms of the *TAA* questionnaires were administered to 201 students of Grade 6 in 4 of the schools with an interval of 5 days. On an average, students took 20-25 minutes to complete each questionnaire. *Interviews* were conducted with some students, who had already responded to the questionnaires from both the rural and urban settings. Care was taken to have an equal representation of boys and girls. Responses of the students were audio-recorded and detailed notes were also taken.

### Table 1: Sample composition

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology-as-objects (TAO)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>88</td>
<td>73</td>
<td>161</td>
</tr>
<tr>
<td>Boys</td>
<td>126</td>
<td>56</td>
<td>182</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>214</td>
<td>129</td>
<td>343</td>
</tr>
<tr>
<td><strong>Technology-as-activities (TAA)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>65</td>
<td>49</td>
<td>114</td>
</tr>
<tr>
<td>Boys</td>
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<td>27</td>
<td>87</td>
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<tr>
<td><strong>Total</strong></td>
<td>125</td>
<td>76</td>
<td>201</td>
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<td><strong>Interviews</strong></td>
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<tr>
<td>Girls</td>
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<td>Boys</td>
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<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>11</td>
<td>7</td>
<td>18</td>
</tr>
</tbody>
</table>

### Results

**Technology-as-objects**: In response to the *TAO* questionnaire we observed that all pictures in all categories were related by some students to technology. There was no picture that was not related to technology by any student. Table 2 presents the objects within each category and the percentage of students stating the objects were related to technology.
### Table 2: Percentage of students relating objects to technology

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>84</td>
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<tr>
<td>Transport</td>
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<tr>
<td></td>
<td>87</td>
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<tr>
<td></td>
<td>83</td>
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<tr>
<td></td>
<td>61</td>
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<td></td>
<td>27</td>
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<tr>
<td>Workplace</td>
<td></td>
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<tr>
<td></td>
<td>59</td>
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<td></td>
<td>70</td>
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<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>79</td>
</tr>
<tr>
<td>School</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>64</td>
</tr>
<tr>
<td>Household</td>
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</tr>
<tr>
<td></td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Warfare</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>29</td>
</tr>
<tr>
<td>Music</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>43</td>
</tr>
<tr>
<td>Natural objects</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
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<td>42</td>
</tr>
<tr>
<td>Sports</td>
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</tr>
<tr>
<td></td>
<td>35</td>
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<tr>
<td></td>
<td>26</td>
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<tr>
<td>Agriculture</td>
<td></td>
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<tr>
<td></td>
<td>23</td>
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<td></td>
<td>40</td>
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</tbody>
</table>
Table 3: Percentage of students relating an activity to technology

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>93</td>
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<td></td>
<td>96</td>
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<td></td>
<td>31</td>
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<tr>
<td></td>
<td>31</td>
</tr>
<tr>
<td>Warfare</td>
<td>69</td>
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<td></td>
<td>66</td>
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<td></td>
<td>78</td>
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<td></td>
<td>64</td>
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<tr>
<td>Transport</td>
<td>69</td>
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<td></td>
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<td></td>
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<tr>
<td>Workplace</td>
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<tr>
<td></td>
<td>51</td>
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<td></td>
<td>64</td>
</tr>
<tr>
<td>Agricultural</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>63</td>
</tr>
</tbody>
</table>
**Technology-as-activities:** Table 3 presents students’ responses to the two alternate forms of the TAA questionnaires. The table shows the percentage of students associating pictures in Form A and B with technology. For each category the pictures from the alternate forms have been presented in Table 3.

**Analysis**

The responses to the questionnaires are complemented by the results from the interview and these are discussed below. The questions in the interviews served as a framework for our analysis.

**Objects, activities and words associated with technology**

<table>
<thead>
<tr>
<th>Category</th>
<th>Form A</th>
<th>Form B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Music</strong></td>
<td><img src="image1" alt="Music Images" /></td>
<td><img src="image2" alt="Music Images" /></td>
</tr>
<tr>
<td><strong>Sports</strong></td>
<td><img src="image3" alt="Sports Images" /></td>
<td><img src="image4" alt="Sports Images" /></td>
</tr>
<tr>
<td><strong>School</strong></td>
<td><img src="image5" alt="School Images" /></td>
<td><img src="image6" alt="School Images" /></td>
</tr>
<tr>
<td><strong>Natural</strong></td>
<td><img src="image7" alt="Natural Images" /></td>
<td><img src="image8" alt="Natural Images" /></td>
</tr>
<tr>
<td><strong>Neutral</strong></td>
<td><img src="image9" alt="Neutral Images" /></td>
<td><img src="image10" alt="Neutral Images" /></td>
</tr>
</tbody>
</table>
The responses of the students to the TAO and TAA questionnaires indicate that some objects and activities were more often associated with technology than others. More students related objects and activities in the categories of communication, transport and workplace to technology. In addition in the activity questionnaire, the warfare category was considered related to technology by large number of students. Less proportion of students considered agriculture, sports and music as technological. It is interesting that in an agricultural economy like India, only a minority of students considered agricultural objects (plough, bullock-cart) as technological. This aspect is discussed further in later questions on traditional/modern and rural-urban differences.

Natural objects and activities in nature were considered technological by a larger percentage of students than even objects in the category of agriculture and sports. When we probed this in the interviews, one reason given by students for considering natural objects or activities to be technological was that they had read about these objects and activities in their science books. A student reasoned that ‘Anything that has life and grows and respires is technology’, while another student related sun to technology using a knowledge-laden argument; ‘It uses hydrogen and produces heat and light’.

Not all objects within a category elicited similar responses. For example, fewer students (27%) considered a bullock-cart (transport category), to be technological as compared to an airplane (87%). In the interviews, students were shown their earlier responses on questionnaire and were asked to support their answers. Some of the reasons for considering an object to be technology related were; it is human-made, is used for speeding and easing activities, is composed of simple and/or complex machines and tools, and is useful. Some responses suggested that some components of an object could ‘have’ technology while other may not ‘have’ (‘Tube-light has technology only if the switch is on’).

During the interviews, students were asked to write words that came to their mind when the word ‘technology’ was mentioned. Objects such as gun, electronic items, vehicles, computers, were most often listed. Other commonly associated words were school subjects (science) activities (driving) and knowledge or research related words (inventions, knowledge of complex machine, discovery), as well as professions (doctor, engineer), and famous personalities (Homi Bhabha, Alexander Graham Bell).

Activities like working on computer, talking on phone and a scientist in laboratory were related to technology by most students. On the other hand, activities perceived as more dependent on skills than equipment, like wrestling (male picture 33%, female picture 27%), teaching (male picture 24%, female picture 29%) and dancing (male picture 30%, female picture 32%) were considered as technological least often. An exception was ‘yoga’ which was associated with technology by over half the students.

The activities in which, humans were shown actively involved (working on a computer) were considered technological by more students than those in which humans were passive (watching TV). Students’ response patterns differed between an object shown alone and an object as part of an activity. In general it was observed that when objects and humans were shown together, more students related it to technology than when the objects were shown by themselves: sitar – a musical instrument – as object (35%) versus playing a sitar (46%); bow and arrow as object (29%) and archery as an activity (>60%) and plough as object (40%) and as an implement in farming (~60%). This reiterates that the use of human skill in association with an object increases its perception as being related to technology. In this context, it was interesting to note that teaching activity using objects (~29%) was associated to technology by almost the same number of students as the object blackboard (31%).
Most students said that all people use technology (‘we all use some or the other technology like phone’). A few students stated that children or those staying at home do not use technology. This is consistent with household objects being related to technology only by half the students in the survey. Regarding who creates technology, most students believed that scientists and researchers working in laboratories or special centers created technology as they ‘engaged in experiments’. About 90% of the students surveyed related the laboratory activity to technology. Only two students stated that their teachers could create technology. Very few students thought that human beings other than scientists and researchers could create technology, even if they had knowledge. One student articulated that God created technology.

Is technology something new (modern) or old?
Objects like bullock-cart, plough and wood-stove were considered technological less often as compared to their more modern counterparts (plane, tractor and cooking range). In the interviews, we probed aspects related to traditional and recent objects: the temporality of technology. All the students interviewed thought that technology involved something new and that it came into existence in the recent past, rather than in ancient times. Some students stated that technology began before or after some specific event: ‘discovery’ of light / fire /steam engine/ life/ electricity/Indian Independence.

One student said that ‘science was discovered before technology’ and other students specified in years when technology came to being, example: ‘B.C.’, ‘100 years’, ‘1000000 years’.

A gradation in technology level was also seen; some students stated that in ancient times there was less technology as compared to now. The ideas of progress (evolution) were exemplified by a boy’s response about various objects: (‘Airplane, we can fly and it has developed over age. Earlier we used to walk barefoot. Pressure cooker is related to technology, as it is a new way of cooking. Earlier we used open vessels. Flower does not have technology because from the starting it is like this. This is no new thing.’)

