Understanding & Providing a Developmental Approach to Technology Education

A HANDBOOK FOR TEACHERS

Edited by John R Dakers and Wendy Dow

The project UPDATE is funded by the European Community’s Sixth Framework Programme
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UNDERSTANDING & PROVIDING A DEVELOPMENTAL APPROACH TO TECHNOLOGY EDUCATION

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UPDATE - THE PROJECT

UPDATE stands for Understanding and Providing a Developmental Approach to Technology Education – The aim of the programme is to improve science and technology teaching in Europe in order to motivate young people’s interest in technology, especially girls. New learning material and methods shall result from the project which focuses on three age-groups mainly: early childhood, elementary school (age 6 to 12) and general education (age 13-18).

Innovative Aspect
The innovative aspect of UPDATE is that the approach includes a strong focus on early childhood and primary education. It is at these ages that most children’s attitudes about technology are shaped and it might be too late to start raising interest only at secondary or later stages. The UPDATE project’s aim is threefold:
1) to examine why girls drop out from technology education at different stages of their education
2) to create new ways and educational methods to make technology and technological careers appear more attractive for both girls and boys
3) to promote, encourage young people, and especially girls and young women, to consider engineering and technology in career terms, and as active users of modern technology.

Multi-national Project Consortium
15 partners from 10 different countries participate in this multinational European project; the members come from Finland, Germany, the United Kingdom, France, Spain, Greece, Austria, Slovakia, Estonia and Romania.
UPDATE Project Partners
University of Jyväskylä, University of Glasgow, IUFM University Institute for Teacher Training of Aix- Marseille, "Alexandru Ioan Cuza" University of Iasi, Ovidius University Constanta, University of Tallinn, Dortmund University of Applied Sciences, University of Koblenz, FCRI Catalan Foundation for Research and Innovation, Competence Center Technology-Diversity-Equal Chances, Institute of Philosophy at the Bratislava Slovak Academy of Sciences, University of Education in Vienna, Technical Institute for Social Activities Galileo Galilei, Aristotle University, University Complutense de Madrid, IDEC S.A.

UPDATE Website
The UPDATE website offers a constantly growing knowledge portal and a newsletter service for teachers, other stakeholders of the educational system, and interested parties. In the form of a “Wiki” on technology education, managed by experts, news, dates, research results, and examples of good practice are presented. UPDATE reports, for example, on new concepts for the youngest visitors in European technology museums, on the amazingly successful project “Girls'Day – Future Prospects for Girls in Germany, Austria, Luxemburg, and the Netherlands, or the Romanian project “Be a Science Teacher for a Week”.

For more information: http://update.jyu.fi/

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UPDATE - PROJECT LEADERS

There are eight sections called ‘workpackages’ that combine to make up the three year research project known as UPDATE. Each workpackage has a leader who is responsible for research in an area described below. The WP Leaders are:

There is also a workpackage that deals with the dissemination of information about the project led by the Competence Center Technology, Diversity and Equal Chances in Germany.
INTRODUCTION

This technology education handbook is intended to act as an interim guide for teachers of technology education in all sectors of school. It is hoped that this will serve to guide the shaping of any teaching and learning provided by those who are active in providing a technology education programme.

Findings revealed thus far indicate, in line with the hypothesis made in the UPDATE project, that issues related to gender in technology education are embedded at an early age and these should be addressed before, as well as in, the secondary sector.

It is recommended that this guide should be read in conjunction with the following resources:
RECOMMENDED READING
RECOMMENDED READING


This book also deals with education in general but has some interesting insights into technology education and gender.

The issues discussed are very important to the UPDATE project.


This book contains chapters from some of the leading philosophers, sociologists, and educationalists in technology education.

18 chapters include issues ranging from the philosophy of technology, ethics, gender and technological literacy.


This is an excellent book about gender and science written from a feminist perspective. Whilst the topic is science based, it deals with issues that equally relate to technology.


This book offers some provocative pieces written by technology education experts in their field.

19 chapters cover a range of issues about technological education including issues relating to design, gender and pedagogy, creativity and assessment.


This book contains offers some splendid examples of actual best practice in technology education from around the world. These initiatives are then analysed by experts in technology education looking at issues such as design, attitudes, ethics and conceptualisation.

This book won the Silvius-Wolansky Award for the Outstanding Scholarly Publication in Technology Education.
RECOMMENDED READING

Papers
Paper delivered at the educational conference in Rennes, France. Available on the WP4 pages. UPDATE: web pages (Internal area)

Reports


THE PREVAILING MODEL IN TECHNOLOGY EDUCATION ACROSS EUROPE

What follows is informed both by the findings of a curriculum analysis on the content and delivery of technology education in six countries in Europe, as well as by contemporary literature on the subject matter. The analysis is specific to the secondary stages, and in particular, the middle school and lower school (ages 12 to 16). However the issues apply to the primary sector and to early years. The countries investigated in this UPDATE project were Austria, Estonia, Finland, France, Germany and Scotland. Several other European countries were investigated in a previous EU report and the findings were very similar. Other influences are the case studies undertaken in Scotland, the questionnaires given out to 300 school aged pupils in both Scotland and Austria and finally, as alluded to above, the research literature that has also served to influence the make up of this document. Technology education across the various countries covers a variety of disciplines including graphics, craft or product design, electronics, structures, mechanics, information technology, food, architecture, textiles. The delivery of the craft or product design element in these countries follows a very similar model. These element account for the most prevalent form of technology education on offer. Students are introduced to the material properties of wood, metal and plastics. They are also introduced to the tools and machines associated with the manipulation of these materials into fabricated artefacts or technologies. Students are introduced to the workshops in the secondary sector as a fresh start approach. This is because the primary sector does not have workshops such as those in the secondary sector. In Scotland (the main focus of this study), students are introduced to the materials, tools and machines by way of the fabrication of models. These models are designed to offer students an incremental introduction to the material properties and forms of manipulation in their fabrication. In other words, the models start out simple and become progressively more and more complex. Early models tend to be material specific (i.e. wood or metal or plastic). As progress is made over the years the models may involve a combination of materials.
TYPES OF KNOWLEDGE

The theory of knowledge is a major area of philosophical debate known as epistemology. There have been many discussions, held over several millennia, about what knowledge actually is – how do we define knowledge? For the purposes of this handbook, three types of knowledge will be considered in relation to technology education. These types of knowledge are:

- Procedural knowledge
- Declarative knowledge
- Conceptual knowledge

The Ancient Greeks and technical knowledge

Before considering the three types of knowledge mentioned, it is worthwhile considering the ancient Greek origins of the term technology. In so doing, we will be able to see that consideration was given to types of knowledge then. For Plato, only two types of knowledge existed: Theoretical knowledge that was considered to be philosophical in nature, and technical knowledge known then as technē. The ancient Greeks argued that technē, or what we will now refer to as technical knowledge, had different characteristics from philosophical knowledge. This is why Plato is famous for using the term ‘philosopher kings’, meaning that this type of knowledge was superior to technical knowledge and only those capable of possessing this type of knowledge were fit to lead and to rule. Not much has changed you might well argue.
Philosophical knowledge dealt with themes like justice, politics, rhetoric, love and virtue for example. These themes were difficult to prescribe in any technical sense and were very much open to interpretation. Technical knowledge was not considered like this. In order to be technical, knowledge had to have certain universal characteristics, as follows:

**Technical knowledge characteristics**

1. Technical knowledge must be technical knowledge related to a specific subject area: in other words, its subject matter is determinate like cooking, weaving, woodworking or metalworking for example.
2. The product, whether physical like a table or abstract like advice given by an expert, must be considered to be useful in a practical sense by both the fabricator and the consumer.
3. The product that is produced must be considered to be reliable.
4. The technician must be recognised by the community as someone that is technically competent, someone proficient in the technical realm under consideration. In other words, the technician must be certified able to undertake the technical task required. (If we want our car to be serviced we take to someone who not only claims to have expertise in the servicing of a car, but can offer some form of certification that supports their claim. This applies equally to a plumber or a carpenter for example)
5. The technical knowledge in question can be explained by the expert to the novice. In other words, this type of knowledge can be taught explicitly. Technical knowledge considered in these terms is clearly made up of a set of rational principles.

The demonstration of a large degree of proficiency in all of these characteristics given above will result in a ‘expert’ (joiner; weaver; cook……etc). However, it must be recognised that in order to obtain ‘expertise’ in any of these domains usually requires complete immersion in the subject matter, usually in the form of an apprenticeship. This is clearly not the case in school based technology education and we must make allowances for that. Moreover. It is important also to mention that in the UK, there is a strong move towards vocational qualifications that, in terms of knowledge, tend to have the same characteristics as mentioned above. These qualifications are all certified and certification proclaims the holder as able to perform in accordance with the standards applicable to the
subject area. For example, someone can train within the food industry and be certified able in aspects relating to food hygiene, or as able to change tyres on a car. The standards in all cases have been specified in advance and those training in the area have to demonstrate that they are able to conform to these standards.

These principles apply to forms of knowledge that already exist. They form the basis of two of the kinds of knowledge that follow: procedural and declarative.

**Three types of knowledge**

**Procedural and declarative knowledge**

Procedural knowledge is, in simple terms, ‘knowing-how-to-do-it’ knowledge. In technology education we teach students ‘how-to’: use a pair of scissors, a saw; draw a truncated cone; cook using the grill etc.

Declarative knowledge is, in simple terms, ‘knowing-that-something-is’. In technology education we teach students ‘that’: glue is used to stick things together, a tri-square is used to mark out wood; an engineers-square is used to mark out metal; wood is obtained from trees etc.

In terms of learning, procedural and declarative knowledge can both be considered as either a process involving the ‘acquisition’ of factual knowledge that is ‘transmitted’ from an expert to the novice as learner, or as constructed by the learner independently from any expert. This can be done through personal experience of actually being-in-the-world: for example, we construct our own knowledge as to how to use a bus, or a train or a tram or how to conduct ourselves in a shop by experiencing these things.

Once ‘acquired’, this type of knowledge is internalised and becomes the ‘property’ of the individual learner. The more of this type of knowledge the learner is able to acquire, the more expert they will become in the application of that knowledge and the more they will be
able to demonstrate and ‘give’ that knowledge to others. The relationship between a skilled artisan and an apprentice forms a good example of this type of learning and also highlights the fact that this type of learning is always set within a particular context. This type of knowledge can only ever be based upon the ‘acquisition’ of pre-existing knowledge in the form of skills and procedures. It is impossible to ‘acquire’ something that does not yet exist. In order to learn in this context, the learner must be capable of ‘acquiring’ a set of pre-existing skills associated with some skill domain. The learner can either ‘construct’ these skills independently (using non human interventions such as books or by trial and error), or they can learn from someone who is considered to have expertise in that skill domain, or a combination of both. The end result will be the creation of an individual who is considered to have attained some level of proficiency in some specialised technological subject domain such as woodworking; metalworking; technical drawing; cooking; electronics etc. The individual’s level of proficiency is assessed by first considering their degree of skill as evidenced in the production of an artefact (procedural knowledge) and by examination of their knowledge related to the subject area: ‘what tool would you use to…’; ‘name four processes (ways) for shaping metals’; ‘describe three of these processes correctly in your own words’ (declarative knowledge).

These two types of knowledge development tend to situate technology education in specific occupational genres that are, for the most part, trades based. In the research carried out for this project, it was found that girls did not, for the most part, aspire to work in these trades based occupations which they perceived to be masculine domains. The research literature supports these findings. This forms the basis of one of our conclusions that suggest that girls are less likely to take a subject that appears to lead towards a job in a male orientated trades based occupation. Technology education does, in general, appear to align itself with engineering occupations and where this has an emphasis on the development of procedural and declarative knowledge, it is more inclined towards trades based engineering occupations rather than professional ones. Evidence from this project and from the research literature strongly indicates that girls perceive engineering, whether craft based or professional, as being male dominated (see the drawings at the end of this handbook).

**Conceptual knowledge**

Unlike procedural and declarative knowledge, understanding conceptual knowledge is a little more complicated. Concepts can be thought of, in simple terms, as being abstract general ideas that attempt to see relationships between ‘items’ of knowledge. It is by making links
between these ‘items’ of knowledge that we can conceptualise the world. For example, the abstract general idea, or concept ‘blue’ can relate to; feeling cold; being sad; being of noble birth (blue blooded). In other words the term ‘blue’ is understood differently depending upon the context in which it is used. The same can be applied to knowledge related to technology. A hammer can be conceptualised as a; a tool; a weapon; a door-stop, once again depending upon the context in which it is used. The use of a hammer as a tool or as a door-stop is not likely to be contentious. However, its use as a weapon may give rise to a variety of value judgements. Whilst the history of a hammer, or most tools used in technology education settings, have had an impact upon society in some way, that impact can be conceived as being relatively small today. It is only when we consider the impact of modern or high-technologies that conceptual issues become more prominent.

The use of ultra-sound technologies in hospitals, for example, allows parents to ‘see’ the baby whilst it is still in the womb. This new technology now affords the parents the opportunity to know the sex of their child and also to determine early in the pregnancy whether the child has some form of a disability that may, or may not prove to be problematic from the parent’s perspective. The technology in this case, enables new possibilities that did not exist before. It now makes it possible for the parents to decide whether or not to abort the foetus on the grounds of disability. Technological development is now close to enabling ‘designer babies’. These and many other issues like them are conceptual in structure and have no correct answers. Whilst they involve technology in a functional sense, they are also steeped in issues that are ethical, political, moral, emotional and value laden. These conceptual issues are socio-historical and cultural. In other words the progress of the technologies mentioned is historical and the impact that they have on our cultural development changes the way we live in the world.

Unlike procedural and declarative knowledge that both have the learning of pre-existing factual skills, procedures and knowledge as their raison d’être, conceptual knowledge is more concerned with the development of critical capacities in terms of technological development. The development of these critical capacities is most effectively done in a social setting. By their very nature, issues relating to ethics, politics and values are social constructions and as such, emotionally bound. We hold our individual beliefs as a result of our cultural inheritance. The social impact of any technology will not necessarily have a consensus amongst a group of students (nor teachers for that matter).
Conceptual knowledge requires the development of a critical capacity that will enable students to consider differing views about the nature of technology. It relies more on emotional intellectualism that gives rise to some form of expression. This form of expression can become manifest through dialogue. The research carried out in this study and as found in the literature suggests that girls are more inclined to be motivated to engage in technology education when conceptual issues are seen to be part of the pedagogical framework.

**TYPES OF PEDAGOGY**

Like theories of knowledge, issues relating to pedagogy have been at the centre of educational debates for some considerable time. The word derives from the Greek ‘pedagogue’. A pedagogue was a slave who was responsible for the education of his master’s son. (Girls did not have access to formal education then). Part of the slave’s responsibility was to lead the son to the school and quite literally means ‘to lead the child’.

The three types of pedagogy that will be under discussion in this section are:

- The transmission method
- The social constructivist method
- Critical pedagogy

The transmission method of pedagogy is a style of teaching that implies an expert teacher and a passive learner. Paulo Freire, who devised critical pedagogy, called the transmission method ‘the banking method’. He suggested that in this style of teaching the teacher deposited information into the child as one does with money in a bank. At a later time it is hoped that some interest will have accrued and in order to check, a withdrawal is made in the form of an examination. In this model, knowledge (see above) is fixed and immutable and not open
to debate. The teacher, moreover, must have already acquired this knowledge before she/he can ‘transmit’ it into the learners. In practical terms, the technology teacher passes on the correct technological knowledge that she/he has acquired and mastered through time. Traditionally, given that knowledge is fixed, classroom practice in this model tends to be whole class teaching where the learners all learn the same thing at the same time over the same time period, like the fabrication of a trinket box and a trowel described later. This style of pedagogy stifles any opportunities for learners to intervene in the formation of technologies in a creative way: they are merely following instruction. Nor does it enable learners to participate in the rapidly changing technologies of tomorrow: the technologies studied are pre-existing.