Is technology found more in urban or in rural areas?
Gradation of technology was mentioned with respect to locales too. All interviewees believed that technology existed more in urban areas. Some of them even had a clear idea about gradations in various places, such as, highest amount of technology in cities, followed by districts (towns) and lastly in villages. The reasons for such answers were that towns have more transport and communication facilities, factories, laboratories and regular power (electricity) supply.

Gender and technology
The TAA questionnaire had 19 activities being done by males or females. Significant differences (paired t-test) were found for 5 activities: archery (male picture- 64%, female picture-78%), pulling rickshaw (male picture- 56%, female picture- 69%), scientist (male picture- 88%, female picture- 96%); playing hockey (male picture- 68%, female picture- 76%) and wrestling (male picture- 33%, female picture- 27%). Of these activities, the activity when depicted by a female was considered technological by more students then when depicted by a male, except for wrestling. 

To the question, ‘Who uses more technology – boys or girls?’ most students (9/15) said that both used technology equally. Two boys said that boys used more technology while two girls stated that girls used more technology. Regarding the use of technology by their parents, most students said that both parents used technology, but related their mother’s use of technology to the household while their father’s use extended both at work and at home. Only one student specifically said that his mother did not use technology because ‘she stayed at home’.

In contrast to the above responses, when asked, ‘If there is a space shuttle on which only one person could go then who should be sent – a boy or a girl?’ most students (13) gave non-egalitarian answers. Three girls and 7 boys said that a boy should be sent and gave several reasons: ‘it needs courage, which only boys have’, ‘till now most astronauts have been boys’, ‘boys can act faster if there is any
trouble’, ‘boys are able to do difficult work’, ‘have better observational powers’. Three girls who were of the opinion that a girl should be sent, reasoned that ‘girls should be given a chance to go to space’.

What do you think is ‘not technology’?
In response to the questionnaires, several objects and activities were not related to technology by a majority of students: especially in the categories agriculture, sports and teaching. Several reasons were given for not relating some activity/object to technology, such as: ‘not human-made’ – a natural phenomenon, ‘it grows on its own like trees’ or ‘it does not move -like a clock without battery’, ‘it does not involve tools’, or ‘is not related to science’. Students’ answers to the question ‘What is not technology?’ focused on natural phenomena such as ‘stone’, ‘blowing winds, sun rays falling on earth’, ‘walking’ ‘nature and living organisms’, absence of electricity ‘when you switch off light’, or something not related to science ‘weaving, dancing, etc’ or mechanical objects, example ‘objects on which no action has been done’.

Conclusions and Implications
From a preliminary analysis of the study, which aims to understand students’ ideas about technology through pictures and interviews, it appears that Indian middle school students have associated technology mostly with objects and activities depicting modern appliances used for speeding work and easing life, usually seen in the urban areas. The product-oriented view of technology is consistent with earlier studies (Raat & de Vries, 1986; de Klerk Wolters, 1989 and Rennie & Jarvis, 1995) where students associated products, particularly computers, transport, domestic appliances and modern electronic gadgets with technology.

Students in our sample also associated school subjects, research, discoveries and inventions with technology. This idea may be due to the fact that technology is introduced in Indian schools as application of science. Students viewed technology as a human endeavor and credited scientists/researchers for technological inventions but considered most other humans as mere users of technology. Indian students thought that technology essentially had an evolving nature, was present in the ancient periods in limited ways and is now used by everyone. They also thought that there was more technology in urban than in rural areas.

Students gave consistent reasons for associating a particular object or an activity to technology. These were mostly to do with the benefits derived from using technological artifacts such as having to use less physical strength, doing work faster, being made by humans and being dynamic. Students who related technology to natural categories stated that plants, waterfall, thunder and lightening had motion and life and therefore were related to technology and also they had studied these in their science books. Reasons for considering something as ‘not technology’ were; it did not have a machine, was not related to science, or was something found in nature.

This survey indicates that objects when presented along with humans tend to be associated with technology more often than humans presented in an activity without equipment, or when objects are presented alone. This finding is in contrast with de Klerk Wolters (1989) and Rennie & Jarvis (1995) studies where pupil’s drawing on technology were mostly without humans indicating that humans are not an essential element of technology.

According to Mammes (2004), the interest of girls in dealing with technology can be encouraged through interventions that reduce gender differences in experiences about technology. Gender biases surfaced in the survey, in the following ways. Pictures showing women involved in activities were considered by more students as technological, than the same activities by men (playing hockey, a working scientist). Perhaps women in these roles as well as the activities were unfamiliar to students. Considering an activity technological differs from considering it suitable for a person and therefore, most students said that a boy more than a girl should be selected for space travel.
The results from this study can be used for planning technology education curriculum in India and can help teachers/planners equip themselves with the ideas that children hold of technology. Our findings suggest that Indian students’ ideas of technology though varied, lacked depth. Their view of technology was rooted in science either as its applications or as its object of study. There is a need to introduce the study of technology at the school level as a subject with distinct knowledge and skill requirements. Teachers and educators need to be conversant with the multiple perspectives of technology so that in their classrooms they may be able to make appropriate linkages of technology with science and society as well as with other school subjects.

References
Role of product evaluation in developing technological literacy

Mike Martin. Liverpool John Moores University. UK
Email: M.C.Martin@ljmu.ac.uk

Introduction
The products that we use on a day to day basis have a significant impact on our way of life and well-being. With particular products and systems, such as the mobile phone, we are able to work and live in different ways. The development, use and disposal of products often have unforeseen consequences, both positive and negative, and the choices we make over their development can affect others quite significantly. Given the significance of products it makes sense that the designing and making of products by pupils should be part of their general education.

This paper explores issues of literacy and product evaluation and is a first step in assessing the significance of product evaluation as part of pupils’ general education.

Technological literacy
The purposes of technology education are many, complex and interconnected. When looking at the descriptions of curricula in national documents it is clear that technological literacy is about much more than the development of motor skills and the acquisition of knowledge about materials and how to process them (DfES 1999, ITEA 2000, LTS 2000). Skills and knowledge developed through the processes of designing also have importance with decision making central to the development of capability (Kimbell et al 1996). In addition to the making and design process elements, many statements can be found that relate to knowledge of the world of technology and the development of dispositions towards technology and its development on a larger scale.

As well as designing and making products themselves, pupils need to be given opportunities to look at the work of others. This has two purposes: first, to inform their own designing and, second, to provide them with a broad understanding of the role of technology in society. For example, by looking at snack-food products pupils can learn about ingredients which provide energy and, at the same time, gain an appreciation of the power of marketing and repackaging existing products.

The processes of evaluating products provide rich opportunities to explore values issues in the widest sense. Technology has been described as ‘values made visible’. If this area is broadened to the evaluation of the products of design and technology, then it will include the systems and environments also created by design and technological activity and the effects of technology beyond those intended.

By looking at the work of others, pupils can:

• appreciate the ways in which different products meet the same need;
• see how their own work relates to the world around them;
• develop observation and communication skills;
• widen their ‘success criteria’.

The study of technological products linked to pupils making, or indeed separate from any making or designing activities, is an important element in the development of technological literacy (Martin 1996) promoting what Benyon and Mackay refer to as ‘real technological understanding’ rather than just ‘technological expertise’ (Benyon and Mackay 1992: 141).

Whilst there are many references to the evaluation and analysis in curriculum documents, what is not completely explicit is the extent to which this part of technology education is to be undertaken.
Nor is the range of products to be evaluated indicated. Often in the practice of individual teachers it will be the evaluation of those products that they have to hand, collected themselves or have acquired in the form of a collection from an external organisation with a specific agenda.

In developing technological literacy a critical perspective needs to be adopted when it comes to exploring products so that pupils become considered users rather than passive consumers of technology who are capable of making technologically informed decisions (Jones 1997:54). The dominance of consumer culture (Lury 1996) is such that pupils need to be equipped to ask the right sort of questions about the products and systems that surround them.

Writing 30 years ago, Paulo Freire highlighted the importance of a critical attitude towards technology:

Indeed, an analysis of highly technological societies usually reveals the ‘domestication’ of man’s critical faculties by a situation in which he is massified and has only the illusion of choice. (Freire 1974:34)

Acquiring literacy about key technologies, from a technological perspective, must surely be a key aim of national curricula in any country. Making the link from technology in the classroom / workshop to the systems that pupils will engage with outside is important if the technology education in the classroom is to have any effect on the values and attitudes of young people (Martin 1995: 60).