In social constructivist models of pedagogy, knowledge is not fixed but is socially constructed or interpreted. Knowledge has historicity and is therefore subject to change. Christianity, for example, is based upon the reading of the Bible. The Bible has (and continues to be) the subject of much interpretation and reinterpretation over time. In other words the interpretation that some of our medieval ancestors put upon the Bible is now considered to be dramatically different from modern interpretations. Likewise, Newtonian physics has been subject to serious doubt after Einstein. These ‘items of knowledge’ are thus not fixed and immutable but are, rather, subject to change over time. Einstein did not live and work in a vacuum. He was not only influenced by the knowledge generated by his contemporaries, but by that knowledge which had gone before and significantly, he did not simply re-learn the existing knowledge relative to his work and reconstitute it. Instead he reconstructed it. He took pre-existing knowledge and reinterpreted it and in so doing, he generated new ways of thinking about the world. Einstein interacted with knowledge that existed on the social plane (it was conceived by humans) and constructed new mathematical models: his theories, in other words, were socially constructed. Knowledge in those terms is not something tangible that exists outside us. It is something that we construct through social interaction. In practical terms, the teacher shares her knowledge but is open to challenge by the learners. Learning intentions would be shared with the class and open to variation. Learning and teaching are more dynamic and subject to alteration in this model. Because knowledge is variable and subject to social interpretation, certain elements of learning become messy and cannot be taught in rigid structures. It is accepted in this model that certain given facts do require to be taught in a more structured way: health and safety rules; safe tool use; the known properties of materials. However, the knowledge brought to the classroom by all learners is shared and new learning evolves as a result. The Nuffield model, as described later, offers an interesting way to implement this style of pedagogy.
Critical pedagogy has its roots in the work of Paulo Friere and advances the social constructivist model a stage further. He advocates for a democratic school in terms of learning. The relationship between the student and teacher is equal both in terms of learning and teaching. For Freire, the teacher must learn from the students and the students must learn from the teacher. Teaching and learning is, for Freire, not a one-way process. It is social in its nature and thus, political. Those teachers who stand opposed to this, whether implicitly or explicitly, fail to acknowledge that teaching and learning, like technology itself, is not a neutral process: the teacher, like the learner, has feelings, emotions and political ideologies.

For Freire, the transmission of knowledge from one human being to another reduces the concept of learning to information which must be memorised or packaged in the form of discrete skills that can be transferred to students. As Ira Shor has suggested, classrooms essentially die as intellectual centres in this paradigm. They become delivery systems for lifeless bodies of knowledge. Instead of transferring facts and skills from teachers to students, a Freirian class invites students to think critically about subject matter, doctrines, the learning process itself, and their [students] society…In the liberating classroom suggested by Freire’s ideas, teachers pose problems derived from student life, social issues, and academic subjects, in a mutually created dialogue.
THE CONFLICT BETWEEN POLICY AND PRACTICE

In Scotland, as well as in other countries taking part in this project, there appears to be a fracture between what is actually delivered in the classroom, assessment and policy for technology education. Figure 1 below depicts the four capacities to be developed by students in areas surrounding the ‘technologies’. Published by Learning and Teaching Scotland, a curriculum for excellence is available at: http://www.ltscotland.org.uk/curriculumforexcellence/

Professor Richard Kimbell, a much regarded academic in relation to technology education, reminds us that policy makers aspirations for technology education in England explicitly point to the need to develop innovative young people, much the same as the Scottish model shown discussed above. The paradox is that these aspirations are more likely to be developed by way of conceptual knowledge development. It is assessment that serves to direct teachers towards a more transmission model of pedagogy. As Kimbell argues, assessment tends to measure performance and teachers have, over time, managed to develop well orgaised systems for ensuring that their students’ work contains all that is required for them to attain the best grade. For Kimbell, this checklist approach results in outcomes that are:

- (typically) not creative – but formulaic;
- (typically) not done in teams – but as individuals;
- (typically) not innovative – but safe.

Assessment effectively rewards teachers for teaching students to produce formulaic, individual and safe work that will ensure a pass. The new ‘Curriculum for Excellence’ in Scotland is purporting to remove the rigid assessment structures from the subject and if this is done, this will enable teachers to teach learners to be more innovative, creative and take more risks. The new case studies employed in this
project must, therefore, only work with classes that are not subject to formal terminal examinations. In the case of Scotland, this can be achieved in S1, S2 and S3. (age 12 to 15 years).
Successful Learners
With:
• Enthusiasm and motivation for learning
• Determination to reach very high standards of achievement
• Openness to new thinking and ideas
And able to:
• Use literacy, communication and numeracy skills
• Use technology for learning
• Think creatively and independently
• Learn independently and as part of a group
• Make reasoned evaluations
• Link and apply different kinds of learning in new situations

Confident individuals
With:
• Self respect
• A sense of physical, mental and emotional well being
• Secure with values and beliefs
• Ambition
And able to:
• Relate to others and manage themselves
• Pursue a healthy and active lifestyle
• Be self aware
• Develop and communicate their own beliefs and view of the world
• Live as independently as they can
• Asses risk and make informed decisions
• Achieve success in different areas of activity

Responsible citizens
With:
• Respect for others
• Commitment to participate responsibly in political, economic, social and cultural life
And able to:
• Develop knowledge and understanding of the world and Scotland’s place in it
• Understand different beliefs and cultures
• Make informed choices and decisions
• Evaluate environmental, scientific and technological issues
• Develop informed, ethical views of complex issues

Effective contributors
With:
• An enterprising attitude
• Resilience
• Self- reliance
And able to:
• Communicate in different ways and in different settings
• Work in partnership and in teams
• Take the initiative and lead
• Apply critical thinking in new contexts
• Create and develop
• Solve problems

To enable all young people to become:
MODEL DEPICTING TYPES OF SCIENTIFIC AND TECHNOLOGICAL KNOWLEDGE

The theory of knowledge is a major area of philosophical debate known as epistemology. There have been many discussions about what knowledge is for many centuries. For the purposes of this handbook, three types of knowledge will be considered in relation to technology education. These types of knowledge are: Procedural knowledge; Declarative knowledge; Conceptual knowledge. Procedural knowledge is, in simple terms, ‘knowing-how-to-do-it’ knowledge. In technology education we teach students ‘how-to’: use a saw; draw a truncated cone; cook using the grill etc. Declarative knowledge is, in simple terms, ‘knowing-that-something-is’. In technology education we teach students ‘that’: a tri square is used to mark out wood; an engineers square is used to mark out metal; wood is obtained from trees etc.

Procedural knowledge is a technical form of knowing how to do something. It relies on skills that have evolved over time: they are historical forms of established knowledge. These skills are likely to have changed over time and are likely to change again in the future. However, in order to learn ‘how to’ undertake some procedure, the novice has to learn skills in the form of knowledge that already exists. Driving a car or using a tool both serve as examples of forms of procedural knowledge. In order to drive a car a person has to learn, amongst other procedures, how to change gear, operate the clutch and steer the vehicle. In other words, the procedural knowledge on how to drive a car already exists and has to be learned by the novice, usually alongside a competent driver. In the case of driving a car, the novice usually finds it difficult to co-ordinate the various necessary procedures whereas the competent driver appears to undertake them effortlessly. It is a relatively easy matter to assess whether a person is competent at undertaking any given procedure. One simply observes the activity or the resultant product arising out of that activity: the act of driving competently or the quality of the artefact produced through the use of tools.
Declarative knowledge is also a technical form of knowing. In this case it is knowing *that* something is the case. Like procedural knowledge, declarative knowledge also relies on historical forms of pre-established knowledge. However, declarative knowledge relies on historically established *information* rather than skills. These forms of information have also evolved over time and will also continue to evolve in the future. A person competent in declarative knowledge will be able to explain how to drive a car or use a tool or even have knowledge as to how a car engine operates. Significantly however, whilst they may have learned these things and are, as a result, able to ‘declare’ them, it would not be a prerequisite that they were actually able to drive a car or use a tool or assemble an engine in order to
have knowledge of these things. Competent footballers do not always make the best football coaches and competent coaches do not need to have been competent footballers.

Both procedural knowledge and declarative knowledge are forms of knowledge that have been established in the past. If these forms of knowledge are considered by the teacher to be fixed and immutable

**TYPES OF PEDAGOGY EMPLOYED IN RELATION TO TYPES OF KNOWLEDGE TAUGHT.**

Different types of knowledge acquisition require different forms of pedagogy. The figures below suggest the types of pedagogy that are best suited to the types of learning scenarios being developed and the types of knowledge that is being learned.

The types of learning scenarios illustrated below suggest that the subject area demands different ways of perceiving the world: one is rational and certain; the other is emotive and open to question. Contemporary research and the findings of the UPDATE project to date, suggest that girls favour the emotive issues in technology education whereas boys, in general, favour the rational. Moreover, whilst design may have some degree of rationality, it is far more orientated towards the expressive domain and this can serve to form a tension between the calculative and the expressive in terms of pedagogy.
Figure 3: Masculine and feminine expressions of technological knowledge development

Types of learning scenarios

<table>
<thead>
<tr>
<th>Value-neutral</th>
<th>Tend to be school based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing how to...</td>
<td>Individual learners</td>
</tr>
<tr>
<td>Knowing that…</td>
<td>Technical knowing</td>
</tr>
<tr>
<td>Understanding connections…</td>
<td>Well-defined problems</td>
</tr>
<tr>
<td>Informed value judgements…</td>
<td>School based scenarios</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value-laden</th>
<th>Tend to be real world based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communities of learners</td>
<td>Psychomotor skill development</td>
</tr>
<tr>
<td>Humanist thinking</td>
<td>Rational</td>
</tr>
<tr>
<td>Ill-defined problems</td>
<td>Certainty</td>
</tr>
<tr>
<td>Authentic scenarios</td>
<td>Calculate</td>
</tr>
<tr>
<td>Development of critical capacity</td>
<td>Emotive</td>
</tr>
<tr>
<td>Open to question</td>
<td>Expressive</td>
</tr>
</tbody>
</table>

Figure 3: Masculine and feminine expressions of technological knowledge development
Figure 4: Types of pedagogy associated with types of knowledge

- **Procedural**
  - Knowing how to...
  - Favoring an ‘expert’ transmitting pre-established facts and methods

- **Declarative**
  - Knowing that...
  - Favoring an ‘expert’ transmitting pre-established facts and methods

- **Lower order conceptual**
  - Understanding connections...
  - Favoring social constructivism

- **Higher order conceptual**
  - Informed value judgements...
  - Favoring critical pedagogy
UPDATE RESEARCH FINDINGS TO DATE

Questionnaires
300 questionnaires were given out to school students in the 12 to 14 age range in order to find out about their perceptions about technology. A more detailed account of the findings, together with the questionnaire can be found on the UPDATE web site. One group of girls were asked to draw a scientist and an engineer. Three drawings are appended to this handbook. They clearly depict both groups as being men. The last one shows a female teacher (one of the teachers in the study) but she is depicted as having male characteristics. (Not true in reality).

Case studies
Seven case studies were undertaken in Scotland in 2007. A more detailed account of the case study reports can be found on the UPDATE website. Some salient factors emerging from the case studies indicated that departments were reluctant to deviate from the established models they had in place. This is further evidenced from a research report undertaken in 2001 entitled “Evaluation of Nuffield Design and Technology Materials Used in a Two Year Pilot Scheme in Certain Glasgow Schools”. Evidence taken from this research indicated a very strong reluctance on the part of secondary departments, to change established models.

The majority of girls questioned did not wish to pursue a technologically orientated career. They saw it as male dominated.

Research Literature
It is evident, from both the literature and the workshop 4 UPDATE project, thus far, that gender stereotypes in schools retain a strong potency. Other research supports this view: Paechter, as recently as 2007, observes that schools as institutions offer countless opportunities for pupils to develop masculinities or femininities and these gender stereotypes are deeply rooted in the subject matter.
Citing the Equal Opportunities Commission, Paechter (2007) highlights the fact that technology education as a vocational subject is conceived very much as a masculine working class domain. This, she argues, leads “young women overwhelmingly [to] opt for pathways that lead to poorly paid jobs with little possibility for advancement or the development of their skills, in contrast to young men, who tend to favour these courses leading to recognised trade qualifications with the potential for self employment and good rates of pay” (129). Patricia Murphy, also writing in 2007, reports similar findings. She highlights the fact that pupil choice in the technology subjects follows gender stereotypes: a significant majority of boys elect to take the workshop based or electronically orientated subjects whereas a significant majority of girls elect to take food or textile orientated subjects. This is in exact contrast to the performance indicators in examination results. Statistically and paradoxically, more girls achieve higher grades in examination results in virtually all technology subject domains. It is not therefore a question about ability. Murphy observes that that these gendered roles in technology education offer us clues as to pedagogies that might be better employed in the delivery of the subject. In one set of observations (2007) she notes “When playing with construction kits young boys were observed to focus on making structures that moved whereas girls were more likely to use structures as part of their social play…Girls’ concern with the social context dominates their designs and they are more likely than boys to consider aesthetics and user needs” (245). Murphy (2007) offers us some bullet points that should be given serious attention, some of which are reproduced below:

- the assumptions we [teachers] hold about what girls and boys can do;
- what tasks are selected and how the relevance of what they offer pupils and their learning is made explicit [shared learning intentions];
- treating girls and boys as individuals and not homogeneous groups;
- what girls and boys bring to their [technology] lessons, i.e. their learned priorities and ways of working;
- the support needed for pupils to develop new learning habits;
- extending subjects to include a broader view of technological practices which embrace a wider future orientated conception of technological activity and careers.
Whilst these issues are extremely important in helping to redress the balance in terms of pedagogy, it is not possible to simply consider issues relating to gender in isolation of other overlapping issues such as class, values, pedagogy and technological assumptions to name but a few. In a recent research project, Dow (2006) found that student technology teachers emerged as holding on to the belief that technology education was still very much based upon skill mastery and was vocationally orientated. Dakers (2008) in his recent study and in concert with Dow’s findings, found that technology education classrooms continue to hold on doggedly to the types of learning spaces described above. Moreover, he found that teachers and student teachers saw their role as experts passing on prescribed skills linked to economic development. Given that technology education continues to be delivered as a trades based vocational subject, this will have a negative impact on girls’ take up of the subject. Moreover, other overlapping issues such as class, values, pedagogy and technological assumptions to name but a few must be taken into consideration.

What appears to be emerging from this study, and from former studies, is that any explicit intentions or interventions such as those carried out in our preliminary investigations are appearing to be problematic. They seem, in our initial investigation, to be attempting to redress the imbalance in girls taking up technology education by attempting to give girls equality with the boys. This follows early feminist arguments that “focused upon the unfairness of the fact that women [are] excluded from some central activities crucial to humanity – the defining activities of modern political identity – which men appear to be granted by natural fiat” (Chanter, 2006: 8). However, postmodern thinking takes a different view. Chanter poses the question that if women are to be given equality with men, or boys in this case, then what boys are they to be equal with? Certainly not “oppressed, disenfranchised, or disadvantaged [ones]” (ibid: 8). Both Murphy (2006, 2007) and Paechter (1997, 2007) argue that technology education spaces in schools are not only masculine preserves but trades based vocationally orientated, working class, masculine preserves. Girls, we argue, do not want equality with boys in this domain.

**A Scoping Exercise**

The following pages offer a variety of teaching styles for technology education. They are designed to offer you the opportunity to be self reflective about the state of technology education that you are currently experiencing. Each has a commentary with some questions for you to answer. They are designed to reveal the types of pedagogy that you employ and the types of knowledge development that you seek.
THREE WAYS TO TEACH TECHNOLOGY EDUCATION

Some illustrations now follow that indicate ways that technology education can be taught. The first is the most common model and is associated with the secondary sector. The UPDATE research strongly advocates for a move away from this style of teaching technology education towards the two other styles demonstrated:

The first way considered, which is the most common in the secondary sector, illustrates a transmission model which, as the research indicates, favours a male orientated perception of technology education. Girls see the subject delivered thus as leading towards a job in engineering manufacturing or the construction industry: both of which are male dominated.

The second way utilises the Nuffield materials. These open out possibilities for incorporating the development of lower order conceptualisation. This model allows teachers to retain the development of procedural and declarative knowledge whilst enabling the development of lower order conceptual knowledge. This is done by allowing students to follow a case study approach where they can design an individual artefact rather that following a whole class approach.

The final model uses critical theory to enable the teacher to link learning to authentic situations. This authenticity allows students to engage in higher order conceptual development.