In exploring this area, it is necessary to look at the range of possible products that exist (individually or within wider systems) and identifying differences in their complexity. Of equal importance is the exploration of how more complex products and systems can be investigated by pupils and how the views of stakeholders can be heard and analysed.

The nature of products
The world of products is vast, coming in all shapes and sizes as well as degrees of complexity. In exploring the role of product evaluation for technological literacy it is necessary to explore the nature of products and attempt to categorise them in a way that can be helpful with progression and continuity issues.

The National Curriculum in England (DfES 1999) is organized according to material areas and the products suggested for evaluation (QCA 1995) are often categorised in a similar way. Whilst this is useful for day-to-day planning, a more sophisticated view is needed to describe the nature of products that we use on a daily basis.

One of the essential considerations is that of context. Consideration of the different aspects of the generalised context (Kimbell et al 1996:41) within which products are used open up opportunities for wider aspects to be considered.

It is clearly easier to look at products separated somehow from their social / environmental context for early phases of technological literacy this is seen to be the right approach as very young people ‘cannot deal with such complex issues’. This can be seen in the progressive nature of the descriptions of what pupils are expected to do (DfES 1999). Whilst this is understandable it presents the possibility of wider contextual issues being ignored. The promotion of design as an activity focused on a product and not its context also goes against moves in contemporary design practice (Buchanan 2001).

However, if you ask young pupils they are very aware of a range of issues. It’s their naive viewpoint, lacking in sophistication, which is a feature rather than their awareness of the interdependence of
products people and the environment. It is important that all technological products and systems are seen as situated in a context that is social, cultural and environmental (Elshof 2006).

With contextual issues in mind, the matrix given below is suggested as one way of looking at products. Central to the matrix is the idea of progression through a variety of elements. For example, it is suggested that evaluating a product that has been designed by another designer or a team of designers within an organisation is harder than evaluating a product designed by yourself. A complex product, which is part of a system in a commercial context will be harder to evaluate than one that a pupil designs for home use. The greater the complexity of issues, the harder they are to resolve and the more sophisticated with pupils’ technological literacy become.

<table>
<thead>
<tr>
<th>Designer</th>
<th>User</th>
<th>Context</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self</td>
<td>Self</td>
<td>Home</td>
<td>Single element</td>
</tr>
<tr>
<td>Other pupil</td>
<td>Other pupils</td>
<td>School</td>
<td>Joined elements</td>
</tr>
<tr>
<td>Single designer</td>
<td>Others outside school</td>
<td>Community</td>
<td>Multi-material</td>
</tr>
<tr>
<td>Organisation</td>
<td>Organisation</td>
<td>Commercial</td>
<td>System</td>
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</table>

Whilst this matrix needs further development it provides an alternative taxonomy to that suggested in the Standards for Technological Literacy produced in the United States (ITEA 2000) which uses seven categories: medical technologies; agricultural and related biotechnologies; energy and power technologies; information and communication technologies; transportation technologies; manufacturing technologies and construction technologies.

At the end of their period of formal schooling pupils should have had the opportunity to see the way in which products / systems are part of our culture and affect individuals, society and the environment and become aware of the need for careful balancing of often conflicting criteria.

**Product evaluation in practice**

Prior to consideration of classroom / workshop based activities it is necessary to consider pupils existing attitudes towards technology? Do they see technology as products or more complex systems?

Whilst there is literature about pupils attitudes towards technology in general (Neale 2003), little research about the breadth of their knowledge about products exists. Research undertaken some time ago by Jones indicated that pupils readily see ‘modern artefacts’ as technology (Jones, P 1997:56).

Whatever their existing knowledge, there is a need to develop pupils understanding of products in context beyond those that can be designed, made and evaluated in the classroom / workshop.

The practical reality of undertaking activities with pupils can be considered in two sections, namely what should be selected for evaluation and what the best pedagogical approaches for learners to develop an understanding of this area are.

**What should be evaluated?**

Products evaluated by pupils developing technological literacy could be placed in three categories:

- Products similar to those that pupils make in order for them to look at similarities and differences.
- Products familiar to pupils in their everyday lives.
- Products felt to be of particular significance, enabling higher levels of technological literacy to be developed.
Which products should be looked at? Who decides which technologies / technological systems we want pupils to be literate with? In the National Curriculum for England (DfEE 1999), when it comes to Geography, Brasil is chosen as a specific country that all pupils will learn about through a specific Unit of work in Year 8 of Key Stage 3.

So when it comes to design and technology, one or two products / technologies could be chosen. The question is which one? Some choices to consider may be:

- Mobile phones / communication technologies?
- CAD (that which is beyond schools’ capability)?
- Construction textiles?
- Biotechnology?
- Windfarms?
- Chocolate
- Transport

What difference does the selection of products make to the kind of technological literacy that is developed? It clearly makes a difference in terms of the knowledge domain but what is needed is depth rather than breadth so that a sophisticated perspective can be developed.

Teachers can be very influential in the development of skills, knowledge and understanding (Morrison and Twyford 1994). In a recent study looking at the interaction of pupil and teacher when exploring products it was clear that the teacher controlled the process of evaluation and that their knowledge of products was a significant factor in the type of interaction that took place (Martin 2005).

How controversial?
Design and technology is an inherently controversial subject as it deals with the development, manufacture, use and effects of technology in human, social and environmental contexts. There are many examples of technological products, such as the mobile phone, that are controversial. Some people feel that mobile phones are both intrusive and bad for our health. Others say that they feel more secure as a result of having instant communication at hand. For most technological products that we use, from the paperclip, to the disposable nappy, to a high-speed train, there will be a range of opinions about a wide variety of issues. Is it the role of teachers of design and technology in schools to deal with these issues? The arguments against dealing with complex issues include:

- the consequences of technology are best discussed and dealt with by adults;
- the role of teachers is to teach skills and knowledge, not to indoctrinate pupils;
- dealing with controversy is best dealt with in other curriculum areas, for example PSHE (personal, social and health education);
- there is precious little time to teach skills, let alone for prolonged discussion.

Arguments in favour of dealing with controversial issues include:

the need to reflect ‘real-world’ technological activity in the classroom (technology itself being controversial);
- developing critical thinking in pupils so they become discerning users and not just passive consumers;
- the importance of understanding other people’s viewpoints;
- crucial distinctions between technical training and technology education.
Pedagogical approaches
It is not enough just to expose pupils to a wide range of products. Thought needs to be given to the appropriate pedagogical approaches and learning environments that will encourage engagement with the potentially complex issues that might be involved. How do we expose pupils to the range of products and systems in context (viewpoints)? Also – how controversial do we make it?

Nuffield case studies (Nuffield 1995) as good examples of illustrating the complexity of technology. As Barlex (2006:191) indicates the role of the teacher is crucial in making the most of such material.

Using questions
Questions need to be structured and of a type that is appropriate to pupils’ age and capability. They should be encouraged to come up with their own questions whatever their age. Teachers might suggest the following questions:

• What is my initial reaction? Do I want to touch/taste/use/discard it?
• Who might the owner be?
• Why might someone buy it?
• Would I want to own and/or use it?
• Is it really needed?
• Can it be part of a sustainable world?

(DfEE 1995:3)

Supplementary questions can be useful in clarifying pupils’ responses to products and exposing deeper beliefs and values. Great care needs to be undertaken with such activities as revealing pupils’ personal constructs can make them vulnerable to ridicule and prejudice:

Of course, strongly held, conflicting values will sometimes be identified and an open, dialogic approach is required of the teacher. An educational climate of tolerance and mutual respect must be developed.
(Siraj-Blatchford 1995:200)

A particularly interesting strategy is to ask pupils to describe who they think the owner of a particular product might be. Something as simple as evaluating different shopping bags can reveal deeply held beliefs about our society from primary age pupils.

How we evaluate technological products with pupils will affect the type of technological literacy that is developed. Values about the nature of technological development will be transmitted.

Conclusion
From the discussion above, the role of product evaluation in developing technological literacy can be seen to be central to developing awareness of the complexity of technology and the development of critical attitudes towards products. If this is not done then there is a danger of promoting a passive role and perpetuating technological determinism rather than fostering the understanding of technological development as a social process (MacKenzie and Wajcman 1999).

Further research is required into this area, in terms of developing the matrix of products in terms of complexity as well as pedagogy that will further pupils technological literacy in relation to products. In addition, the use of personal construct psychology (Siraj-Blatchford 1995) could be used to explore what pupils already know about products.
References


Fixated on popular culture and other things: What students can tell us about generating ideas in D&T.