There are other more modern forms of teaching technology available and these can be found on the UPDATE website.
Woodcraft: An introduction to working in wood.

Tools.
(Illustrations are scanned from the Module 1 handbook by Heinemann).

Students will be examined upon their knowledge of these tools and the various parts listed opposite. They are assessed on their declarative knowledge by being required to answer questions such as:

Name the wooden part of a try square. Answer; the stock.
or
What kind of hammer would you use for nailing panel pins? Answer; a cross pein hammer

One project in wood that involves the use of these tools is shown on the next page:
Woodcraft: An introduction to working in wood. Trinket box.
(Illustrations are scanned from the Module 1 handbook by Heinemann).

Students will be examined upon their ability to construct the prescribed trinket box shown opposite. They are tested on their **procedural** knowledge: their ability to fabricate the trinket box using the tools and materials available.

The projects are very prescriptive as illustrated on the next page. All pupils are expected to fabricate the same artefact. They will be assessed by the quality of the artefact produced.
Woodcraft: An introduction to working in wood. Procedure. (Illustrations are scanned from the Module 1 handbook by Heinemann).

Students are taught ‘how to’ carry out the task. Each stage is very carefully planned out and demonstrated by the teacher. The whole class tends to move at the same pace in this style of teaching. This form of pedagogy is known as a ‘transmission’ model. (see next page)

1. Mark out the sides B as shown
2. Saw and sand the sides to length as demonstrated by the teacher.
3. Mark out the ends C and then saw and sand them to size.
4. Sand the surfaces of all the pieces.

See Teacher

5. Glue and pin the sides B to the base A and allow the glue to set before proceeding
6. Lightly sand the ends A and B flush.
7. Mark the gluing position lightly on the ends C.
8. Glue the ends to the assembly as demonstrated by the teacher.
THE TRANSMISSION MODEL

The worksheets above are taken from the Heinemann STEM series published in 1981. The example given illustrates the type of teaching that still forms the mainstay of technology education in Scotland. Recent research indicates that this is also the case in England. Moreover, the research undertaken from this project to date suggests that this model is also typical of other countries in Europe.

All subject areas will follow the same model. The artefact, whether a trinket box, a trowel, a technical drawing or a cooking method is the same for the whole class. The emphasis is on the development of procedural and declarative knowledge development. Each member of the class is encouraged to follow exact processes as indicated in the projects above. When in difficulty or when a more complex skill process is required, it is the teacher (expert) that demonstrates. Assessment is based upon the quality of the artefact. The teacher asks questions on an ongoing basis regarding declarative knowledge retention.

The development of creativity is extremely difficult in this model. Supporters of this style argue, however, that a set amount of procedural and declarative knowledge is required before aspects relating to creativity can be developed. Modern educational thought, on the other hand, disputes this notion by arguing first, that both can be developed simultaneously, and second, that if assessment is based upon known facts and procedures as espoused by the teacher, students will always take the safe option rather than taking risks - a prerequisite function of creative endeavour.
THE NUFFIELD MATERIALS

The Nuffield approach is designed to start with a Case Study, and work on Proficiency Tasks before and during a main theme called a Creative Practical Task. Skills in this model are learned as and when required for the purposes of the case study rather than in isolation prior to designing and building a specific artefact.

The Nuffield approach enables a teacher to adopt a social constructivist pedagogy and allows for a greater degree of conceptual knowledge development. A great deal of free Nuffield downloadable resources are available at the Nuffield web site (including the examples given in this handbook):

http://www.secondarydandt.org/

This schema integrates well with the Scottish Framework philosophy for achieving technological capability. The schematic diagrams shown below demonstrate the strong similarities between the Nuffield approach and the Scottish framework approach.
The Nuffield materials in a teaching sequence

Use a **Case Study Task** from the *Study Guide* to set the scene.

Use a **Creative Practical Task** — designing and making assignment — from the *Capability Task File*.

Use **Proficiency Tasks** from the *Resource Task File* before and during the Creative Practical Task.

The *Student's Book* provides support.

The *Teacher's Guide* helps you construct the learning experience for the stages P7 to S2.

The SCCC Position Statement: Technology Education in Scottish Schools (1996)

**Case Study Tasks** — in which pupils study technology in the wider world and its interactions with society.

**Creative Practical Tasks** in which first-hand experience of the processes which are central to technological activity is gained.

**Proficiency Tasks** — which provide opportunities to acquire the necessary knowledge and skills.
These diagrams indicate almost identical terminology, structure and delivery. They both suggest an integrative approach based on themes set by case studies, which serve to contextualise the subject matter. Creative Practical Tasks in association with Proficiency Tasks aid pupils in the realisation of the activity.

The Nuffield Capability Task Files follow the pattern shown above, and serve as a focus and guide for various other components. These Capability Task files clearly lay out a programme of study for the delivery of the work. Whilst the Scottish National Guidelines do not prescribe any single approach to planning and delivering Technology education, they do advise the development of a “Programme of Study”. The Programme of Study is described as a plan of action for teaching the technologies. It will consist of a series of lessons (or studies) dealing with particular attainment outcomes, sometimes set in the context of a series of topics or themes.

Both the Scottish framework and the Nuffield materials favour an integrated, thematic approach in the delivery of the technological component. This form offers greater scope for contextualising learning.

If the subjects are taught in an integrated way, the studies can often be made to link more directly with pupils’ experiences and the interrelatedness of separate subjects is easier to maintain. However, it requires very careful planning of projects to ensure that there is a steady development of knowledge and skills. Integrated studies favour coherence in this part of the curriculum but make it more difficult to achieve continuity and progression” (McClelland, 1993). There is, however, an emphasis in the Scottish system and in the new ‘curriculum for excellence’ guidelines on an integrated approach with links to other subject areas indicated within the strands.

**The case study approach**
The Scottish CCC Position Statement for Technology Education indicates that one of the characteristics necessary for the appropriate types of learning activity is “Case Study Tasks”, in which pupils study technology in the wider world and its interactions with society and the environment.
The Nuffield approach contains Case Study Tasks which give descriptions of the technology of others, including other times and cultures. They are designed to enable students to reflect on technology in practice and to appreciate how user needs and preferences may, or may not, be met through technology.

These Case Studies can be used to assist in pupils’ understanding of technological perspective and are referred to in the Capability Task File. The Case Studies can also aid in the delivery of Understanding and Using Technology in Society.

The Case Studies could also be used to give inspiration to teachers for other themes which relate to technology in society. Indeed, teachers could use the case studies to inspire more localised case study material which may build upon pupils’ own social experiences.

Cross curricular link
It has been established that the Nuffield materials are concordant with the SCCC framework and tend to favour an integrated thematic approach. It is also clear that an integrated approach can be made to link more with pupils’ experiences in the environment and lend themselves to “Understanding Technology in Society.” This integrative approach can further enhance pupil understanding of the cross curricular links between subject areas.

The Nuffield materials used in this handbook pilot is based around the theme “Novelties Incorporated”. Cross curricular links might include:

• **Using Mathematics:**
  • Students may use simple modeling and calculations to estimate the price of the novelty product to cover production costs.

• **Using Art:**
  • Students may have already looked at the work of Jewelers and artists for inspiration.
•Using Information Technology:
  •Use desk top publishing and CAD software to design their product

•Using economic and industrial understanding:
  •To identify those organisations or individuals who may wish to market the novelty and to study which consumer group to target.
A cricketer wears face, body and leg protection against the impact of a very hard ball against bowling.

Sometimes it is necessary to provide the face and eyes with protection from other hazards. Swimmers and divers need to protect their eyes from the water and so a different form of mask is required.

**Question**

3. Look at these pictures. How have they tried to solve the problem of protection?

4. Why are the solutions different?

5. Why do you think that this form of face protection is more common nowadays that it used to be?

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**Taking cover**

The resources of design and technology have been used to provide better forms of protection for the head and face.

Although the human body offers its own defence against many forms of attack, there are numerous dangers that can prove harmful or even lethal. Our skin can protect our inner organs to some extent, but when faced, for example, with excess heat, extreme cold, flying objects, radiation or chemicals, we need added protection.

People have always recognised such dangers and have tried to protect themselves. In the past armour was used for protection in warfare. From just a helmet and leg guards in Bronze Age Greece, this developed into full body armour in sixteenth century Europe.

**Question**

1. Look at the suit of armour shown here. Why do you think it stopped being used?

2. What took its place?
NUFFIELD CAPABILITY TASK FRONT SHEET

Focusing on using thin sheet materials – card, plastic and metal

Novelties Incorporated

The big picture
Task
To design and make a novelty product suitable to sell as a small gift or souvenir.

The story so far
Novelties Incorporated is a small firm that specializes in producing small gifts and novelties. One of its clients is a garden centre which has a butterfly farm and aquarium.

The student’s task is to develop products that could be sold in the centre’s gift shop. Other possible settings are a restaurant, museum, stately home, theatre, summer fayre.

Learning
Designing
Using natural form as a basis for design.

Making
Shaping sheet materials to a high standard of finish. Using batch production techniques for producing multiple copies (optional).

Technical matters
Properties of materials.

Commercial matters
Retailing and costing.

Design decisions
The sort of product
The student can decide on the nature of the product to some extent. Is it in the form of jewellery – a bracelet, a bangle, a pendant? Is it a domestic novelty – a fridge magnet, a hanging ornament, a layered decoration, a useful item – bookmark?

The point of sale
The students are unlikely to decide this as the teacher will probably set the nature of the retail outlet for the class.

The customer
The student can decide whom the product is for.

The appearance of the product
The student has to choose an appearance that relates to the nature of the retail outlet.

The materials, adhesives, fixings and components
The student can choose from:
- thin card, corrugated card, acrylic sheet, polycarbonate sheet, aluminium sheet;
- liquid adhesives, spray adhesives, tape adhesives;
- paper fasteners, click rivets, pop rivets;
- stick on shapes, letters and decorations.
NUFFIELD RESOURCE TASK FRONT SHEET

Retailing: Why are shops different?

**What to do**
1. Look at the following information and use it to discuss the questions with your partner:
   - You can buy mirrors at any of the following 'shops':
     - jumble sales
     - junk stalls at markets
     - antique shops
     - specialist shops
     - department stores
     - internet shops.

**What to write**
- What sorts of mirrors will you be able to buy from each of these 'shops'?
- In what ways will they be similar and in what ways will they be different?
- What sorts of people are likely to buy from each of these 'shops'?
- In what ways will they be different from one another?

**What to do**
2. For homework, visit some of these 'shops' and check out your answers.

**What to write**
- Make a record of your observations
- Were you right or wrong?
- Now try to answer the question, 'Why are shops different?'
THE SOCIAL CONTRUCTIVIST MODEL

The worksheets above are taken from the Nuffield web site. They are available for free download and give much more detail and help than indicated in the examples above. They allow the teacher to work on a more thematic approach which can incorporate cross-curricular themes. The student is encouraged to make connections both in cross curricular terms and in terms of bigger picture thinking.

The Nuffield materials were developed (and research reviewed) over a significant period of time. They are designed for the English curriculum but can be easily modified and used in other curricula around Europe. The one defining thing that sets this method apart from the one described earlier is the element of ‘design’. Design plays a crucial role in the Nuffield materials and they will be more difficult to use if the design element is removed. In so doing the model is more likely to revert to a transmission model.

THE CRITICAL PEDAGOGY MODEL

In order to adopt a critical pedagogy which has a larger, if not exclusive focus upon the development of conceptual knowledge, teaching and learning will concentrate upon technological issues related to ethical, political and value laden judgements. Knowledge here is not fixed but open to interpretation and re-interpretation.

One area that has a number of resources related to this kind of thinking is the “Foresight” web site. The Foresight aim is to provide visions of the future using robust science to be used by policymakers to inform government policy and strategy, and to improve how science and technology are used within Government and by society. It is a live project and can influence Government. Whilst the bias is towards science, it has some very strong technology related issues worthy of discussion. Access is available here”

http://www.foresight.gov.uk/index.asp
One of the downloadable documents looks at possible future scenarios as illustrated below.

- Everyone is aware (or made aware of their own personal carbon emissions and it is a decision making factor in the way we are allowed to live our lives.
- Years of energy guzzling have left their mark…the skies are grey from the carbon emissions.
- Vehicles are, by necessity, designed for ultra-energy-efficiency and only provide as much space as needed, therefore they are smaller, ultra-lightweight and biodiesel powered. The consumption is also closely monitored.
- Cycling is now a way of life, not only for those who want to save the environment and keep fit, but also for those who have run out of carbon credits.
- Carbon is the new currency – carbon credit top up points are now as ubiquitous as ATMs.
Some future issues related to technology that could be used for classroom debate might include:

- Growth in ‘cyberfraud’
- Emergence of radical solutions to climate change
- Satellite location devices
- Smart antennas
- Increasing use of ‘telepresence’ technology
- Converging revolutions in biotech,
- nanotech, infotech and cognitive science
- Rise of ‘zero waste’ movement

The Young Foresight project which is an educational initiative for design & technology within the English and Welsh National Curriculum was designed for pupils in Year 9 (age 13/14) but has been used successfully with both older and younger pupils. Some of the design innovations are quite spectacular and this may be because the task of fabricating the artefact was removed from the project. In other words, pupils were able to express high tech originality without the fears and constraints associated with having to manufacture their design. The site is worth looking at:

http://www.youngforesight.org/

David Barlex who was the director for this project can be seen discussing it on the WP4 UPDATE pages.

A timeline for good intentions might look like this:

2055
2051 Worldwide citizen protests for more stringent carbon emissions targets
2046 UK citizens campaign for greater action on climate change after freak storms
2045 Increasing migration from parts of the UK and Europe subject to frequent flooding
2042 Contraction and Convergence Criteria Re-evaluation Summit
2039 Gridlock on carbon emissions negotiations at G12 Summit
2038 Biodiesel bus network in place across much of the UK
2036 Census ‘Social and economic inequalities across the UK significantly reduced’
2030 Personal CO2 allowance introduced as part of Contraction and Convergence Agreement
2024 G10 Contraction and Convergence Agreement reached; harsh intra-G10 sanctions for those who fail to comply
2022 Dynamic Traffic Flow Management System rolled out nationally
2020 Environmentally driven airport landing taxes introduced across the EU
Notes

For a more detailed discussion on types of knowledge, see:
For a more detailed discussion on ethics see:
For a more detailed discussion on pedagogy see:
And
For a more detailed discussion on innovative practice, see:
GENDER STEREOTYPES AS DRAWN BY 11 YEAR OLD CHILDREN

Very strong gender stereotypes are seen to emerge. Note the screwdriver in the hand of the engineer: clearly not considered an engineer in the professional domain.
GENDER STEREOTYPES AS DRAWN BY 11 YEAR OLD CHILDREN

Very strong gender stereotypes are seen to emerge once again. Note that engineering is considered to be boring; clearly not considered an engineer in the professional domain one again.
GENDER STEREOTYPES AS DRAWN BY 11 YEAR OLD CHILDREN

Yet again, very strong stereotypes are seen to emerge. Note that whilst the engineer is female (the teacher for this class was female), she is still depicted in a trades based way: “blue overalls; cars; dirt.”
RESEARCH PAPERS ABOUT GENDER AND TECHNOLOGY EDUCATION

The following papers have been published elsewhere. They offer the insight of several prominent thinkers in the area of technology education and several have gender as a subject area.

Are girls equal in technology education?

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Abstract

The Finnish technical studies in general education dates back to 1866 when compulsory folk school was introduced in the country and together with this craft education was one of the subjects among other areas of learning. One of the biggest changes since this was a move to comprehensive school system in 1970. Already the 1970 National Curriculum suggests that boys and girls should study both technical craft and textile craft. Equal education in craft studies has been emphasized also in the 1985, 1994 and 2004 National Framework Curricula. The 1994 Framework Curriculum introduces a concept “technology” in its introduction part but it does not give any operational instructions how to teach the concept. Through the history of general education the myth of men’s and women’s work has directed the craft curriculum in schools more than the national documents. In this paper we will discuss the development of technology education since Finland moved to comprehensive school system. We also try to foresee if the 2004 Framework Curriculum which emphasizes technology education and which also introduces a new cross-curriculum theme “human beings and technology” is going to make any change in the school practice?

Keywords: technology, technology education, craft, technical work, textile work, equality, gender equality, curriculum

Introduction

Finnish technology education dates back to 1866 when craft education was accepted to be one of the compulsory subjects in the school curriculum. Uno Cygnæus, founder of Finnish general education, considered “technological” contents an important part of craft education. Cygnæus emphasized dexterity, design and aesthetics but also consideration, innovation and creativity. (Kantola 1997, p. 18)
There have been many pedagogical and administrative changes in general education since Cygnaeus’ times, but one remarkable change took place in the beginning of the 1970’s when the parallel school system (folk school and gymnasium) was abolished and the comprehensive school was introduced in the country. A significant reform was introduced in teacher education in 1979. Since then all comprehensive school (grades 1 to 9) teachers, both class teachers and subject teachers, have been trained up to master’s level.

In this article, we will discuss the changes in Finnish technology education since 1970 from the point of view of changes in curriculum, particularly from the gender point of view, but also considering pedagogy, teacher education, society, and the concept of learning.

**Technology education and craft education**

Handicraft teaching and technology teaching have seldom been compared in research literature. Comparisons are mainly made between technology, science and mathematics. The reason for this is obviously that, for instance, in England and the United States handicraft education has developed into technology education. According to Alamäki (1999, p. 37), technology education has evolved from craft education in many countries. He also argues that, due to technology education still being in the evolution process, many approaches from crafting to applied science are being used in technology. Järvinen (2004a p. 45 and 2004b p. 8) claims that technology education cannot be monopolized by either craft or science education because it involves mathematics, science, arts, handicrafts and genuine innovative problem solving.

Kantola (1997) and Parikka (1998) define technology as an umbrella concept for handicraft education. Anttila (1993), Peltonen (1988) and Suojanen (1993), on the contrary, regard handicraft education as an umbrella concept for technology education. Alamäki (1999, p. 14), then, explains that ‘käsityö’ (craft or handicraft) is the official name and overall term for a subject group that consists of the school subjects ‘tekninen työ’ (technical work) and ‘tekstiilityö’ (textile work). ”Käsityö in the Finnish educational context has no direct English equivalent but implies a combination of crafts, design and technology education.” (ibid. 1999, p. 173.) He also notes that “the contents and processes of the Finnish ‘tekninen työ’ correspond to the international view of technology education”. He goes on by saying that in many Finnish publications (e.g. Alamäki 1998a; 1998b; 1999; Alamäki & Suomala 1998; Kankare 1997) the English equivalent of the term ‘tekninen työ’ is technology education. (ibid. 1999, p. 14.) By merely changing the title of the subject there is no change in learning. What matters is the contents of teaching. Therefore, the objectives and contents of craft education have to be discussed and altered towards technology education.
Experts in craft education and technology education, whether Finnish or foreign, agree on particularly one view. Both groups see that an essential part of learning is the creative planning and production process (Antila 1993, Hill & Luther 1999, Eggleston 1994, Lindfors 1992, Peltonen 1988, Suojanen 1993, Yli-Pipari 1991). Kojonkoski-Rännäli (1998, p. 368) distinguishes, mainly following Bunge (1985, p. 220), the handicraft production activity and the technological production activity. According to her, hands-on methods are used in handicraft, whereas in technology, methods of modern technology are used. In this article thinking and use of the brain is considered to lead all work done by hand. Technology is seen as “logos” of “techné”, where technology is not restricted to modern technology, but is seen from a wide perspective - from traditional to modern.

The 1970 Framework Curriculum and the 1970 Curriculum


In 1970, the Ministry of Education published two memoranda to guide teachers in transferring from the old parallel school system to the comprehensive school system. The 1970 Framework curriculum (Peruskoulu opetussuunnitelmakomitean mietintö I, 1970) gave the rationale and philosophy, aims and objectives, information needed to implement and develop the curriculum, different methods, information about learning materials, information about differentiation, evaluation, extra mural activities, counselling, organizing the work and co-operation between the school and homes for the schools.

The 1970 Curriculum stated the attainment targets and contents for different school subjects and in craft education listed grade by grade the techniques (i.e. measuring, marking, sawing etc.), materials (i.e. planks, metal rod, plastics etc.), and objectives (mainly different techniques) with some ideas for different projects. It also gave information on different working, learning and teaching methods, evaluation and integration. Craft education was divided into two sub-areas: technical craft and textile craft. The document emphasized that the division should no longer be according to one’s sex, but both girls and boys should study textile craft and technical craft. All pupils were supposed to study the same programme from grade one to three, then choose one of the two subject areas for grades four to seven. During the spring term (January – May) grade six pupils were supposed to
change the subject area. (Peruskoulun opetussuunnitelmakomitean mietintö II, 1970). However, boys mainly went for technical craft classes and girls for textile craft classes. Girls were more open-minded in their choices than boys were.

Technology as a concept is not to be found in the 1970 Curriculum. In turn, the concept of technique is to be found under the title “technical craft”. One of the general objectives in technical craft studies was to become acquainted with technical domains. The pupils’ own designprocess was regarded as important and the contents of, for instance, machinery and electronics can be seen to be of a technological nature. The 1970 Curriculum and Framework Curriculum documents is a very radical, educationally professional, ambitious and future oriented.

**The Framework Curriculum for Comprehensive Schools 1985**

*Both sexes should study technical work and textile work* (Peruskoulun opetussuunnitelman perusteet, 1985 p. 206)

Since the 1970 Curriculum document there has not been a national curriculum in Finland. The documents since then have been framework curricula, and the municipalities and schools have planned their own curricula following the national framework. The reasons for this are decentralization of the educational management, reform in teacher education, and need to plan the curriculum to fit the local circumstances. In the 1980’s the inspection system was also abolished. Inspectors’ posts at national and regional level were changed to instructors’ and supervisors’ posts. Their role was not to check if the teachers had done their job, but to assist and help teachers in planning, developing, and organizing in-service education for teachers. Schools and municipalities were guided to develop their own curriculum following the national framework curriculum. Teachers were highly educated and they were considered to be able to develop their own curricula.

In 1985, after 15 years experience of the comprehensive school- system, a Framework Curriculum for Comprehensive Schools (Peruskoulun opetussuunnitelman perusteet 1985) was published by the National Board of Education. The document introduced six general objectives, one of which is gender equality. Enhancing equality at school means offering the same possibilities for both boys and girls (ibid. 1985, p. 13). There are references to the discussions in parliament about promoting gender equality. According to the law, the schools should promote equality between sexes. The National Board of Education leaves it to the municipalities to decide how to organize craft education. However, from grade one to grade three all pupils should study both textile work and technical work, from grade four to six part of the studies are common to all pupils but part is either
technical or textile work. At grade seven technical work and textile work are common subjects to all pupils. However, if the municipalities want they can, on top of the common studies, differentiate teaching into technical or textile work. (ibid. pp. 206 – 207).

For the first time also the concept of technology was introduced - but not defined. However, the concept is to be found only under “Craft, technical work and textile work”. Technology is the starting point of technical abilities, planning, and implementing (ibid. p. 206). During technical work lessons pupils should also learn to manage technology (ibid. p. 208).

In the curriculum the sector on craft, technical work and textile work introduces first the general objectives and gives information on how teaching should be organized. After this, the objectives of technical work and textile work are introduced together with contents grade by grade. The contents are mainly different techniques (i.e. cutting, sawing, soldering etc.). There is also information on how to differentiate the curriculum in different municipalities, how to evaluate, and what the opportunities for integration are. Although the general objectives are to develop problem solving and planning skills, the specific objectives are a mere list of different techniques (ibid. pp. 208 – 213). The approach in the curriculum can be characterized as behaviouristic. It has been written from teachers’ point of view rather than from pupils’ point of view. Such expressions as “pupils will be taught to turn wood” and similar are used (ibid. pp. 208 – 213).

In practice, many schools continued to differentiate pupils after grade three in either textile or technical work groups. The groups were in most cases formed according to sex. Pupils were probably offered a chance for a short change of three to six weeks to study the other subject area of craft.

The Framework Curriculum for Comprehensive Schools 1994

“Craft, technical work and textile work form an entity at primary and junior secondary level which is meant for all pupils regardless of sex.”
(Peruskoulu opetussuunnitelman perusteet 1994, p. 104)

For the first time in the history of the curriculum development of Finnish general education schools, technology is clearly mentioned in the general objectives of the curriculum. For the comprehensive school the national guidelines state that the technical development of society makes it necessary for all citizens to have a new kind of readiness to use technical applications and to be able to exert an influence on the direction of technical development. Furthermore, it states that students without regard to sex must have the chance to acquaint themselves with technology and to learn to
understand and avail themselves of technology. What is particularly important is to take a critical look at the effects technology has on the interaction between humanity and nature, to be able to make use of the possibilities it offers and to understand their consequences. (Peruskoulun opetussuunnitelman perusteet 1994, pp. 11 - 12) However, the document does not give any operational instructions on how to study technology.

Under chemistry, the concept technology is mentioned once: “pupils should be able to acquire such a terminology that they are able to discuss questions concerning nature, environment, and technology” (ibid. p. 86). Under craft, the technological objective is that pupils will acquire knowledge of the traditional and modern technological materials on their own, knowledge of tools and techniques that can be applied in daily life, further studies, jobs, and hobbies (ibid. p. 105 - 106). Despite the stated objective at the end of 1990's woodwork was mainly taught during technical work lessons in the Finnish primary schools. Electricity and electronics tasks, plastic work, and service and repair were taught to a certain extent. Lack of financial resources and ideas were regarded as the most significant obstacles to the development of technology education. (Alamäki 1999, p.136). In informal discussions between teachers and teacher educators, technical work education in schools has been said to mainly include copying and reproducing processes, such as the copying of wooden and metal items, not modern, design-oriented processes. (ibid. p.39) According to Kankare (1997, pp. 156 – 157 and pp.176 – 177) woodwork was mainly emphasized by the Finnish technical craft teachers, although most teachers did not want to divide the contents according to materials, but considered the subject area in an holistic manner. Also Sanders (2001, p. 50) has found in the USA that most technology education teachers still stick to traditional general technology education and woodwork courses.

Although “craft, technical work and textile work form an entity at primary and junior secondary level which is meant for all pupils regardless of sex” (Peruskoulun opetussuunnitelman perusteet 1994, p. 104) in addition to having partly common craft education for both boys and girls, the document allowed the schools to emphasize one of the two craft domains. This meant in practice that most schools continued dividing pupils into either textile work or technical work after grade three.

This is the first document since 1970 where cross-curriculum subject areas are introduced. The 1970 and 1985 curricula mention holistic teaching and integration but there are no clear cross-curricular titles.

Framework curriculum for comprehensive education 2004

The human being and technology – a new cross-curricular theme
For the first time in the history of Finnish general education curriculum planning the 2004 framework curriculum introduces a cross-curricular theme:

- the human being and technology.

The other six are:

- development of personal identity
- culture identity and internationality,
- communication and media skills,
- committed citizenship and entrepreneurship
- responsibility for the environment, well-being and sustainable future
- safety and traffic behavior (ibid. pp.36 – 41).

Under the title ”the human being and technology” the meaning of technology in our everyday lives and dependency of human beings on modern technology should be studied. This theme will offer basic know-how of technology, the development of technology and the effects of technology, guide pupils to make reasonable choices and guides them to consider the ethic, moral and equality questions related to technology. Teaching should also improve the ability to understand how different devices, equipment, and machines work and how to use them.

The aims are as follows:

A pupil will learn

- to understand technology, the development of technology and its impacts on different fields of life, different sectors in society, and on the environment
- to use technology in a responsible and critical manner
- to use information technology equipment, programs and networks for different purposes
- to state one’s opinion concerning technological choices, and to consider the effects of today’s decisions about technology on the future

The core contents
technology in everyday life, in society and in local trade and industry
the development of technology and factors affecting the development in different cultures and different fields of life during different eras
the development, modeling, and assessing of technological ideas and the life-span of a product
the use of information and communication technology and information networks
the ethical, moral, well-being, and equality concerns related to technology
future society and technology

(ibid. p 40 - 41).

“Teaching will be conducted following the same contents for all pupils including contents from technical work and textile work.” (grades 1 -4)
(Perusopetuksen opetussuunnitelman perusteet 2004, p. 240)

“Teaching comprises contents of technical work and textile work for all pupils together, on top of this pupils can be given a chance to emphasize in their craft studies either technical work or textile work according to their interests and aptitudes.” (grades 5 – 9)(ibid. p. 242)

In the framework curriculum, references to technological studies can be found only under science (particularly physics) and to a considerable extent under craft (particularly technical work). The subject groups in other subjects have not considered the cross-curricular theme ” the human being and technology” in their text. However, the instructions from the National Board of Education are that the schools have to clearly indicate in their curricula how these cross-curricula themes are included in different school subjects and they have to be seen in the activities of the schools (ibid. p. 36). The framework curriculum does not give instructions how this should be done, this is left for the schools to decide and think about. By studying 50 Finnish municipal curricula (this will cover an average of 400 schools) one notes that often ” the human being and technology”-cross-curricular theme is understood to be information and communication technology. This indicates that the theme has not been understood in its’ broad sense, but in a very narrow manner.

Technology education objectives under craft education are as follows:
pupils

• familiarize themselves with everyday technology
• familiarize themselves with Finland’s and to an appropriate extent also other nations’ design, craft, and technology culture for building their own identity and their own design activities
• familiarize themselves with the know-how connected to traditional and modern technology which can be applied in daily life, further studies, in future jobs, and hobbies
• learn to state their stand on the development of technology and the meaning of it for the well-being of human beings, society and nature (ibid. 241 – 242)

If one compares the objectives to the contents of technical work and textile work, it is obvious that by studying only one sub-area all technological objectives can not be achieved. However, most municipalities (of the 50 municipal curricula studied) have decided (against the regulations of the framework curriculum) to differentiate pupils after grade four into technical work or textile work.

The document suggests integration between different school subjects. It is based on a constructivist learning concept where the learner is active and target oriented. The objectives are stated from the learner’s point of view, not as teacher’s activities.

**The myth of girls’ and boys’ jobs**

There has not been much research done on gender equality in technology education in general education schools. Haynie (1999, 2003) has conducted studies in gender issues in technology education in the USA. His interest has been in if women are accepted into the technology education professions. Sanders (2001 p. 41) noted that despite some gains in diversity, “technology education is still taught by middle-aged white men”. Haynie (2003 p. 29), for his part, asks the question: Why? One can assume that if the subject is mainly taught by men, the pupils tend to think it belongs to “the masculine category” and are not willing to choose to study the subject. However, there has been a remarkable change in the number of girls choosing technology education in the USA since industrial arts was abolished and technology education introduced. Nearly half (46.2 %) of middle-school technology students in 1999 were female (Sanders 2001, p. 43). Out of all school levels one third of students were female in 1999 while the percentage of females enrolled in industrial arts classes was 2.1 % in 1963 and 16.8 % in 1979.
The fact that girls do not choose technical studies can be explained by the myth of men’s and women’s jobs. During the agricultural era women took care of homes, cooking, nursing, making clothes and tended the domestic animals. Men, in turn, made sledges, furniture, hunted and worked on the fields. During the industrial era men went to work in the factories while women remained at home to take care of cooking, nursing, cleaning, washing, mending the men’s clothes… We no longer live in an agricultural or industrial era, but in an information or technological era where women are no longer working at home but outside the home.

However, the myth of women’s and men’s jobs is still to be seen when one examines the statistics on how the different sexes are divided across different fields of study. Nowadays the number of female and male students from vocational institutions to universities in Finland is about equal, for example 52.3 % of university students in 1997 – 1998 were female students (Suomen virallinen tilasto 2003). Female students choose health oriented studies while male students choose technically oriented studies (ibid. 2003). The number of female students studying in technical and technological institutions at vocational, polytechnic and university levels in Finland is minimal compared to the number of male students studying technically oriented branches. A minor increase in enrolment of girls in technical universities has taken place in recent years, but the number of female students is still very modest. In vocational institutions, polytechnics, and universities the number of female students in technical fields in 2000 was less than 20 % (ibid. 2003).