Bill Nicholl and Dr Ros McLellan, University of Cambridge, UK
Email: ban22@cam.ac.uk

Abstract
This paper focuses on how young people aged 11-16 years generate ideas when solving design and technology problems. A number of methods including focus interviews with pupils (N=120) and teachers (N=14), lesson observations (N=10) and analysis of documents and pupils portfolios is used to help explain how young children aged 11-16 years generate their design and technology ideas. We found that a significant number of pupils produced stereotypical design ideas such as love hearts and sports logos. This was the case regardless of their age and gender and happens at various stages when designing and making. A review of the creative cognition literature suggests that this is a normal way of thinking and is referred to as fixation. We suggest that fixation manifests itself in other ways, such as a strong desire to do the first thing that comes into your head and an inability to generate any ideas. We believe that a true understanding of how fixation manifests itself, will give insights into what causes fixation in the D&T classroom. This understanding we believe, will help the teacher of D&T to develop and introduce appropriate strategies to help young people overcome this dominant mode of thinking. Hence the important role of the teacher in nurturing creativity is stated.

key words
creativity, fixation, generating ideas, creative cognition, 11-16 years

1. The context
In the UK debates about the importance of creativity in both the commercial and educational worlds has once again gained prominence; see for example, The Cox Report (2005), Sternberg et al. (2005) and the Robinson Report (1999). The creativity agenda has become influential within Design & Technology (D&T) education. Both Kimbell and Barlex have referred to creativity as being in 'crisis' (Barlex, 2003; Kimbell, 2000a, 2000b). Furthermore, D&T inspection reports have continually referred to the lack of design opportunities, particularly for pupils aged between 11-14 (Office for Standards in Education, 2003).

Sternberg and Lubart, define creativity as, 'the ability to produce something novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints),' (1999). This would seem to us to be a good working definition as it is complementary to the creative cognition approach (discussed in more detail below), and is widely accepted in Education (Robinson, 1999). Whilst acknowledging the different approaches to studying creativity (for a general overview see Cropley, 2001; Sternberg, 1999; or Sternberg et al., 2005) in this paper, we focus on the cognitive dimensions to creativity and in particular, the creative cognition approach developed by Finke, Ward and Smith (1992). This work focuses on the processes involved in the generation of ideas, processes Finke et al. suggest are normative and can lead to both big C creativity (eminent creativity) and small C creativity, shown by all of us in our everyday lives (Gardner, 1993). It is these processes that we believe to be crucial in the development of creatively designed ‘products’ in D&T. To focus only on the end product - the unusual piece of furniture, the innovative personal alarm, the smart textile waistcoat or novel food product - would deny the opportunity to understand the processes involved in the design and development phase - and such an understanding in education is important.

2. Generating ideas
Most areas of design (e.g. product-engineering design) involve generating ideas at an early stage when designing and this has been emphasised not only by academic researchers (Jansson & Smith, 1991),
but also by practicing designers (Powell, 2006). Indeed, the D&T National Curriculum programmes of study states that pupils should be able to 'generate design proposals' (DfEE & QCA, 1999, p. 20). Furthermore, 'generating ideas' is one of the 'six sub-skills of designing and making' identified in The Design & Technology Key Stage 3 Strategy (2004). It would seem that the ability to think creatively, that is, to generate novel, purposeful ideas, is an important and necessary part of solving design problems. We shall discuss the generation of ideas in the context of the literature on creative cognition.

Ward, Smith and Vaid (1997) suggest that generative activities that lead to creative ideas have one thing in common in that they are all instances of conceptual expansion. This is where people 'extend the boundaries of a conceptual domain by mentally crafting novel instances of the concept (Ward et al., 2002). The phrases, 'extending the boundaries,' and 'novel instances' highlight the expectations of creative thinking that goes beyond what is easily predictable. However, a number of studies have shown that when participants have sought to generate novel responses their ideas are often similar to existing ideas (see for example Jansson & Smith, 1991; Karmiloff-Smith, 1990). This fixated state 'refers to a blind, and sometimes counterproductive, adherence to a limited set of ideas in the design process' (Jansson & Smith, 1991, p. 4).

Other studies have focussed on how existing knowledge can influence the generation of new ideas – a process that Ward refers to as 'structured imagination' (Ward, 1994, 1995; Ward & Sifonis, 1997; Ward et al., 1997; Weisberg, 1986, 1993).

Structured imagination refers to the fact that when people use their imagination to develop new ideas, those ideas are heavily structured in predictable ways by the properties of existing categories and concepts. (Ward, 1995, p. 157)

Ward offers further insights by predicting which aspects of existing knowledge people are likely to 'retrieve' and therefore use in the generation of new ideas (Ward, 1995; Ward et al., 2002). He refers to this as the 'path-of least resistance' model (Ward, 1994, 1995) which suggests that 'items that come to mind more quickly and to more people are the ones most likely to be used as sources of information for the development of new ideas' (Ward et al., 2002, p. 203).

Smith (1995), making the analogy to a road map, suggests that this is a normative cognitive process whereby an individual plans a route (formulates a cognitive plan) in order to get to their destination (or goal), in this case to generate ideas in D&T. This route is pursued until an obstacle is reached (i.e. not knowing a particular process or technique) which ultimately leads to the individual becoming fixated.

3. The Study
The purpose of this particular study was to examine whether the creative cognition literature could offer insights into what pupils were telling us about the information they used to inform their ideas when undertaking design and technology tasks.

Research Question:
What does fixation look like in Design and Technology (11-16 age range)?

We contacted and negotiated access to six secondary schools. Although this could be regarded as a convenience sample (Cohen & Manion, 1994) we selected a variety of schools in terms of socio-economic background, ethnicity and GCSE results. Semi-structured interviews were conducted with D&T teachers (N=14) and students (N=126). Teachers were interviewed individually and students in same-sex, same cohort groups. All interviews were taped and transcribed. In addition various documents were gathered (e.g. project booklets used by students, schemes of work, Ofsted reports). Samples of student work were also collected.

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In addition to these interviews we observed 10 key stage 3 lessons where students aged 11 to 14 years were mainly generating and developing ideas. One researcher constructed an narrative of the lesson (Ely et al., 1991), which included a description of events and some commentary. The other researcher focused on teacher-student interaction as this was a key area of interest. These notes were written up and discussed so that the approach could be refined in later observations. The dialogue in the lessons was also tape-recorded and key (audible) moments were transcribed.

Interview transcripts, observation narratives, fieldnotes and memos were transferred to the QSR NVivo programme (Fraser, 2000). We then developed an initial set of descriptive codes (Miles & Huberman, 1994), which related to the questions asked during the interviews and additional ones were added that reflected important strands in the responses. Coded segments were examined to see whether there was evidence of ‘fixation’ and what aspects of practice appeared to be associated with it. From this a number of themes emerged which are discussed below.

4. Results
4.1 The analysis: evidence of ‘fixation’ in D&T

We asked students in interview to describe some of their design ideas, in relation to both their current project and previous projects, and where they got their ideas from; how many ideas they were expected to come up with; what happened typically in lessons when they had to come up with ideas; whether they felt their ideas were similar to those of other students or different, and whether they wanted them to be the same or different. The interviews suggested that students found idea generation difficult and we probed this specifically, asking them what they did when they got stuck. We also asked each student whether they felt they were creative and to justify their response. We then looked at what teachers had told us about students’ design ideas, and at our observational data on idea generation in lessons. We also analysed the sample of students work. Evidence of fixation was rife across the 11-16 age range, but it appeared in a number of guises.

4.2 Manifestations of fixation
4.2.1 Stereotypical design ideas

Overwhelmingly students’ design ideas reflected popular teenage culture, and, perhaps not surprisingly, stereotypical ideas reflected gender patterns. The following quotations are typical of student responses.

\[ Y11G \quad \text{‘I printed off loads of cartoon characters, like Winnie the Pooh and stuff, which I used for my design.’} \]

\[ Y7B \quad \text{‘I did a football boot. That’s what I did on my photo frame.’} \]

Boys’ designs tended to be based on sport, particularly football. Hence football logos were common decorations and the shape of a football figured regularly in the shapes of products. Girls were more likely to use hearts, flowers, animals and Disney cartoons in their designs, although the Playboy Bunny also appeared. The ideas clearly reflect the hobbies, interests or popular culture of students of this age and were similar to findings reported by Nicholl (2002). Figures 1 and 2 illustrate typical ideas students generated in work we analysed.
Fig. 1 Love hearts as ideas. Year 11 female

Fig. 2 Ideas based on popular culture. Yr 7 male.
Such designs irritated D&T teachers: ‘Oh yeah, yeah you get a lot of love hearts. The year 9s are notorious for love hearts. Everything is love hearts.’ (teacher, D&T). But teachers did not know how to intervene to prompt less predictable design ideas. An additional source of irritation was that students thought these ideas were creative and original:

Y10G ‘Well my friend. She had a skirt with loads of kisses all over it so…, so I’d say that’s wacky’

Y11G ‘I think they (my ideas) are quite different… One of my ideas was to have a flower, a purply flowery print with a purple lining’

Indeed the design ideas mentioned by the vast majority of students interviewed could be classified as stereotypical. But while this may seem unsatisfactory in relation to a valuing of originality in design, when considered in the light of the creative cognition literature, it is far from surprising. Students will draw on existing knowledge that is most accessible to them (Ward et al., 2002), which, arguably for teenagers, is the culture they are, and want to be part of. The path-of-least-resistance models suggests that the predominant tendency is to retrieve fairly specific, basic level exemplars from their cultural domain (Ward et al., 2004). Hence students will use the common shapes and images they are familiar with, such as hearts or footballs, rather than attempt to think of something more original and more complicated. We should emphasis that students are not being lazy when they do this; rather it is the result of ‘normal’ thinking processes operating. Furthermore, this process is subconscious; hence it was not surprising that many students found it hard to articulate where their design ideas came from: a common response from younger students was ‘dunno’, whilst others didn’t even attempt a reply or tended to agree that ideas just appeared in their heads.

We argue therefore that the overall effect of these subconscious, automatic and normative cognitive processes, in the case of students working on D&T projects, is often the literal reproduction of popular culture images in design ideas, a dominant approach explained by Ward’s path-of-least resistance model.

4.2.2 Design Ideas that are similar in style

Stereotypical ideas were more evident in some projects than others. For instance, if students had to decorate or embellish a product (for instance, the lid of a pencil box or the design on a cushion), stereotypical ideas were particularly common. If, however, students’ design work was more concerned with the function of the product then stereotypical ideas were less common. In a Y7 toothbrush holder project we analysed, students successfully avoided stereotypical designs. However, some degree of fixation was still evident: many students – like this one - commented on how similar their design ideas were:

Y7G ‘I think some people do come up with the same ideas, but slightly different. They would be each unique but some of them might be similar and have the same feet positioning.’

So although the designs in this case were not stereotypical, as the project did not lend itself to this, there was little evidence of original, creative thought. Students in other schools also commented on the similarity of design ideas across a class (which may also be stereotypical in type), as this quotation demonstrates:

Y10B ‘We all have to do the same project…some of the final designs look a bit similar I mean…you can see like…the similarities between each and every one

The important point to note here is that students were accessing the same sources to generate ideas, and because cognitive processes operate along the path-of-least-resistance, similar end points were
being reached, i.e. the resulting products were almost identical. This lack of creativity would seem to reflect the operation of fixation.

4.2.3 Acceptance of the first design that is thought of
Another form of fixation can be seen in students’ desire to stay with the first design they think of:

Y7B  ‘As soon as they said come up with an idea for a pencil box (decorative lid design) I already knew that I was gonna do either a Man United player or just the team.’

Students often reported that they felt annoyed that they had to sit and think of a number of ideas, when they knew straight away what they wanted to do – and what they wanted to do was, as the example above illustrates, often stereotypical. Teachers across the schools also found this problematic, as this extract shows:

‘They get a fixed image, that’s what I want to make. It’s very hard to make them see that you can change it and modify this. They’re fixed, they think now that’s what I want and that’s what I’ll do.’ (D&T teacher)

4.2.4 Inability to generate Ideas
The active cognitive plan can come to a dead-end when information necessary to achieve the design goal has failed to be retrieved from memory. This is experienced as ‘being stuck’ and is something that students complain about quite often, as the following quotation reveals:

Y11G  ‘When I’m designing….I’ll put my pen to my paper like…I gotta design something…but nothing really springs because there’s nothing there to spring from.’

Students were particularly likely to complain when asked to come up with more ideas once they had generated one or two already - as this student explained:

Y9G  ‘Sometimes, like, ‘cos if you think of an idea then usually that’s the one you want to do and like if you think of other ideas, then you really usually go through with your first one, so it’s like hard to come up with others.’

The inability to generate ideas in this instance seems to be due to the fact that the dominant cognitive plan relates to a previous idea that has already been generated; the student keeps thinking about her first idea and is unable to launch a new plan to generate a different idea. This is an instance of what Smith (2003) calls ‘retrieval bias’ and in this case can mean that once an idea has been generated, often using obvious, predictable information which can lead to fixation, it acts as a blocker, constraining the opportunities to retrieve other information from memory, that perhaps could lead to more novel and appropriate ideas.

5. Conclusions
When discussing our findings here, we are not suggesting that young people's culture is not important, nor are we saying that popular cultural images cannot be used to generate creative ideas and eventually products. What we are saying is that, left on their own, young people find it difficult to generate novel ideas that extend the boundaries of a domain. They copy images from their popular culture and use these exact copies as their ‘ideas’. These copies, we argue, have not extended the boundaries of possibility, nor are they novel, even in the little C or everyday sense. During our investigation, and something we shall elaborate on in future papers, numerous students told us that they do their research on their own "at home" and the predominant response to the question, where did you get your research was, "I got it off Google images." In our minds, the teacher has a crucial role to play in helping young people overcome fixation. The modern default research strategy is clearly Google images. Nicholl (2004) reported that the earlier source of design ‘ideas’ was the Argos catalogue, a practice he banned...
Nicholl acknowledged removing the main source of fixation was not going to overcome this problem. The wider literature discussed here and in particular our own research has allowed us to understand more fully, the nature of fixation in the D&T classroom. According to Ward (1995) it is possible to change the dominant processes of structured imagination.

Note that structured imagination predictions are about the natural or default tendencies that people will follow due to the nature of category structures and processes. These default tendencies determine paths along which imaginative ideas are most likely to be guided. They do not represent absolute constraints that can never be overridden. (Ward, 1995, p. 162)

This is why we believe the teacher has a crucial role to play in nurturing creativity, not least in teaching strategies that can help young people extend the boundaries and produce novel and appropriate ideas and eventually products.

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Moving Beyond ‘Artifactual Knowing’: Emergent Ideas for a 21st Century Technology Education

Leo Elshof, Acadia University, Canada
Email: Leo.elshof@acadiau.ca

Introduction
This paper will explore the relationship between our problematic understandings of technology and the need for a new emergent form of eco-technological literacy. It will be argued that an eco-technological literacy is essential if technological education is to make a genuine and significant contribution to the development of young people and the sustainability of their communities. We need to ask to what degree have our culturally inherited ways of thinking about technology and its relationship to our economies and our ecosystems become an impediment to reconceptualizing technological education (TE) in more sustainable terms? An underlying question will be; whose real interests are being served by instrumental and ‘artifactual’ approaches to TE?

The siren call of TE for economic competitiveness, higher achievement standards and the push for curriculum standardization across contexts, cultures, nations and worldviews is symptomatic of a broader failure to see the more crucial picture. We need to re-imagine TE as a potentially powerful dynamic to transform the deeply dysfunctional relationship between many of our technologies and the health of the biosphere. Most importantly we in TE need to stop ‘tinkering’ with small incremental changes and fully embrace eco-technological literacy if we to genuinely serve the needs of young people. We continue to tinker with change, when what is required is both a systemic and systematic change in the entire way we in the rich north think about the relationship we have created between our technologies, economies, the developing world, and the health of the planet’s crucial ecosystems.

Homer-Dixon suggests that five global ‘tectonic stresses’ are accumulating beneath the surface of our societies:
1. Population stresses arising from the differences in population growth between rich and poor societies, and from the spiraling growth of mega cities in poor countries;
2. Energy stress from the increasing scarcity of conventional oil;
3. Environmental stress from worsening damage to our land, water, forests, and fisheries;
4. Climate stress from changes in the makeup of the atmosphere;
5. Economic stress resulting from instabilities in the global economic system and the ever-widening income gaps between rich and poor people (Homer-Dixon, 2006, p. 11).

Technology in all its facets plays a central role in all of these ‘tectonic’ forces. How well we prepare young people to act with ‘informed precaution’ (Orr, 2002) in response to these forces will to a large part determine their quality of life and the ecosystem health of the planet they themselves will one day leave behind for future generations. This entails engaging young people in critical thinking about eco-technologies, the concept of ‘least regrets’ design and the precautionary principle.

What is desperately needed is rapid, even ‘radical’ growth in ‘eco-innovation’ in terms of the way we use energy, transport ourselves, build and maintain our homes, organize our economies and create sustainable livelihoods. In part the educational vision for this eco-innovation requires new forms of eco-technological literacy. This new literacy would transcend parochial ways of looking at the environmental impacts of technological product design and development, moving beyond ‘end-of-pipe’ design strategies which treat environmental concerns as an afterthought, as some tertiary procedural step in the design process. Technological education has a key role to play in helping young people interpret and create their own forms of design culture, cultures which incorporate new symbols,
metaphors and meanings and thoroughly infused with an understanding of a technology’s ‘ecology’ in terms of how it impacts the biosphere.