Our school curriculum before 1970 has supported the division of duties into women’s and men’s work. While girls at school studied cookery and textile handicraft, boys were doing woodwork and metalwork. Since 1970 the Finnish school authority have realized that crafts curriculum did not treat the two sexes equally. Already the 1985 but particularly the 1994 Framework Curriculum (Peruskoulun opetussuunnitelman perusteet 1994) states clearly that “craft, technical work and textile work form an entity at primary and junior secondary level which is meant for all pupils regardless of sex” (p. 104). This type of thinking is supported by a memorandum of the working group on the renewal of basic education (Perusopetuksen uudistamistyöryhmän muistio 2001). This document states that “the contents of craft education for grades 5 – 7 should be mainly the same for boys and girls including elements from textile work, technical work and technology” (p. 31). Also the 2004 Framework Curriculum (Perusopetuksen opetussuunnitelman perusteet) emphasizes equal craft education for all pupils. However, the 1985, and 1994 framework curriculum expressed a possibility for an emphasis on one of the two subjects. Also, according to the 2004 framework curriculum, pupils can be given a chance in their craft studies to emphasize either technical work or textile work according to their interests and aptitudes.
More than ten years ago, a technology education experiment was launched at the University of Jyväskylä. One of the aims of this experiment was to develop the craft curriculum in the direction of technology education. The reasons behind this were the awareness of the development of craft education globally and the development of Finnish society from an agricultural via an industrial to a technological or an information society. (Rasinen 2003). According to Parikka (1998, p. 40) craft education has developed via education of techniques towards technology education. Kantola (1997, p. 181) also supports the idea of craft education developing towards technological education.

In spite of national regulations, experiences from other countries (see e.g. Rasinen 2000, pp. 43 – 83) and experiences from some schools in Finland (Autio 1997 pp. 120 - 123), and research findings (Autio 1997, pp. 235 - 240 and Rasinen 2000, p. 130) supporting the importance of offering girls equal possibilities to study technological contents, the tradition in crafts education in many schools is still that after grade three pupils have to drop one domain of general education (see e.g. Heinonen p. 76). From then on they will study only textile work or technical work. It is claimed that pupils have a choice. However, this does not seem to be a choice but an obligation to leave aside one important field of education. The choice is quite often made by teachers or parents, not by the pupils. Or, if the pupil decides, there is always social pressure when making one’s choice. Because girls have traditionally taken textile work and boys technical work, it is difficult to make individual choices which deviate from the mainstream. According to Linda Gottfredson (2002), different choices are made more based on sex than interest. The dominant factor is primarily one’s sex, secondly social suitability and thirdly what is nice to do. Why force pupils to choose? We do not ask them at grade three or five if from now on they would prefer geometry to arithmetic. Nor we do teach English, music, history… separately to girls and boys.

By choosing the learning contents in both branches of craft education in such a way that they are not gender biased allows girls and boys to study a similar curriculum at all levels. This is reality, for instance, in teacher education during basic courses (4 credit units). The number of female students specializing in technology education and technical work (15 credit units) at the University of Jyväskylä is increasing annually and is 40 % this year.
Girls’ versus boys’ performance in mathematics and science

Another myth explaining why girls do not choose technological careers has been that they do not manage as well as boys in mathematics and science in schools. Because of this they will not be able to pass examinations at technological universities. This myth has no basis in reality. The 2002 international PISA (Programme for International Student Assessment) -studies proved that there are no gender differences in mathematics performance amongst Finnish junior secondary school students at 15 years of age (Välijärvi, Linnakylä, Kupari, Reinikainen & Arffman, 2002, p. 22, 26, 39). Finland’s performance in mathematical literacy also showed high equality. The standard deviation for student scores in mathematical literacy was the smallest among the OECD countries (ibid. 2002, p. 10). Also in scientific literacy Finland showed a high level (ibid. 2002, p 12). In scientific literacy the standard deviation was the second smallest (ibid. 2002, p 13). Both in mathematical literacy and scientific literacy Finland seems to have achieved a high level of performance and low disparities (ibid. 2002, p 14). In mathematical literacy, no differences were found between Finnish boys and girls. The same applies to science. “In scientific literacy Finland displayed no significant gender differences“ (ibid. p. 39).

The 2004 PISA study (Kupari, Välijärvi, Linnakylä, Reinikainen, Brunell, Leino, Sulkunen, Törnroos, Malin & Puhakka pp. 24 – 25.) found that the gender difference was relatively small. In mathematical literacy boys gained 548 points (mean value) and girls 541 (mean value) points. The difference of 7 points is, however, statistically significant. In the 2002 study the difference was only 1 point. Also the scientific literacy of the Finnish pupils can be characterized by high performance and equality. Although the standard deviation gives an impression that equality is being realized, the score gained by the girls was significantly better than the score gained by the boys. Also in 2000 (reported in 2002) the difference of the mean values was 6 points, but then it was not statistically significant. (ibid. pp. 26 – 28)

These results do not support the myth of girls being less able to study in technological institutions. However, in senior secondary schools girls tend to choose fewer courses in mathematics and physics than boys do. When applying for technical universities high marks in mathematics and physics are recognized and valued by the universities. This partly explains why technical universities and technical polytechnics are male dominated.
Discussion

There have been several attempts to interest girls in technical studies. Unfortunately, the campaigns have been aimed mainly at students at the secondary school stage. It seems that it is too late to start affecting attitudes at this age. The attitudes are formed at a much earlier stage of development of the individual.

Technology has to be studied by all pupils at all levels. As long as technology is a cross-curriculum theme, different subjects should consider how it should be studied. There should be continuous consultation between different subject areas and strong co-operation and, where it is advisable, integration should be applied. Technology education is mainly to be seen under the objectives and contents of craft education. Therefore, this subject area should take main responsibility for making sure that all pupils will study technology and co-ordinate the activities at school level. Different studies (e.g. Alamäki, 1999, Kankare, 1997 and Rasinin 2000) prove that to develop the subject area learning materials and in-service education have to be improved. In future, to guarantee more efficient learning, the subject area of “technology” should be introduced.

However, even today by following the approved framework curriculum, schools can offer equal technology education to all pupils regardless of sex. The contents of the studies have to be developed in such a way that they are not gender biased. What would our globe look like if female brains were actively developing technology?

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Gender and Technology: gender mediation in school knowledge construction

Patricia Murphy: Open University. England.

Introduction

Historically technology education was perceived as an instrument of social reform and control designed to maintain and reinforce the social spheres of males and females. Current representations of technology, which cohere around notions of technological capability, are considered to be ‘free’ of symbolic gendering. This assumption fails to take account of the deeply gendered nature of technology. As Layton (1993: 35) observed technology is understood as a ‘masculine’ preserve not a place for women who are relegated to the roles of users and consumers. This phenomenon can be traced to the historical exclusion of women from skilled work, which was appropriated by men restricting ‘women’s work’ to the unskilled and routinised and set up a pattern regarding women’s involvement with technology (Wajcman, 1991). Consequently ‘technical competence’ came to be understood as an integral part of hegemonic masculinities and positioned women in opposition to this as the ‘outsiders’ or the technically incompetent (Wajcman, 1991). Thus in the discourses that circulate about technologies women’s and girls’ technical competence is denied and beliefs about their ‘lack’ and men’s and boys’ ‘expertise’ becomes part of our ‘common sense’ knowledge about the way people are. Women’s involvement in technology continues to be problematic with product design, decision-making and development dominated by men (Southwell, 1997). This coupled with beliefs about girls’ and boys’ technological competence has major implications for the social construction of technology and for the ways in which teachers represent technology education and students experience it.

The chapter examines some of the evidence derived from an English curriculum context about gender-technology interactions that have international relevance. It examines first the roots of the subject and how these position teachers and students in relation to it. Next
students’ course choices and performance are discussed as outcomes of the way gender mediates knowledge construction. To gain insights into the meanings that students construct in their technology education findings about gendered views of salience are discussed. Researchers have challenged the emphasis on the individual in the study of gender arguing for a shift in attention towards the social relations in which gender is used i.e. the situated meanings of gender (Stepulevage, 2001). In the final section evidence from an ethnographic study in one co-educational school, which adopted a single sex grouping strategy to enhance access and learning is discussed to consider how girls’ and boys’ feel positioned in technology.

**Reforming Technology education**

Lewis (1999) in his argument for a more authentic curriculum challenged the devaluing of the ‘practical arts’ which included technology education and attributed this to the Platonic conception of knowledge that dominated Western cultures. The current curriculum in England was seen as narrow with its emphasis on academic knowledge excluding many human practices including those concerned with the solution of existential problems connected to everyday life. The bringing together of subjects in the reconceptualisation of technology education was intended to bring it into the mainstream of all students’ educational experience, increasing its breadth, quality and status. In that sense it was conceptualised as a ‘new’ subject that would enable young people to: “learn to think creatively to improve the quality of life…become autonomous and creative problem solvers…look for wants, needs and opportunities and respond to them…with an understanding of…social and environmental issues, function and industrial practices” (DfEE, 1999). Such a subject would therefore benefit all students whatever their career aspirations. Currently all students in England have a legal entitlement to study technology education from 5–14 years of age. Before 2004 this statutory entitlement extended to students aged 15–16 but since 2004 the requirements became non-statutory. Schools, nevertheless, are required to make available at least one technology course to all students aged 14–16.

Like the domain itself school subjects are social constructions that have a social history and making a subject compulsory and changing its specification and purpose cannot eradicate the influence of these historical roots. The technology curriculum specification for England drew together subjects which had “deeply gendered histories” (Paechter and Head, 1996: 23). Two of the main contributing subjects were Craft, Design and Technology education (CDT) and Home Economics (HE) which traditionally were taught to boys and girls as separate
groups with the expressed aim in HE of training working class girls into the domestic roles that they were destined for. CDT, which was a subject taught to boys, drew on the workshop skills traditionally associated with male working class occupations and crafts, skills that have been associated with forms of hegemonic masculinity. Both subjects were aimed at non-academic students and were viewed as lower status than academic subjects like science and maths. These subject roots can be traced to the development of technical education in England based on an apprenticeship model which left technology education rooted in workshop practices, hostile to academic theoretical knowledge and “perennially low in status” (Green, 1999: 60).

**Teachers’ professional identities**

The significance of this gendered history relates to the way that subject identities are generated and made available through dominant subject discourses. The discourses in a subject are constantly reproduced and reconstructed in the classroom setting and teachers are pivotal in regulating and legitimising ways of knowing, acting and being. James (1999) citing Gleeson’s work described the culture of crafts and trades teachers as an ‘exclusive masculinity club’ and that prevailing views within the culture included the belief that teaching girls was acceptable but girls taking up careers and ‘men’s jobs’ was not. She argued that technology studies teachers’ construction of masculinity could be traced in part to the discourses shaping their histories and current lives, and a socio-historical relation to the physical world and labour bound up with hegemonic masculinities (398). It is to be expected that in technology education, with its very different subject roots there will be competing and conflicting discourses circulating about what should be taught; who should be educated in this way; and by what means.

Paechter and Head’s (1996) characterisation of the subject cultures of technology education teachers in England in the early 90s has significant overlaps with that of James’ technology studies teachers. They referred to the significance that teachers gave to close relationships with students, particularly disaffected and working class boys, in their construction of their professional identities. They related teachers’ beliefs, particular CDT teachers’, in the importance of students creating individual products with the need for boys to present to their parents the results of their physical labours and argued that it reflected the importance of physical work to working class masculinity. Female technology teachers in the study were described as a minority of pioneers whose views of the subject were losing out to dominant perceptions of curriculum based on segregation. Paechter (2003) found that the reasons for taking up teaching careers
mediated teachers’ professional identities. CDT teachers valued craft skills as a source of professional satisfaction and regretted the increased emphasis on design in the reformed curriculum. This Paechter argued led some to attempt to reinterpret the curriculum to reflect “more closely the areas in which they felt powerful and comfortable” (137).

**Students’ agency**

Although the teacher is identified as a key agent in maintaining or contesting the gender order of the classroom (Dixon, 1998) this is not to deny students’ agency. The view of gender increasingly advocated in the field is that gender is constructed in social interaction and is not a fixed attribute of an individual. Different contexts and the discourses within them offer a range of ways of being male and female but some are privileged and these become hegemonic reinforcing certain practices in a setting and subordinating others. Gender from this perspective is understood as a hegemonic social representation that circulates as a set of norms, ideas and conventions and provides some of the resources from which individuals construct social identities (Lloyd and Duveen, 1992; Ivinson and Murphy, 2003). Some of the symbolic resources that students draw upon to manage a social identity in a subject are from representations of gender that provide them with clues about what are socially legitimate ways for them to act. In this way gender mediates knowledge construction as part of a more general process in which identity formations structure and frame educational choices and performance (Murphy and Ivinson, 2004).

**Course choices**

Brooks (2003) commented on gendered option choices in technology at age 14 that ‘there are still many areas of life where boys will be boys and girls will be girls’ (4). The author is far from alone in representing students’ choices as a passive response to socialisation processes. Murphy and Whitelegg (2005) however noted that studies about girls’ participation in physics showed that students’ self-concept, that is their sense of current and future possible selves in relation to physics, interacted with their experience of the subject to mediate their course choices. Roger and Duffield (2000) in their review of the factors underlying girls’ persistent opting out of science and technology courses in the context of Scottish schools similarly identified students’ self-concept, and career awareness as influential. They described the relationship between self-concept and career awareness as the ‘interaction between the way pupils see themselves and the opportunities they perceive are open to them. If they way they see themselves excludes technical or scientific competence, then the opportunities perceived as realisable will also exclude science, engineering and technology’ (374).
Since the introduction of a national curriculum in the late 80s the study of technology education in England is a statutory requirement but post 14 it is optional in terms of the particular aspect of the subject studied. The General Certificate of Secondary Education (GCSE) examination taken by the majority of students at age 16 offers a range of technology courses. All courses share a common structure based on design and making skills and content is considered in terms of materials and components, design and marketing influences and processes and manufacture. The courses differ in their subject content in terms of the types of materials and systems studied and the skills and processes associated with their use. The entry figures for males and females for 2002–2004 showed continuing major differences in course entry patterns. For example Electronics has a male entry of around 17,000–18,000 compared with between 1,000–2,000 for females. Textile technology has a female entry of around 50,000 compared with less than 2,000 for males. About three times as many girls as boys enter for Food technology and the converse is the case for Resistant Materials technology. Graphics is the one subject where entry is more equivalent. Entry for Systems and Control technology remains male dominated. Study post 16 at advanced level reveals the same pattern of entry for males and females but the gaps are more dramatic.

The entry figures represent student choices but choices that are reinforced by teacher and institutional discourses. There are small subgroups of males and females crossing gender boundaries but no evidence that this phenomenon is on the increase. The figures suggest that many girls and boys studying technology education post 14 continue to feel a sense of belonging in the subjects that were traditionally constructed for them. Their course choices being mediated by the discourses about what it is to be a successful person in the various realms of technology and what they, in turn, understand to be appropriate ‘masculine’ and ‘feminine’ behaviours. Students’ decisions also reflect their views of what it is worthwhile to study i.e. what makes sense, has personal relevance and engages them, which may reflect career aspirations for some students but not for others.

The GCSE examination results for 2004 show that across all the technology courses, girls achieved significantly more passes than boys as a group. It would be assumed that where there is a major imbalance between girls’ and boys’ entry that the smaller group is the more highly selected and a performance advantage for that restricted group would be anticipated. There is some evidence that this may be the case with girls taking Electronics and Systems and Controls, and this is also the case in the advanced level examinations but it does not
hold for those girls choosing to study Resistant Materials or for those boys choosing to study Textiles and Food Technology. In the advanced level examinations taken at age 18 girls continue to achieve more of the higher grades A--B in Food Technology even though they significantly outnumber the boys. These results may suggest something about the sub populations but might also indicate that for some of these boys and girls once their choices are made the gender boundary crossing is experienced as difficult and hazardous and this in turn constrains their access to and engagement with their chosen subjects.