The instrumental vision of Technology and the myths this vision sustains
It could be argued that it is unreasonable to expect young people to see technology today as anything but an ephemeral culture of relatively disconnected and short-lived disposable artifacts because their experiences both within and outside formal education reinforces these problematic notions. For example, in the U.S. cell phones built to last five years are thrown away after eighteen months of use for something ‘better’ (Slade, 2006). The idea that TE needs to inculcate a ‘stewardship of objects’ (Strasser, 2001) does indeed seem quaint as the useful life of products continues to shrink in the face of cultural and psychological obsolescence. It has become increasingly important for students to critically examine the relationships within our socio-economic systems that have a vested interest in the perpetuating the notion of technological products as ‘immanent landfill’.

It must be emphasized that this instrumental or artefactual ‘vision’ of technology is not without merit on its own terms, at least from the perspective of some in the marketing and business communities. Continually expanding the realm of human material wants and needs fulfills a very basic function within a consumption-oriented economic system, a system which valorizes the needs of the ‘economic man’ (sic) above all others. TE embodies particular ways of framing and ordering the world, as such it privileges particular practices and worldviews above others. Technology as predominantly ‘artifactual’ knowing which emphasizes the particularities of product-forms, or the ‘device’ (Borgmann, 1987) above all other ways of knowing technology (relational, social, ecological, political) has been identified as problematic (deVries, 2006; Elshof 2006).

We can summarize some of the problematic commonplace perceptions of technology:
- Technology is fundamentally artifactual in nature, it’s what we see. Use it and all too quickly ‘lose it’ because the next best thing is just around the corner.
- It is acceptable to continue to design technologies as ‘solutions’ looking for proverbial problems. This includes the idea that creating a technological ‘want’ and then fulfilling it by designing, manufacturing, marketing and selling ‘it’ is an unproblematic even ‘natural’ process. The implicit notion of a ‘better life through the availability of more products’ is a widely held belief.
- Levels of technological product consumption, energy consumption and material well-being can continue to grow indefinitely.
- Our major human problems whether they are related to health, environment, or human security all have at their heart a ‘techno-fix’ solution.
- We can continue to ignore the immense ‘ecological debt’ (Simms, 2005) being accumulated by technologically rich western countries and owed to the world’s poorest.

Designing learning activities that assist students in challenging these assumptions are difficult in part because they permeate so many facets of our economies, our popular culture and our educational activities. Confronting them requires us to reconsider some of our comfortable worldviews and assumptions about how the world currently operates and how it might work differently in the future. As Keirl (2006, p.98) points out “the judgments made when critiquing can expose the intentions behind designs”, exposing new meanings and knowledge, offering “other ways of seeing, judging and living in the designed world”. The key point being that many aspects of our built environment and technological traditions should be interpreted not as the result of an inevitable ‘march toward progress’ but as often a reflection of embedded economic power relationships, inequities and fractured even simplistic thinking. Fourez (1997, p. 919) reminds us:

Becoming scientifically and technologically literate means developing an attitude which accepts these traditions, not as absolutes, but as the results of a history that could have been different.

The globalization of manufacturing facilities and the manner in which individuals and communities are often treated as little more than ‘outsourced’ pawns in a larger corporate profit game, the role of
technological ‘maker’ has in some ways become insignificant. As Lynn (2005:149) explains the attitude of today’s business ‘leaders’:

Rather than being celebrated as one of the great competitive arts, indeed as one of the great human arts, manufacturing was ever more loudly dismissed as a business dead end, a sort of junkyard inhabited by the greasy kids who took high school shop class and raced unmuffled cars. Suddenly factories, trucks, salespeople, and other assets that once defined most companies’ competitive edges have become a liability.

Under this new economic paradigm of contract manufacturers, only bottom line considerations matter, the production of ultra-cheap ‘branded goods’ has become the sine qua non of global manufacturing today. These trends exacerbate the ongoing shift away from a citizen’s democracy toward a ‘consumer’ democracy where people not only expect but demand ever lower prices regardless of the externalized costs. It is crucial for students to understand that ‘cheap’ products always have their real costs, someone, somewhere pays eventually.

Inhabiting ‘Place’ with Precaution and Humility
Gruenewald (2003, p.3) argues that ‘place-based pedagogies are needed so that the education of citizens might have some bearing on the wellbeing of the social and ecological places people actually inhabit’. ‘Place’ according to Gruenewald becomes a critical construct because it “focuses attention on analyzing how economic and political decisions impact particular places” (Gruenewald, 2003, p.3). If we consider the idea of place-based learning, the manner in which we approach technological design becomes important. Should design in TE focus on generic ‘product’ oriented design in which ‘place’ remains insignificant in terms of the nature of the materials used, processes applied, local concerns and cultural contexts etc? Or should design be a practice which necessarily embodies an understanding of design locality, awareness of where energy and material provisions are obtained, the people and communities who will benefit and be adversely impacted and so on? This is not to advocate a parochial form of TE, but one in which students explore the ‘technologies of place’ and in doing so become ‘inhabitants’ not merely temporary ‘dwellers’ (Gruenewald, 2003).

The precautionary principle is an ‘emergent’ concept, one rooted in social learning about environmental concerns, it acknowledges that waiting for unreasonable levels of scientific proof before acting to take preventative action when environmental risk is high, is in some cases an ‘irrational strategy’ (Whiteside, 2006). Students require insight into how politics and experts have influenced the character and composition of our built environment. This might include critical engagement with issues that relate to subsidies for products and manufacturing industries, the role of lobbying and corporate influence. As Whiteside explains:

Precaution invokes politics in the noble sense of the term—politics understood as broadly inclusive, deliberately engaged activity on behalf of the well-being of the whole community (Whiteside, 2006, p. 151).

The intention of using the precautionary principle as an underlying and fundamental principle for design education is not to stifle innovation and creativity, but to help students recognize that not all technological products conceived should be made and that some currently in use should have restrictions placed on their use or be phased out altogether.

Toward New Design Ensembles
Feenberg challenges us to question our taken-for granted assumptions concerning the rationality of modernity. To mount such a challenge he suggests requires a critical perspective, one in which “technologies are not seen as mere tools but as frameworks for ways of life” (Feenberg, 2006, p.14). These frameworks are underdetermined, full of potentialities and spaces within which multiple forms of human-technology relationships are possible, all with their own uniquely contextual and value-based set of priorities. As deVries (2006, p.29) points out the normative dimensions of TE, the ‘ought
to’ aspects are essential: “knowledge in technology is often about what should be, not about what is”. However until we understand just how unsustainable our existing technological practices and ‘ensembles’ are, what hope is there that the designs of tomorrow will be substantively different? It is precisely the nature of our ‘mundane technologies’, the technologies which as Michael (2006) asserts “more or less invisibly co inhabit with us in our everyday lives” that makes their “embroilment in sociotechnical ensembles” as Michaels puts it, so difficult to see and understand from an environmental perspective. Teasing out these relationships is an essential part of eco-technological literacy. It is precisely because TE too often continues to emphasize mere “assembly” or “the bringing together of more or less transparent resources, skills, knowledges, systems in order to allow for the design and production of a technological artifact” (Michael, 2006, p.57), that deeper understandings of sustainability still remain effectively marginalized. In overemphasizing skills and competencies, what Kierl (2006) terms the ‘operational’ at the expense of the cultural-symbolic and the eco-critical dimensions of technology, a hidden curriculum is at work.

While most philosophers of technology adopt critical sociocultural perspective of technology, the dominant thinking within most formal education systems remains rooted in much more instrumentalist and deterministic frameworks. Much of the credit for this stems from the direct and indirect pressures applied on the education sector by business and industry groups, whose unrelenting discourses of accountability and economic competitiveness underpin their demand for an ongoing supply of the up-skilled ‘human capital’ they require to function and expand. This discourse has been internalized in the popular view held by many technology education professionals who see business and industry as ‘natural allies’ in supporting and expanding their programs, as ‘key partners’ within educational systems which are often at best seen to be ambivalent to the whole TE enterprise. There is nothing wrong with this insofar as TE is not also importing the problematic attitudes and often superficial environmental policies of these organizations. Perhaps a natural reluctance to cast potential allies in a less than favorable light is one of the reasons that learning activities aimed to promote critical thinking about existing business and manufacturing paradigms through an environmental sustainability and social justice perspective, are not a commonplace in schools.

**Fostering an ‘Eco-Technology Advantage’ mindset**

TE has an important opportunity to foster an ‘Eco-Technology Advantage’ mindset (figure one). All three areas identified, redesign, cultural critique and eco-tracking reflect a mindset which understands the multiple advantages of eco-technology. The ‘advantage’ dimension reflects the fact that more efficient, less wasteful technological practices lead to not only ecological advantages but competitive and economic advantages as well (Esty & Winston, 2006).