‘Boys will be boys and girls will be girls’
Teachers’ common sense beliefs about the way boys and girls are can lead them to accept that students’ choices reflect the ‘natural’ order and their role in regulating and reproducing gender orders is often not recognised. The Electronics in Schools (EiS) project funded by the Department for Trade and Industry (DTI) in England was a national project to increase students’ access to electronics in both primary and secondary schools through a combined process of teacher training, and funding of resources (Murphy et al, 2004). The evaluation of the project surveyed hundreds of teachers and undertook case studies in twelve schools. The study found that most schools had very low numbers of girls studying electronics post 14. Teachers generally had definite views of the type of student that studied electronics. The characteristics of a successful male student were associated with high intellectual achievements, logic and rationality and a successful female student with neatness, attention to detail and artistic responses:

“The lads who are really good scientists, mathematicians, they tend to go for the electronics side of it.”
One teacher commented that, “Electronics in the end isn’t a girls’ thing’ even though he described girls who opted for his electronics groups as doing ‘fantastically well’. He characterised girls’ approach to the subject:
“they’re neat about what they do. Their attention to detail is often better than the boys, so the chances of their products working are great.”
Another teacher who had successfully motivated girls to study Systems and Controls having almost equal numbers of girls and boys in his groups described his perception of boys and girls:
“girls are better at a lot of the programming work and their graphical work is usually better. You have your high technological boy…and he is able to work at very high level, logical, technical, mathematics etc. The girls are more artistic in their approach. They’re far more quality-conscious than the boys.”

Whilst this teacher was successful in motivating girls it is interesting to note that ‘technological’ is associated with boys and ‘artistic’ with girls in his discourse about success. The extent to which students, particularly girls associate themselves with teachers’ representations of success will affect their self-concept and their course choices. Clegg et al (1999) described how students in higher education discussing choices about design and IT were “making statements about their perceptions of the dominant disciplinary discourse” (54). Unsurprisingly the EIS project found that about a third to a half of the boys in the case study schools thought they would continue with their study of electronics post 16. No girls reported that they would continue to study the subject either because it was too difficult or because they had plans to study other subjects.

**Students’ responses to technology tasks**

Social constructivist views of learning based on Vygotskian theorising recognise that knowledge emerges first between people and it is this shared understanding that is appropriated by individuals. Students’ ability to appropriate shared knowledge depends on their prior experience, understanding and commitments. Human understanding of the world develops through a process of simple associations between characteristics of objects, people and experience. These associations lead to objects and people gradually acquiring ‘ever more eccentric and intense degrees of significance’ (Greenfield, 2000). In this way people and events acquire differential degrees of importance. This individualised way of knowing begins to determine our interpretations of, and responses to, new situations. Social representations of gender divide social life into masculine and feminine marked activities, objects and attributes. Thus human experience is shaped in part by what is represented as legitimate ways of behaving for boys and girls and in this way gender mediates what we come to pay attention to and consider salient.
Views of salience

Studies, which make problematic what students’ bring to technology activities, have identified differences in views of salience between girls and boys as groups. A common finding is that girls more than boys are concerned with the social context and this is reflected in the details they include in their initial designs. Murphy (1991) found that all students identified essential and non-essential details but showed clear differences in their initial interpretation of needs and wants in their designs for boats to go round the world. Girls’ concern with the social consequences of their designs directed their attention to peoples’ needs. In contrast boys tended to design without reference to social and environmental consequences and included detail about mechanisms and structures. To exemplify this further Murphy reported on a study where secondary students were given the opportunity to design a moving vehicle. A group of girls focused their design on improving the stability and efficiency of a pram for transporting a baby and redesigned the wheels and the pram shape. A group of boys also chose a pram design. They wanted to amend the design to computerise the pram so that a baby could be taken for walks without an accompanying adult.

In a study of secondary students’ technological problem-solving given the opportunity to generate authentic designs it tended to be girls who situated their response in the context of the person’s needs and the circumstances of use (Murphy 1999). Thus water sensors were used to create a bath alarm for a grandmother housed in a ‘water drop’ shaped casing. A rain alarm for a mother’s wash line involved a sock-shaped housing. Brunner, Bennett and Honey (2000) reported similar findings in their study of middle school students’ fantasy designs. They described girls’ vehicles as household helpers or improvements to technologies that solved real life problems. Boys’ vehicles were characterised as having the capacity to take them wherever they wanted to go instantly.

Girls’ attention to aesthetic details and boys’ to mechanisms and structures has been widely noted but needs to be understood in relation to the purposes that students perceive for their designs which mean that different details become more or less significant. This impacts on students’ opportunities to learn. For example in a study that evaluated the Nuffield Primary Technology resources for teachers one activity had children designing a bus. In response to this most boys began their making task with the moving parts whereas girls generally focused on the interior features for the passengers and the exterior appearance. When the topic ended many girls’ buses looked like buses
but lacked wheels or else had rather inefficient wheels whereas many boys’ buses looked like moving cardboard boxes (Murphy and Davidson, 1997). Rennie (2003) working with elementary pupils making pirate boats also noted this effect referring to the different levels of construction skills as well as differences in how the boats were designed and furnished. Only boys made boats from wood and girls made all the boats that were less well constructed. This reflected the different value the students gave to the design features of the boat, as the girls were more likely to have furnished their boats and to have made model pirates.

The Electronics in Schools (EIS) project found that in the settings where girls were motivated to study electronics, tasks were set in contexts where their social significance was obvious. The choice of task alone is not sufficient to engage girls, the social circumstances have to be integral to the solution. One task observed involved programming a pelican crossing, i.e. a road crossing controlled by traffic lights. The following excerpt is from a discussion with a student about how to think about the three waiting times for the traffic lights to change from red – amber; amber--green and green--red. The design decisions involved giving thought to the context of use and to the users.

- Teacher: Well, one of the three ones [wait times] will be determined, say, by road conditions or by the amount of traffic. You've pressed the button; this automatic would link; amber appears; so, wait there.
- Girl: Where?
- Teacher: There's a timed wait. You put it in between the commands. So, you just put a little arrow there and say: here we'll wait. We don't know how long the wait is at the moment – we don't really mind – but there is a specific wait time band between you pressing the button and the system operating, and there are two more. It might be a wide road.
- Girl: Longer for an old person.
- Teacher: Yes, for granny pushing a trolley, easy to hit.
- Girl: We put that in there?
- Teacher: OK, when the people are crossing. It goes, yes, there.
- Girl: Wait’s put in it or…?
Teacher: Yes, put a wait there. OK, we're stopping the traffic here... so the traffic's stopped here. What are the people doing? They're going. The wait light is on, so you actually have to tell them to wait all the time...

The excerpt shows how the teacher maintained the authenticity as a reference point for students' decision making and how this in turn enabled the student to engage with the users' problems.

**Situated meanings of gender**
Markwick (2001) argues that to explore how girls and boys are positioned in technology there is a need for discourses that legitimate crossing gender boundaries. Insights from a study of a co-educational school, which had chosen to organise students into parallel single-sex groupings for teaching shed some light on the discourses that legitimate boundary crossings. The strategy was based on two assumptions one educational - that girls and boys learn in different ways and have different needs and the other political - that single sex organisation is associated with high achieving schools in England. The study observed classrooms across the curriculum and only some findings from the technology classes are reported here.

**The Study**
In the research a sociocultural view of learning was adopted which allowed a focus on the embedded nature of classrooms in which teachers' practice are understood as forms of mediation that regulate the boundary between classroom settings and the other social contexts that students negotiate (Lave 1988). During the pilot two technology teachers were observed. The intention was to identify a teacher who used the strategy to attempt to develop a discourse that enabled gender boundary crossings. The selected teacher was observed over several weeks as he taught the same task to two single-sex classes of students age 13 – 14. Data was collected by observation (video, audio recording and field notes) and interviews (the teacher and 8 students).

**Some findings**
The teacher spoke of teaching the ‘whole student’ i.e. preparing them for their future life and for flexible work careers by providing them with generic transferable skills, in particular ‘problem-solving’. The teacher recognised the low status of the subject seeing it as ‘much
maligned”. However, he took pride in being seen by students as “not like other teachers”. The dynamic nature of the subject was evident in the teacher’s account of the ‘old’ versus the ‘new’ technology teacher.

“My background is electrical engineering control systems etc. although I’ve worked in engineering environments so I’m familiar with all the processes and everything else. People like myself, who’ve been in architectural product design etc and who hadn’t been anywhere near a machine or a tool in their life we’re the second breed [of teachers]…Sometimes it’s quite difficult for some of the older lot to have to change and accept that change.”

The images the teacher portrayed of the future, which he anticipated for the students, were overwhelmingly of the domestic realm. In so doing he gave value to the domestic whilst allowing for both ‘masculine’ and ‘feminine’ behaviours within it. “decorating your house, doing little jobs around the house themselves, the ability to cut a bit of wood, the ability to join a bit of wood, help my mum, put a shelf up, hang wallpaper, arrange tiles, carpet fitting, buying a microwave, get the dimensions [for the space of the microwave].”

He referred to the decline in the manufacturing base in the UK and made no reference to technology education as a preparation for future jobs.

In his social representation of gender, he drew on the ‘feminine’ behaviour of ‘learned helplessness’. This was in conflict with the teacher’s aims for the subject, which was to promote learner autonomy and willingness to take risks, in the teacher’s words, “to be adventurous and/or dangerous”. Although he made no reference to ‘masculine’ behaviours, risk taking and acceptance of danger are part of a hegemonic social representation of masculinity. He compared himself as a teacher with his role as the ‘workshop supervisor’ when he was an electrical engineer. He was anxious to stress the way he saw the setting as a social space where ‘non-academic’ conversation was legitimised. He described his view of children as social beings which he saw as in opposition to how they were positioned in academic subjects where isolation was the norm in his view. The community he was trying to reconstruct related back to the workshop. Both of
these aspects of his characterisation of the setting reflect the historical subject roots and suggest that boys more than girls might feel a sense of belonging in the setting.

Girls and boys from their interviews understood that designing and making artefacts was the overarching aim of technology education. All students highlighted the dangerous nature of the subject and how important safety and learning how to use tools appropriately was. Only one student, a girl, described the subject aims in terms of her own autonomy to function competently within and beyond school. This was interesting given the extent to which the teacher emphasised capability in life beyond school in his representation of the subject. The activity the teacher identified was to design and make a vehicle with four wheels that could carry a 2lb weight and travel 16 feet. For the teacher the skills acquired through the design and making of artefacts such as a model car had an obvious relevance to life. Thus measurement in relation to where to drill the holes for the model car axles was linked to the context of putting up a shelf and buying a microwave to fit a given space. Creating joints was another feature of the activity and for the teacher this knowledge would enable students to “do those little jobs around the house”. However, for the students their actions and their learning were associated with the task, as they understood it and this was determined by what they valued and considered important.

All the boys identified meeting the design brief as the main aim of the activity i.e. the task represented by the teacher. The activity had value in its own right. Its purpose was experienced as unproblematic on the whole. One pair of boys turned it into a competition to make the fastest vehicle, which was not a criterion in the brief. The boys worked first on the structure to ensure that it met the design criteria of stability, strength and movement. Two boys emphasised the significance of the movement in terms of structures for example that the wheels should not rub the chassis and the axle should turn smoothly. Only one boy mentioned appearance and talked of making his car “eye catching” but in elaborating this he talked of detailed structural features such as the bonnet. Two boys were explicit that appearance was a secondary consideration. As one put it “it’s the capability [not the appearance] of the designs that’s key.” The girls tended to put design as the primary concern and meeting the brief as a secondary criterion. Three of the girls gave priority in their design to presentation and the appearance of the finished product. These were considered as important as structures. For one the main concern was appearance, she wanted her car “to be like neat and nice on the top and to be different.” This had led her to work with plastic and vacuum formation. The students related these views of salience to the teacher’s concerns and his representation of the subject.
Yet they suggest a gender-technology interaction that is shaped by students’ values that conflict, for some girls, with what is considered legitimate ways of doing technology. For boys there is congruency between their values and those legitimised by the teacher.

Girls were aware of conflicts. One girl explained that the teacher valued meeting the design brief but her personal commitment was to the design. Another student was conscious that the value she placed on design might prevent her from achieving the aim of the activity as she observed, “I don’t think mine will make it”. This girl sought validation for her product outside of school. In her interview she emphasised the importance of her parents and brother in validating her subject identity in technology to the extent that she was prepared to take a risk. “I’m just hoping that the design mark is really good and it will make the five metres [the 16 feet distance specified]”. The study found that for several girls their identity as technologically competent came from the home and allowed them to resist aspects of the teacher’s representation of success. Donna’s father’s active encouragement was important in determining her self-concept in technology. “My Dad’s a builder and he’s got them sort of things [tools] at home. I always go out to the garage and play with them and build things… Little aeroplanes and things but I’m making a doll’s house at the moment.”

“When I was little I used to watch him making things and when he did things around the house I used to always do that and want to help make it with him”.

Donna was aware too of the gender valence of the technology practices describing them as things “girls don’t normally do”. She went on to explain:

“When they grow up they’re just beauticians or working on computers and all things like that and when something goes wrong, like, my Mum, she can never do [fix] it…When I get older I just want to be able to do it all myself instead of relying on everyone else.”

Donna understood technology to be about learning how things work “even if you don’t get it right”. This emphasis on learning through your mistakes was part of the way the teacher addressed girls’ perceived technological incompetence. For some girls this was empowering within the setting but it is questionable whether such a view would translate into a positive career aspiration. Donna talked of wanting her
artefact “to be different” and how she liked “doing it my own way”. The teacher had stressed in his interview that he valued individuality
and Donna saw this as legitimising her reformulation of the teacher’s task. Donna was expressing a social identity as a competent female.
She was able to take up this identity and manage it because of the teacher’s valuing of the domestic realm where Donna already
experienced herself as technologically competent. Although the teacher was unaware of this, his representation of the subject provided
the possibility for Donna to cross gender boundaries. It also enabled girls to create meaning in the subject as they identified family
members as the clients for their products, which enabled the home-school boundary crossing. The home-school boundary crossing was
more complex for boys.

The strategy of single-sex organisation was predicated on the need to address girls’ deficits within a safe learning environment. Boys were
not considered problematic in the context of technology and so common sense beliefs about the way boys are were not challenged. The
boys assumed that technology was a ‘masculine’ subject. They did not have to create meaning in the subject but rather assumed it. The
teacher’s discourse about the relationship between technology and the domestic realm disrupted the assumption that boys’ identities were
bound up with their relationship to the physical world and labour and therefore valued the opportunity to take home the product of their
physical labours. Consequently the role of individual products in enabling the home-school boundary crossing was only supportive for
boys with an identity as technologically competent, an identity the teacher assumed. One boy said it was important to him to show his
parents what he had achieved. This boy considered himself to be “very competent... I always get high marks”. Another boy described
how he policed what he took home as he anticipated negative feedback particularly from his mother. He saw himself as not very good at
technology an identity he was not comfortable with, and an individual product made visible his inadequacies. The assumption of boys’
technological competence positioned some boys as ‘outsiders’. Two boys commented on their dislike of the subject and would not
continue with it. They considered themselves to be insufficiently skilled to participate successfully. One of these boys related his feelings
about the subject to his fear of the machines. “I’m just afraid of hurting myself.” The positioning of boys as competent risk takers in
technology education does not allow the possibility of the ‘frightened’ boy and seeking help would risk revealing this. The practices of
technology education including the emphasis on products made the boundary crossing hazardous for these boys and not worth it. Three
of the girls referred to the machines as “scary”, “dangerous” and “worrying”. However their experience of the single sex setting had been
empowering in relation to their access to the machinery. They talked of “knowing how to work it [the machine]” and that “it is nice to be
trusted to use the machine”. The gender valence of the machines and tools was disrupted in the girls’ setting but reinforced in the boys’ setting.

Discussion
Large numbers of boys and girls continue to take up traditional subjects in technology post 14. Furthermore achievement patterns suggest that for those who risk crossing gender boundaries the success of these depend on changes in the practices and discourses within technology subjects to transform dominant gender orders and these have yet to be achieved. It is argued that women’s marginalisation in technology is a problem for technology itself. Similarly continuing to practice technology in schools without attention to gender mediation is to undermine the purposes and values of the subject, and students’ experience of it. Constructivist approaches to science education emphasise the significance of students’ prior knowledge in the learning process, although rarely its social and cultural situatedness. However, it is rare for teachers to elicit what students bring to their technology projects and to use these insights to inform their approach. Technology activities typically start with a brainstorm of needs and wants. The needs and wants that students identify reflect their values and commitments. The needs and wants that emerge in turn define the problem space in which students work. Whilst it is essential to allow for and recognise diversity between students it is also important for teachers and students to be aware of the different learning opportunities that may result from students’ diverse commitments. Understanding what students consider salient and how that might direct their attention to certain solutions is important for three reasons. First it impacts on learning; second it helps to understand how students’ may feel positioned in technology education when they struggle to make sense of the value and purpose of tasks; and third it provides the insights for both teachers and students to challenge gender constructions.