Redesign involves changing classroom technological practices so that materials are used in a much more mindful manner and design practices which reflect an awareness of how ecological impacts can be distributed over time and space. To the degree possible, we need to model a new ‘closed-loop’ relationship with the materials which would normally flow through a classroom. This includes involving students in ‘greener’ material procurement processes and ensuring that both a quantifiable and qualitative environmental awareness informs design practices. Redesign in the classroom is informed by a broad cultural critique and in turn influences and promotes eco-technology culture through activism and the promotion of different cultural attitudes toward technology and consumption.

Similarly redesign is informed by eco-tracking, that is a closer awareness of the nature of material and energy flows in the classroom, local community and the wider bioregion. Eco-tracking has as one of its goals, to make our aggregate materials and energy ‘heaviness’ (Thackara, 2005) visible. Technology in the form of sensor systems, RFID tags and other monitoring devices can provide a real-time window on the magnitude of our energy and material consumption. Students can also be involved in exploring ways in which community sustainability indicators might be improved through the design of new types of product systems and behaviors which help reduce material and energy consumption (dematerialization and decarbonization).
Conclusion
This paper has outlined a number of ideas and contexts in which to reconsider technological literacy, as such they only represent a beginning step in moving away from artifactual understandings of technology toward more relational and ecologically responsible perspectives. Young people need to be prepared for a future with much inherent uncertainty, on top of rapid social and technological change; this is the first generation in modern history that will be forced to deal with accelerating environmental change as well. Their TE should prepare them to be resilient and systems oriented problem solvers, people who have the courage to apply precautionary thinking before embarking on any ‘imperative’ the market demands. A place-based understanding of how a community creates and uses energy, materials and deals with wastes and the broader ecological relationships and its constraints is a fundamental educational prerequisite for understanding how eco-technologies might be designed and employed.

The hope is that efforts which help facilitate closer collaboration between technology, science and environmental educators will lead to curricula better suited to helping young people understand the intimate connections between our technologies and the environment.

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Teachers and tools: Crafting technology education
(A prospective five-year research project in South Africa)

Werner Engelbrecht, Piet Ankiewicz and Estelle De Swardt. University of Johannesburg, South Africa.
Email: wernere@uj.ac.za

Abstract
The TechnEd Catalyst Project, inter alia, entails the CPTD of Grade 7, 8 and 9 technology teachers from 130 schools in the North West Department of Education in South Africa. They are trained on how to implement the customised TechnEd learning and teacher support material (LTSM) in their classrooms.

The purpose of this paper is to determine the teachers’ experience of the Catalyst Project, where partners from trade and industry, a department of Education and a Higher Education Institute are involved. In the qualitative study, semi-structured questionnaires, interviews and observations were used to collect data.

The main finding is that the teachers experienced the workshops as rewarding and fruitful. However, we do not know how technology teachers engage with technology tools (including the LTSM) as mediators in their pedagogic practice and to what extent they collaborate with and support their peers once they leave the workshops.

1. Introduction - The dilemma of old pedagogy and a new curriculum
From the authors’ experience with postgraduate students, Advanced Certificate in Education (ACE) students as well as teachers encountered in continuing professional teacher development (CPTD) workshops, observations were made with regard to the competency of technology teachers, which is supported by the literature on CPTD. Teachers lack many of the skills or competencies required to teach technology effectively.

Among the reasons for this is the fact that technology is a new learning area, as well as the newly introduced pedagogy of Outcomes based education (OBE). The majority of teachers who had been assigned to teach Technology had not received sufficient training. Where some training had taken place, the majority of the recipients did not find it very useful. Some of the reasons that were given for this were the fact that the training was very generic, with little technology specific content (Chisholm, 2000; Engelbrecht, Ankiewicz & De Swardt, 2005; 2006; Potgieter, 2004; Ziqubu, 2006).

To teach technology in an effective way at school it is necessary for the education sector to enter into partnerships with trade and industry. Although learning and teacher support material (LTSM) is available, schools do not have sufficient funds to supply learners with the material. TechnEd, with trade and industry as partners, are involved mainly in a school-focused CPTD initiative based, inter alia, on the prerequisites of CPTD (Gettly 2002; Steyl 1998).

2. TechnEd’s school-focused CPTD initiative
The Technology Education Catalyst Project comprises partnerships between the University of Johannesburg (specifically TechnEd as part of the Faculty of Education), departments of education and the private sector. The private sector supplies funds, earmarked for social upliftment, for the provision of workbooks and teacher guides (LTSM) to schools and for continuing professional teacher development (CPTD). As part of the Catalyst Project, Anglo Platinum sponsored the training of 120 technology teachers in 2004 and 260 in 2005 in the Bojanala West Region (four geographical areas namely Rustenburg, Kgetleng River and Moses Kotane East and West) of the North West Department
The technology teachers in this region are familiarised with the LTSM by means of workshops facilitated by TechnEd staff. Four four-hour workshops are facilitated with both the Grade 7 and the Grade 8 and 9 teachers. The CPTD is done according to a school-focused model (Engelbrecht, Ankiewicz & De Swardt, 2005; 2006).

Each teacher is supplied with LTSM, including a TechnEd learner workbook and teacher guide on a specific theme of technology, as well as additional notes. This fulfils a need expressed by many teachers by giving them a customised set of lessons to facilitate a complete project in the classroom on one of the technological themes. During the workshop, teachers are also supplied with all the tools and materials to participate in the hands-on activities. In order to satisfy the need for subject specific content vs. the generic nature of previous training, the purpose of this CPTD is to develop technology teachers’ pedagogy and subject knowledge.

The purpose of this paper is to determine the teachers’ experience of the Catalyst Project, where all these partners are involved. The research question addressed in this paper is: What is the teachers’ experience of the Catalyst Project?

3. Research design
A qualitative case study was conducted among the technology teachers who are participating in the Catalyst Project. Data were collected through the observation of the teachers during the various workshops, open-ended questionnaires (questions were adapted after each workshop to try and get the richest data possible) and interviews. One purposefully sampled (Merriam 1998:62-63) teacher was given an open-ended questionnaire and a follow-up interview, and two purposefully sampled (Merriam 1998:62-63) teachers were individually interviewed to confirm the emerging findings. The data were analysed using the constant comparative method (Merriam, 1998).

4. Findings
The main finding and the four specific findings are summarised in figure 1 below.
The main finding is that the teachers experienced the workshops as *rewarding and fruitful*. Some of the specific experiences that made it rewarding and fruitful are included in the responses of the teachers from the open-ended questionnaires:

- The workshop was so fruitful to me since it was my first time to attend such a workshop.
- I found the workshop very rewarding and fruitful. The learner guide as well as the facilitator’s guide are comprehensive and to the point. I wish more workshops of this nature could be held regularly.

The main finding is supported by four specific findings which will be discussed in more detail.

### 4.1 Teachers felt empowered by the workshops through the development of their technological knowledge (both conceptual and procedural) as well as their pedagogy

Under this finding the aspects of the workshop that made the teachers feel empowered were the development of their conceptual (“knowing that”) and procedural (“knowing how”) technological knowledge as well as their pedagogy.

#### 4.1.1 The teachers mentioned in the open-ended questionnaires that they, inter alia, experienced the learning of concepts like linkages, levers and energy. This was an indication that the teachers developed conceptual technological knowledge:

The lesson was excellent; we have gained a lot about levers and linkages.

Evidence from the interviews:
What we get from the workshop is also enhancing our vocabulary as far as the concepts of technology is concerned.

4.1.2 The teachers experienced the development of **procedural technological knowledge**, which entails the thinking and technological processes as was mentioned by the teachers in the open-ended questionnaires:

I have gained a lot in making a model of a structure i.e. house. I also gained in how to work out a scale of a plan for a house.

4.1.3 Teachers felt **empowered through developing their pedagogy** (instructional approaches, strategies and skills). Teachers claimed that they can present a lesson, know how to integrate activities, can use assessment instruments like rubrics, learned about guidance and facilitation and how to manage materials for a project. From the open-ended questionnaires the teachers said the following:

It empowers me with knowledge and how to teach technology to …

It gives us ideas on how to do a lot of practical work with learners and learners enjoy it a lot

Evidence from the interviews:

I think the mere fact that you are here prepared now, automatically you know you would feel more confident in stead of you are going to go up there and think what are you going to teach now today.

4.2 Teachers experienced the workshops as being conducive to learning among learners

In the open-ended questionnaires teachers reported that the workshops affected the learning in their classrooms in the sense that learners, among other things, understand technology better and that they benefit from the material given at the workshop:

The learners understand better than before. They also enjoy doing their work because they use the supplied booklet …

Learners gain a lot from the materials I have received from the workshops.