Technology by its very nature is diverse and wide ranging and this provides the possibility for students to engage with it according to their commitments. Students would need however, to understand how their commitments might limit both their solutions and their learning about the subject. To do this the discourse in classrooms has to develop to allow students a voice and a critical stance to what they are asked to study and how they study it. Differences between students in their consideration of the social circumstances of tasks point to the gap between the rhetoric and practice of a subject that has at its core an understanding of social and environmental issues. If the subject were achieving its purposes and giving value to social considerations then teachers’ representations of successful students would begin to
shift, and ‘technological’ would not be associated with boys’ achievements alone. Furthermore boys’ tendency to ignore social and environmental circumstances would be seen as a matter for teaching rather than something to be accepted. That these differences remain invisible to most teachers suggests that the gap between rhetoric and practice is not a small one. Teachers’ choice of tasks and their understanding of how to consider social issues in a culturally as well as personally authentic way are crucial. Yet evaluation studies suggest that in both respects teachers need support to change their practice.

Evidence from the single-sex classes revealed that the teacher’s discourse allowed girls to create meanings in their technology experience that was empowering. He also ensured that their relationship with the tools and machinery was transformed creating a sense of belonging in the workshop. However he did not challenge some of his assumptions about gender-technology interactions and remained unaware that girls’ identities relied heavily on validation outside of school in order to resist the view of them as technologically helpless. Whilst some girls’ identity in the domestic realm was transformed through the experience it was not clear that this would in any way impact on their understanding of themselves in relation to the workplace. The research also provided insights into the commitments of girls and the conflict that they experienced between their values and those of the teacher’s. From the students’ perspective a wider range of learning tasks including an emphasis on design in its own right would enhance their motivation to study at the same time as giving them a more authentic understanding of technology as it is practised in the world. Importantly, practice that represents a broader, holistic vision of the subject would allow students to understand the important relationships between design and production and manufacture. Boys’ relationship to technology continues to be viewed as unproblematic. Yet the evidence from the ‘all boys’ class revealed how a hegemonic representation of masculinity constrained boys’ learning. The assumption of boys’ expertise denies access to some boys in the same way that an assumption of girls’ incompetence denies access to them, positioning them both as outsiders.

Gender-technology interactions are complex and are mediated by students’ self-concept in relation to technology and their perceptions of future possible selves, as one girl from the EIS project noted: “although I enjoy electronics and am fascinated by it, I am not thinking of doing it more seriously, I don’t see the point.” Paying attention to gender and the language of discourse requires a revolution in pedagogy and technology education has long way to go if gender is to become less significant in students’ construction of identities in relation to it.
The direction in which to move though is increasingly clear and the reward at a minimum might be students who understand themselves to be technologically competent and increasingly see the point of their engagement with it.

References
Primary School Children’s Perceptions of Design and Technology

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Introduction
During the last fifteen years there has been a significant increase in the amount of educational research that pays attention to children’s own accounts of their experiences of school. This trend reflects a change in the way in which children are viewed, moving from a model of children as passive recipients of education to one which positions children as active participants of educational processes and key stakeholders in education (Rudduck and Flutter, 2000). As design and technology educators, it is important that we take account of children’s perceptions in order to develop appropriate curricula and classroom experiences. Research into children’s perceptions in the field of primary design and technology education is at a very early stage. However, these preliminary studies, together with work from a broader field, provide some evidence which can illuminate our understanding and provide a foundation for future research.

This chapter reviews the work carried out in the field of design and technology with children of primary age, and draws upon evidence collected in two empirical studies conducted in England with children aged 9-11 (Benson and Lunt, 2007a; Lunt, 2007). While it is acknowledged that children are individuals with unique perceptions of their own particular worlds, it is still possible to provide indications of the value which children place on their experience of learning and participating in design and technology and the chapter concludes by considering what we, as educators and policy-makers, have to learn from children’s own accounts of their experience.
Researching children’s perceptions

The majority of work on children’s perspectives of their experience of education has until recently focused on social processes and issues of social differentiation (Erickson and Shultz, 1992). Curriculum content and learning processes have generally been relatively peripheral issues in studies focusing on, for instance, socialisation and peer culture (e.g. Davies, 1982; Pollard and Filer, 1999). The majority of work has been carried out with secondary-aged pupils. In England, the longitudinal Primary Assessment and Curriculum Experience (PACE) project (1989-1997) was a ground-breaking study in that it was the first major study in the UK that paid serious attention to the perspectives of primary children with regard to their experience of learning in school. Children’s views were sought on their experience of the curriculum, individual curriculum subjects, teacher-pupil relationships, their teachers’ teaching, learning and assessment (Pollard and Triggs, 2000). Consulting pupils as part of school improvement initiatives has also made a major contribution to the literature in this area (e.g. Rudduck and Flutter, 2004; Arnot et al, 2004; McIntyre et al, 2005).

There are a variety of arguments made for researching children’s perceptions and these influence the nature of the research and how the findings are used. For example, a romantic argument is founded on a view of children and childhood in which children are characterised by innocence and naivety and are positioned as beings in need of adult patronage. From this perspective children’s views are collected and are sentimentalised, but are not used to make a serious contribution to educational debates or to bring about significant change in their circumstances. Despite appearing harmless, this position undermines children’s status as people whose views should be taken seriously. In contrast, a critical argument is founded on the notion that children are central actors in the teaching and learning process and as such have very particular insights to offer us in helping to develop our understanding as educational practitioners. This argument positions children as experts of their own experience with important and potentially critical contributions to make to current education debates (Pollard et al, 1997).

Although there are many reasoned arguments that support the principle of researching children’s perspectives, there are also balancing considerations to be made. Some would argue that children are too immature or naïve to shed light on the complexities of teaching and learning – that they simply do not have the cognitive or communicative competence to make a contribution to education debates. However, an increasing number of research studies involving primary aged children suggest that young children are capable of providing
valuable insights into their experience (e.g. Gipps and Tunstall, 1998; McCallum et al, 2000). Furthermore, the kinds of changes to teaching and learning activities which pupils suggest when consulted tend to be very sensible and realistic (Jeffrey, 2003; McIntyre et al, 2005).

Naturally the most articulate pupils are the ones most able to express their views and consequently there is a risk that the overall view of children’s perspectives might be biased. Rudduck and Flutter (2000) argue that we should do more to enable children to talk about their learning and about themselves as learners. With the increased interest in researching children’s perspectives, more attention has been given to developing appropriate methodologies for researching children’s views and consulting with pupils in schools (e.g. Greig and Taylor, 1999; Christensen and James, 2000).

However, of all the challenges involved in researching pupils’ perspectives of their experience in school, perhaps the greatest is that, given a voice, pupils may well criticise the dominant power structures (Pollard et al, 1997). This then raises the issue of how this is handled and how pupil perspectives are interpreted and made use of by researchers and teachers. Although pupils’ perspectives are not the only ones, effective teaching is underpinned by a recognition of the concerns, interests and motivations of learners.

**Researching children’s perceptions of design and technology**

Researching children’s perceptions of design and technology has as yet received minimal attention within the research community. In three reviews of educational research in design and technology (Kimbell, 1996; Eggleston, 2000; Harris and Wilson, 2003) there are only passing references made to eliciting and considering pupils’ views and, in the studies where it does occur, it is used as a supplementary method of data collection rather than as a focus of research. The work which exists is small-scale and the majority of studies relate to secondary-aged pupils.

Two recent studies will be discussed in more detail here. The first, a children’s survey, was a pilot project conducted in England with 304 children aged 9-11 (Benson and Lunt, 2007a). Both qualitative and quantitative data were collected through a questionnaire using a variety of methods to elicit children’s responses. The children were invited to answer questions in their own words (e.g. ‘Why do you think you have to learn d&t in school?’); indicate a set response to a question (e.g. ‘Do you enjoy d&t?’ - always, usually, sometimes, never) and
indicate a set response to a statement made by someone else about d&t (e.g. ‘It puts a smile on your face when you have made something of your own.’ - agree, disagree, not sure). The children were also asked to identify their three favourite subjects and the three subjects they thought they were best at. A further qualitative response was required of children through asking them to imagine they were describing design and technology to a new classmate who had never experienced it before. The study is on-going and the data discussed here is from the initial pilot. However, it provides some insights into children’s perspectives in this age group in relation to the design and technology curriculum in England and highlights a number of themes and issues worthy of broader consideration.

The second research study is an on-going investigation into writing tasks in design and technology with children aged 9-11. 65 children from 3 schools in England were interviewed before and after a unit of work in an action-research based study to ascertain their perceptions of design and technology in general and specifically in writing tasks in design and technology. Writing tasks were defined as any task in which children are required to write in design and technology. Writing often takes place in conjunction with other modes of representation such as drawing or discussion and is usually brief, sometimes using spatial organisers such as tables or mind maps. Typical examples of children’s writing include annotated drawings, lists, labels, storyboards, comparison charts and web diagrams. The interview data is supported by data collected through a variety of methods including observer participation and interviews with teachers.

In the next section the evidence from these studies will be discussed in the light of other studies in design and technology and those relevant to general education with this age group.

**Children’s views of the nature and purposes of design and technology**

The evidence from both the children’s survey and the writing study suggests that children clearly perceive design and technology as a curriculum subject distinct from other subjects. The children’s survey showed design and technology to be among the four most liked subjects together with art, physical education (PE) and information communication technology (ICT). In both these studies the majority of children were extremely positive about design and technology, a finding supported by other small-scale studies which have elicited pupils’ views (e.g. Twyford and Burden, 2000; Barlex et al, 2005). In the writing study interviews the children were asked what they thought of their design and technology lessons in general. The most frequently articulated word was ‘fun’, with many children using
phrases such as ‘very good’, ‘really exciting’, ‘interesting’, ‘brilliant’, ‘I look forward to it’. Only one child out of the 65 interviewed was anything less than enthusiastic. However, design and technology was perceived by the children of both studies as more than just an opportunity for fun in the classroom; it was also regarded as educationally worthwhile. In the children’s survey, the majority of children recognised the educational benefits of design and technology, positioning it as both fun and work. 81% thought that they always or usually learnt a lot; 83% that they had to think really carefully in design and technology lessons while 86% thought they learnt to be creative in design and technology.

Researchers in the PACE project found that many children constructed design and technology in opposition to work (Pollard and Triggs, 2000). They observed that in contrast to the core subjects of English, maths and science, in design and technology teachers allowed their children more autonomy, took a more relaxed approach to pupil grouping, encouraged collaborative rather than individual learning and engaged with ‘mess and doing’. It is suggested that this change in the teaching and learning frame might have contributed to the children’s perceptions of this subject. Design and technology was frequently linked with the criteria ‘fun’ and ‘interesting’ and comments from individual children giving reasons for their subject preferences referred to the opportunity to make things, having fun, playing and the active nature of design and technology. Although this study was carried out when design and technology was in its infancy as a curriculum subject, it appears that its characteristics as a practical and creative subject were already proving popular with these children.

In the writing study the practical dimension of design and technology was dominant in children’s reflections about their experience of the subject. For example when asked to reflect on how the unit of work they had just completed had helped them to get better at design and technology, more than 50% of the responses in each of the schools referred to developing technical ‘know-how’ and skills in making. However, to varying degrees the children were conscious of other elements of their progress in design and technology. Designing featured quite prominently in one of the schools, whereas in another school more general skills such as teamwork, problem-solving and memory were mentioned. This varied response might have been due to the emphasis placed on these elements by the individual teachers or the specific nature of their most recent design and technology project. Attitudes such as perseverance, overcoming problems and confidence were also recognised by a small number of children in each school.
In the children’s survey, a large majority of children recognised the value of designing as well as making with 86% thinking that designing was really important if you wanted to make a good product. However there was some inconsistency in the results between schools in response to the statement ‘I would prefer just to get on and make, not to design.’ The responses for ‘disagree’ ranged from between 25% and 77%. There is no data to explain why this might be so but the results might reflect how designing is taught in these schools, the pressure on time for making or the differing needs and interests of these children.

Children in both studies were asked why they thought they had to learn design and technology in school. In the children’s survey, the responses indicate that the children view design and technology as relevant to their future lives – both in jobs or careers and in other elements of adult life, for example, as parents. This is supported by the findings of the writing study where there was a consistent pattern across schools with the top three categories being ‘preparing for adult life’; ‘developing their ability to design and make things’ and ‘preparing for a later stage of education’. In their responses the children mentioned a wide range of jobs and activities including architect, builder, cook, designer, engineer, mechanic and making biscuits and food packaging. It is likely that these were influenced not just by their most recent project or the views of their teacher but also by their experiences beyond school. A narrow vocational view of design and technology is one which frequently causes concern in secondary education (e.g. Dow, 2006). However, in the context of these primary schools, the children seemed to be reflecting an interest in themselves and their changing identities as they moved on to secondary school and looked ahead to adult life rather than a narrow prescription of activity in design and technology lessons. Listening to the children it appeared that this sense of relevance was a motivating factor which ran alongside the more immediate gratification of their enjoyment in learning and participating in design and technology.

It’s good fun - I like working in groups. When I’m older I might become an engineer or go into making biscuits or food packaging – and also it’s enjoyable. (girl, 10)

It helps you when you go on (to secondary school). It’s important for you to be able to do lots of different things not just English and maths – D&T involves lots of things that aren’t included in other subjects. (girl, 10)

To help you when you get older – you can build things and fix things. (boy, 10)

When we’re older, when our kids ask us how to do all that we can tell them. (girl, 11)
However, an analysis of the data also reveals the lack of any mention of design and technology concerning the development of technological literacy in which one might see the development of skills necessary for active and critical engagement with an increasingly technological world. This might be a reflection of children’s engagement with the practical rather than reflective dimensions of design and technology, although it is more likely to be a reflection of current curriculum practice in English primary schools.

**Children’s values and concerns in learning design and technology**
The data from these two studies show that these children perceived their experience of design and technology in the classroom as a highly valued activity which they enjoyed and found worthwhile. In the writing study the children’s interviews were analysed and coded to identify reasons which children articulated for enjoying design and technology. The codings were developed from those used by Pollard and Triggs (2000: 88) when analysing primary-aged children’s judgements of the curriculum:
- Success/ease
- Interesting
- Activity
- Autonomy
- Educational (mention of learning/challenge/future value)
- Fun.