Evidence from the interviews:

Because the mere fact that the learners are also enjoying this, I think that, you know, that also proves that there is… you know the workshops are helping.

4.3 Teachers experienced the accompanying LTSM as well as the materials and tools, supplied during the workshops, as informative and helpful, and have a need to use it in their classrooms

The following responses, of teachers in the open-ended questionnaires, illustrate that teachers experienced the LTSM and the materials and tools used in the workshops as informative and helpful:

Their study material is so fantastic and helpful.

…Learners gain a lot from the materials I have received from the workshops.

Evidence from the interviews:

Because of the sponsorship, you know, we really get away with the subject because these books we are getting from Anglo Platinum… it really making a difference.

4.4 Organisational aspects (some of which TechnEd had control over, and some of which the DoE had control over) regarding the workshops were part of the teachers’ experience

Under this finding the responses of the teachers were classified under two sub findings, namely organisational aspects that TechnEd had control over, and organisational aspects that the DoE had control over.

4.4.1 Organisational aspects that TechnEd had control over
Under organisational aspects that TechnEd had control over, teachers expressed their experience of the facilitation and the methodology of the workshop, inter alia, as excellent, as well managed, as well presented and as well organised in the open-ended questionnaire as follows: Excellent and very competent in managing the workshop. Their study material is so fantastic and helpful. The good delivery will be to the benefit of our learners and to the community as well.

The teachers’ experience of the facilitation and methodology of the workshop was also mentioned in the interviews:
The manner that these workshops are being conducted they are very professional manners, in stead of the other ones where you go and talk and talk and talk all the time.

The teachers stated in the open-ended questionnaire that they would prefer the workshops to be scheduled in the beginning of the term/year:
I wish such courses should be conducted at the beginning of every term so as to guide educators before it is too late.

The teachers’ experience of more frequent workshops was mentioned in the open-ended questionnaires:
I wish more workshops of this nature could be held regularly. Thank you.
This could be done more often for the facilitators to learn more about Technology Education.

The teachers’ experience of the duration of the workshops was mentioned in the open-ended questionnaires:
If possible next time we ask more time.
The workshop was too short

The teachers’ request to increase the frequency of the workshops were also mentioned in the interviews:
I wish we can have more of this kind of workshops.

4.4.2 Organisational aspects that the DoE had control over
Over the three years that the workshops have been running, various venues have been used. Teachers had varying experiences with regard to the different venues, and they preferred the central venue (like Rustenburg) which is close to the taxi rank, a cool and well ventilated venue, spacious and well lit, as illustrated in the following comments from the open-ended questionnaires:
The venue is next to town where transport is available.
Well organised, well ventilated and more spacious.

Teachers expressed a need in the open-ended questionnaires with regard to the notice sent out by the DoE, to contain clear and accurate information as well as to be sent out earlier so that it could reach them timeously. Teachers complained about the notice, saying that they either receive it very late (in some cases the day before the workshop), or not at all and they have a need for the DoE to send out the notice earlier so that it could reach them in time:
We would like you to inform us about the workshops and not the department. I received info on this workshop on Friday.

In the open-ended questionnaire teachers also complained about information on the notice being vague or incomplete:
Do not use abbreviation on circulars noting the venue e.g. HTS – we were lost.

5. Summary
In contradiction to the earlier reference that teachers found CPTD as too generic (Chisholm, 2000;
Engelbrecht, Ankiewicz & De Swardt, 2005; 2006; Potgieter, 2004; Ziqubu, 2006), it seems that teachers experience TechnEd’s CPTD with a specific focus where they are supplied with customised LTSM, material and tools that they can implement in their classrooms, and where they are orientated and trained in the underlying knowledge and pedagogy, as fruitful and rewarding. From the findings as well as from the relationships between them we realise that the customised LTSM played a central role with regard to the teachers’ overall experience of the workshops as being rewarding and fruitful. The LTSM served as point of departure for the facilitation of the workshops, contributed towards the teachers’ empowerment in terms of knowledge and pedagogy, and it promoted learning in the technology classroom.

However, we do not know how technology teachers engage with technology tools (including the LTSM) as mediators in their pedagogic practice and to what extent they collaborate with and support their peers once they leave the workshops.

6. RNA: Teacher development in ecologies of practice

6.1 Focus of the RNA

We see the recently awarded National Research Foundation (NRF) Research Niche Area (RNA) to the Faculty of Education at the University of Johannesburg as a platform to extend our research on the Catalyst Project in the Bojanala West Region of the North West Province.

In this project, we wish to capture what happens to the knowledge (conceptual and procedural) that teachers carry to the workplace and how teachers collaborate to continue to develop professionally in ecologies where the catalyst is ultimately the empowered “keystone species”.

The focus of the Niche Area is in the scientific area of research on continuing professional teacher development, using technologies of mind, of hand (and of ‘heart’). We search for ways of learning and configurations of learning groups that may prove to be innovative and useful for teachers in their continuing professional learning. The central premise of our work is that teachers learn (and train) in their professional practice optimally in an everyday, communal setting. In such a setting, groups function in what we wish to refer to as a social ecology, and also a social semiotic system, according to Lemke (1995). The learning group is metaphorically characterised by the same components that constitute a biological ecology, with the addition of meaning-making as human activity.

In the case of teachers this would mean that there are few ‘outsiders, and mostly ‘insiders’ who drive the process of teacher (continuing) development and that the ‘programs’ of learning are not generic, but custom designed/amended for the group, by the group, under the leadership of varying “keystone species” (in the ecology metaphor discourse). These “keystone species”, or seminal participants, may be within the always fluid group, or may be interested and caring outsiders who may remain members of the group until they are no longer needed.

The umbrella research body (the RNA, “Teacher development in ecologies of practice”) comprises seven RNA sub-projects, each with a different focus, of which the Technology RNA (Teachers and tools: crafting technology education) is one. The various envisaged projects will thus engage in research to theorise professional learning in in-situ groups, while also developing tools to scaffold this learning.

6.2 The Technology RNA: Teachers and tools: crafting technology education
We believe that there are so-called “keystone species” in the group (ecology of practice), that will, if they are empowered by training, most probably create a shift from school-focused (where outsiders/experts act as external catalysts) to school-based CPTD (where the keystone species act as internal catalysts), which will be more effective. According to Edwards (1991:42) a school-based CPTD model has as basic point of departure that training occurs within the normal working milieu and is managed mainly, but not completely, by the school’s own personnel in order to fulfil the immediate and specific needs of the school (Gettly, 2002:31).

The focus of the inquiries in this Technology RNA project will be on how teachers harness the tools that they teach as mediators of the content and how teachers collaborate in sharing both knowledge and tools. The guiding research question therefore is, “How do technology teachers engage with technology tools (including the LTSM) as mediators in their pedagogic practice and to what extent do they collaborate with and support their peers?”

For the second phase of the RNA, after two years, the question will shift to the way in which the ecologies are developing and how they are nurtured, with emphasis on the LTSM as unit of analysis. We will also investigate the role that these ecologies can play in CPTD and how the designs for teacher learning and practice can “travel” (Greeno’s term for “transfer” or “generalise” – see Ford and Forman, 2006) to other settings. A school-focused and school-based CPTD model for technology teachers will then be developed, based on these findings.

6.3 Research aims and objectives

In the studies that will be located in this technology RNA project the overarching aims are:

- the identification of technology teacher learning in practice (ecologies of practice, communities of practice, learning and practice communities, and novel descriptors that may come from the teachers as participatory researchers who may describe their ways of doing from local knowledge)
- multi-layered analyses of the social semiotics and the pedagogy that constitute these practices
- in-depth analyses of teachers’ technological knowledge
- in-depth and multi-method analysis of technology teachers’ instructional methodology
- analysis of technology teachers’ discourse – related to their CPTD needs
- the identification of possible “keystone species” in the ecologies of (technology education) practice
- the training of teachers as practitioner researchers, in practice-led research, to assess the development of ecologies of (technology education) practice
- the development of customised teacher development programmes that are culturally and contextually sensitive, and that can be adjusted according to a teacher development mapping tool that we are constructing in the SANPAD project ("Teacher identity and the culture of schooling") presently.
- the evaluation of learner performance in selected schools/classrooms in non-experimental format in order to capture links between teacher change and learner activity.

7. Conclusion

The findings of the CPTD as part of the Catalyst Project will serve as an important point of departure for the prospective Technology RNA project. This project will afford us the opportunity not only to determine what happens in the technology classrooms once the teachers have left the workshops, but also how to refine TechnEd’s CPTD in order to promote effective technological literacy, both among teachers and their learners.

8. References