During the analysis of the interviews in this study, new categories emerged and modifications to the existing set were made. In the children’s responses, ‘interesting’ and ‘fun’ often occurred together. For the purposes of this analysis these words were grouped together to describe a positive affective response, a personal engagement with what was happening in the moment. In addition, there were three reasons articulated for enjoying design and technology not covered by the original categories: ‘novelty/difference’; ‘goal-oriented’ and ‘social’. ‘Novelty/difference’ was created to include responses which suggest that design and technology is valued by children because it is perceived as different from other subjects and can be viewed as a welcome change from some other types of educational experience. ‘Goal-oriented’ refers to the notion that in a design and technology project, children are working towards designing and making a
successful product. In England, the national exemplar schemes of work (QCA, 1998) have promoted a particular structure for design and technology projects, in which children prepare for their designing and making assignment with a series of shorter activities to develop relevant understanding and skills. Although this model followed uniformly can be criticised for being repetitive and rigid, it also has several advantages, including an internal coherence where every task is related to the achievement of the main goal – the successful designing and making of a particular product. The final additional category is ‘social’. This category emerged, as for some children, the opportunity to work with, sit next to, or talk to friends during their design and technology activity was a significant reason for enjoying it. Figure 1 shows how frequently these categories of response were mentioned by the children during the course of their interviews. This provides insights into what was at the forefront of these children’s minds rather than relying on researcher-prescribed categories. Many of the children gave multiple reasons.
The active nature of design and technology was the most frequently mentioned reason for enjoying design and technology. These children enjoyed practical activity: they liked making things and using tools, solving practical problems, tasting food, gluing, sewing, painting, building and constructing. However, it was not just the process of these activities they enjoyed, it was also the fact that they were making a particular product and all their activities led to this. In each design and technology project, these children had a particular goal they were aiming for and this seemed to give momentum and purpose to their lessons. The high frequency of ‘fun/interesting’ might be expected in design and technology. Pollard and Triggs (2000) observed that ‘fun’ had a range of meanings for children. It was most often linked to
‘activity’ and ‘autonomy’ and less frequently with ‘interesting’. Liking something because it was ‘fun’ was also linked with seeing it as play, finding it enjoyable because you could ‘have a laugh’ and sometimes because it was sociable and you could ‘have a chat’. The results here show that these children made stronger links between fun and activity, creating things, autonomy and novelty/difference than working with friends. This might have been a reflection of the way in which design and technology was organised in these classrooms, although further research as a participant observer with these children and their teachers suggest that this is not the case. It might just have been that this was not the reason at the forefront of their minds. The representation of ‘educational’, although small, suggests that some children enjoy design and technology because of what they learn and are able to do as a result of it. The very low representation of ‘success/ease’ contrasts with the high rating attributed to it by the children in the PACE study. However, in that study the pressure of testing and assessment in the core subjects of English, maths and science was probably an influencing factor on the overall categories. So what do children not enjoy in design and technology? In the writing study the least liked aspects of design and technology were defined as ‘writing’, ‘time issues’, ‘waiting for equipment or the teacher’, ‘unnecessary activities’ and ‘problems with making’. These were echoed in the children’s survey although the responses of children from different schools was inconsistent. For example, in one school 74% of children identified writing as the aspect they liked least in design and technology compared to 2% in another. This suggests that there might be a marked difference in practice between the two schools in the presentation of writing tasks. ‘Problems with making’ was another significant category but again the response was variable between schools which might suggest a different teaching approach. The highest overall category was ‘nothing’ which again demonstrates the popularity of this subject for children.

Writing tasks in design and technology are seen by some children as detracting from the enjoyable business of designing and making. However, the more in-depth work carried out in the writing study shows that this is not necessarily the case (Lunt, 2005; 2007). The majority of children in this study came to view writing tasks in design and technology positively. A significant factor in pupils’ perceptions was the relevance of the writing task to the successful achievement of their designing and making assignment. McCormick and Davidson (1996) highlight the central place that the creation of products has in the domain of design and technology and the motivational effect that has on pupils. The pupils in the writing study strongly confirm that view. The children’s comments about the helpfulness of the writing tasks were directly related to the contribution they made to the specific creative act of this unit of work, rather than to wider educational goals such as learning to design. The writing tasks judged least positively were those where they could not see a clear purpose
to benefit themselves as designers and makers or where they were required to write in what they considered to be an inappropriate format, e.g. paragraphs when bullet points were more appropriate. Quantity of writing did not in itself seem to be a factor as long as there was a strong connection with achieving the designing and making assignment. In fact writing was most positively viewed in the school where the children did the greatest amount of writing but the teacher ensured that it was closely integrated into designing and making. The level of challenge might also have been a factor in that writing which was considered easy by the children was also perceived as less helpful. Many children talked about particular writing tasks making them think and moving their ideas forward. They also spoke of the outcomes of their writing tasks as external objects that could help them, e.g. ‘It tells you what to do’; ‘If you forget you can just get it out and it helps you to remember’.

From the children’s survey particular features of classroom practice emerged as being highly valued by children. In the two schools where design and technology was regarded the most positively a large majority of the children perceived that in design and technology they were able to move around the classroom more than in other lessons (78%) and that they were able to work with other children (81%). In the writing study, the majority of children stated a preference for working with others as opposed to individually, although some articulated difficulties in working with others such as ‘falling out’ or ‘taking over’.

I like mixing with other people, being sociable. (girl, 10)
It’s easier with someone else – we have half a job each. You get to decide with your friends and you can help each other when you get stuck. (boy, 10)
I prefer it with someone else unless you have arguments. You get to talk and use the other person's skills. (boy, 11)
It depends on how many is in a group. Pairs is OK. I like it on my own but not all the time. We are four friends. (girl, 11)

The majority of children in the children’s survey also enjoyed the sense of autonomy that came with being able to develop their own ideas rather than being told what to do by the teacher (80%). This also contributed to a sense of fulfilment gained through creating a product themselves (90%). These perceptions indicate something inherent in the nature of design and technology which children find appealing but also suggest that the teaching and learning approaches used are significant in affecting children’s perceptions and levels of
engagement with the subject. The lack of physical constraint, the opportunity to exercise their own agency in the classroom and to work with peers suggest particular teaching and learning approaches and a less pressurised classroom atmosphere than might be found in many of the other lessons experienced by children in the later stages of primary school when there can be intense preparation for end of key stage tests.

In the writing study three main concerns emerged for children: time, relevance and control. Time was the most frequently mentioned category of response when children were asked what they would wish to change about their design and technology lessons. These children wanted more of it and in larger blocks of time to avoid the frustrations of being interrupted in the flow of their ideas or making and the repeated clearing away of equipment. Children from each school referred to having to wait for equipment or while the teacher talked to the whole class. There was a sense of impatience and urgency to get on with their activity. This might have been an immature desire for immediate gratification as the children enjoyed making but in this study it also related to a perceived scarcity of time and the threat that this posed to the successful completion of their product. Time pressure has been identified by other studies into children’s perceptions of their experience in school particularly since the introduction of a standardised curriculum (Pollard and Triggs, 2000; Ruddock and Flutter, 2004). Relevance is a related concept in that the children were less positive about any tasks which detracted from their primary purpose of designing and making a successful product, e.g. writing tasks which did not directly contribute to their ability to design and make. It also referred to the level of challenge of particular tasks with more children commenting on tasks which were too easy for them and therefore perceived as a waste of time than those which were too demanding. In terms of control, negative comments were about tasks which the children found constraining or being interrupted by the teacher; positive comments related to being able to do things for themselves and making their own decisions. A sense of autonomy has been found by many researchers to be closely associated with a greater level of engagement (Rudduck and Flutter, 2004).

Implications for teaching and learning
The evidence from these studies suggests that there might sometimes be a mismatch between teachers’ and children’s expectations of design and technology. Although many children at the top end of the primary school perceive design and technology as educationally
worthwhile, their main focus of attention is located in their immediate experience of designing and making a particular product with a strong internal driver to achieve success. Teachers’ perceptions are likely to cover a much broader range of objectives than the short-term objectives of the children (Cooper and McIntyre, 1996). In the context of design and technology, the goal-focused objective of designing and making a successful product can act as both help and hindrance to the teacher. It is undeniably motivating for the children but can also be constraining in two main ways. Firstly, the desire for a successful product outcome can sometimes lead teachers to restrict children’s options in an attempt to take greater control over their designing and making. This leads to fewer opportunities for authentic designing together with less risk-taking and genuine problem-solving (McCormick and Davidson, 1996). Children are less likely to learn from their mistakes and to develop the necessary creative and problem-solving skills which form such an essential part of design and technological capability. Secondly, insufficient attention is often given to wider learning objectives, such as developing a critical understanding of the technological world and its impact on how we live our lives. The challenge for primary teachers is to work with the grain of pupil motivation in order to develop more effective teaching and learning situations. As teachers we need to recognise the potency of the creative act of designing and making a product and weave into this the necessary opportunities for children to experiment, to problem-solve and to make their own decisions in such a way as to support success. We also need to consider the best ways of bringing in other important dimensions of learning into design and technology, such as technological literacy, whilst maintaining the high levels of engagement that children have with the subject.

Children’s enjoyment of opportunities to work with others in design and technology lessons reminds us of the importance of children’s social identities in the classroom. For them lessons are not merely about learning objectives and learning activities. How they go about tasks in relation to one another as social beings and the potential for fun can be critical factors for engagement. Add to this the significant role which discussion plays in effective designing (Kimbell et al, 1991) and learning (Mercer, 2000), and there emerges a strong argument for teachers to look for more opportunities to enable discussion and collaborative working in design and technology. However, what children also tell us is that as teachers we need to be aware of group dynamics and the difficulties that are sometimes experienced when working with others – particularly the ‘falling out’ or ‘taking over’ syndromes.
Several research studies have found that time is an issue for children and is experienced by many as a commodity in short supply. There are often feelings of stress and anxiety caused by having to rush and not having adequate time to accomplish work (Doddington et al, 1999; Pollard and Triggs, 2000). Time was an issue for many of the children in the studies discussed here. The children either wanted more time for design and technology because they enjoyed it or felt anxiety about not being able to complete the task successfully in the time available. Time has also been identified as an essential component of a creative climate for developing creativity in the design and technology classroom (Nicholl et al, 2008).

The findings from the writing study and the children’s survey identify several features of effective learning which concur with more general studies of children’s perceptions. The literature suggests a high level of consensus among children of various age groups about the characteristics of lessons and learning situations that help or hinder learning. Ruddock and Flutter (2004), in a summary of findings from their own studies in primary and secondary schools over a ten year period, identify four broad categories that describe pupils’ views about what makes a good lesson:

Opportunities for participation and engagement
Active lessons with a variety of learning tasks
Challenge (that is exciting but not overwhelming)
Opportunities to exercise autonomy. [p79].

These categories are represented in various ways in the responses of the children in these studies. In particular the children talked about the active nature of design and technology, challenge and autonomy. Nicholl et al (2008) interviewed students aged 11-16 about their experience of design and technology and also found that autonomy and challenge were two key values for children. Where levels of autonomy and challenge were insufficient, students became de-motivated and were more likely to become disengaged with learning processes. This confirms earlier findings from small-scale studies in secondary school (e.g. Hughes, 2001; Neale, 2003). It could be argued that challenge and autonomy are two inherent characteristics of design and technology and yet what the children remind us is that we do
not always get the levels right and that these are factors which have a significant impact on levels of engagement and consequently achievement.

**Implications for curriculum policy**
The children in the writing study and the children’s survey appeared to find their experience of design and technology relevant to their lives in three important ways: as children in the present moment, as future learners and as future adults. However, their focus was emphatically on designing and making with minor references made to broader skills such as team-working and attitudes such as perseverance. Although children showed an awareness of how design and technology might prepare them for future learning, jobs, careers and parenthood, there was no reference to preparing to be a citizen. Technological literacy and the ethical issues so central to design and technology such as sustainability did not feature in the perceptions of these children. This might reflect the emphasis of the current curriculum although there is an increasing requirement for schools to develop children’s awareness of these issues and practical resources are beginning to be developed to support this dimension of primary design and technology (e.g. Benson and Lunt, 2007b).

It can be argued that future developments in the curriculum for primary design and technology need to ensure a high degree of authenticity – both personal and cultural. For personal authenticity, the learner has to be involved and the learning has to be meaningful for them. Listening to the pupils' voice will be essential to achieve this. For cultural authenticity the teaching and learning activity in school should relate to design and technology in the world outside school (McCormick, 2004). An increased emphasis on current technologies and technological literacy might prove to be a challenge for primary teachers working with children who perceive design and technology in terms of the designing and making model which has become so popular. Changes in the curriculum on a national, local or school basis will need to take account of children’s perceptions. Children are not the only stakeholders yet they are an important voice in the debate. Our understanding of children’s perceptions of design and technology is a benchmark against which to judge the activities which we include in the curriculum. If these activities do not match children’s current perceptions or values, we will need to consider the most effective ways of expanding children’s current construct of design and technology education.
Conclusion

Research into primary school children’s perceptions of design and technology is still at an early stage but the available studies confirm anecdotal evidence that design and technology is a subject which children find engaging, enjoyable and educationally worthwhile. The research distinguishes between inherent characteristics of the subject such as practical activity and its goal-oriented nature, and features of particular teaching approaches such as the level of challenge, the degree of pupil autonomy and the amount of collaborative working. More research is needed in order to investigate pupil perceptions across the full age range. Research into children’s perceptions of specific elements of design and technology such as designing or the use of ICT might also provide valuable insights to help us to refine our teaching of the subject. The research discussed here was conducted in England and therefore only reflects one particular model of design and technology education. Research conducted in different countries would provide a richer picture of children’s perceptions related to different curricular experiences and cultural contexts. The research shows that investigating children’s perceptions can help to reveal implicit subject constructs, values and concerns as well as gaps in provision. The construct of design and technology as a goal-oriented activity focused on the creative act of designing and making is a powerful model which needs to be considered in any future development of the curriculum as it is highly valued by children. The more we can learn from children the more we can fine tune the teaching and learning experiences we provide in order to maximise the learning potential of this dynamic and exciting subject.

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She in technology education: Impact of supports aids on the interest and knowledge acquisition.

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Introduction
The interest of taking account of gender in education is widely recognized today (Jarlégan, 2009). This concern is largely motivated by the disinterest of the girls for paths and scientific professions. But this is as much about technology education. This justifies that cares and how to engage the girls from an early age for the activities of a technological nature.

In France the teaching of technology as a general subject area is compulsory for all pupils between the age of 3 and 15. After that (in secondary school), education technology is no longer taught to all pupils, as it becomes optional. Its teachings are defined nationally in curricula detailing for each cycle and level: objectives, skills, content and the appropriate teaching method. In spite of this framework, technological and scientific study courses and jobs have been neglected by girls for decades.

The low number of girls in study courses and jobs involving science and technology is a longstanding and widespread phenomenon (Baudelot C. & Mossuz-Laveau J. 2004; Chaponnière, 2006 ; Duru-Eccles & Jacobs, 1986 ; Duru-Bellat, 2005 ; Mosconi, 1994 ; Robine,
Numerous initiatives and measures taken here and there in an attempt to solve the problem have nonetheless remained partially ineffective, due to the fact that this phenomenon which is socio-culturally and psychologically rooted and constructed is very difficult to combat.

Recommendations likely to be made through research (Marry, 2004; Jarlégan & Tazouti, 2007; Chevet, 2006; Jackson, D., Rushton, J. 2006.) have also proved largely ineffectual, probably because of their very general nature and the scarce amount of research able to more aptly explain the way in which, for each discipline, teaching and learning processes create or reinforce segregatory mechanisms to favour either gender.

Are these, for example, the same processes (but inversed) which are in force in language and technology teaching, even though one of these subject areas is favoured by girls and the other by boys? In the same way, for instance, that girls often seek help in technology from boys, is the opposite common in language classes, with boys asking their female counterparts for assistance?

There is little comparative (Roustan et al, 2002; Ginestić, 2005), qualitative and significant data available regarding phenomena surrounding relationships between: gender & teaching content; gender & kinds of activities; gender & forms of study; gender & the teacher's actions; gender & academic structure....As a result, we don't know, for instance, whether certain contents, types of activities, forms of study, teaching traits and academic structures are more suitable for girls than boys and vice versa.

Since social norms are constructed through pupil activity in the process of forming differing viewpoints of a socio-cultural, socio-professional or socio-economical kind, is it possible to identify factors likely to generate or reduce differentiation in technology? The study presented here concentrates on relationships between pupils and the object used to provide a teaching media in the accomplishment of an artefact design task.

More masculine subject areas (electronics, mechanics and civil engineering) allow teachers to use more masculine objects. Is this really the case?
These study support objects/tools in France are chosen by the teacher. Providers of teaching materials develop a lot of them, but there is nothing to prevent the teacher from developing their own objects. The choice is made principally in terms of what academic benefit the chosen object offers. Is benefit to teaching balanced from a gender point of view, if the artefacts used in class privilege objects of which the social usage is mainly reserved for boys? One can expect choices of study support tools made by teachers to take gender into account, either by inhibiting or exacerbating it. As far as pupils are concerned, we can anticipate that girls who have learnt using a study support that is suitable for them have greater success than their masculine counterparts who have learnt using a feminine study support, and vice versa.

Method and results
This work is based on two empirical studies involving college (middle school) pupils. The first is a pre-investigation of the feminine, masculine or neutral gender attributed to study support tools by pupils. The results will confirm whether or not teachers take into account the effects their choices have on the gender of the group they are teaching. The second is an experimental study about pupils' attitudes in an artefact design situation, the usage of which is primarily socially defined, and in which girls and boys may precede differently. It is more specifically a matter of highlighting the effects produced by feminine and masculine artefacts upon girls' and boys' learning.

2.1 pre investigation
To examine the social use of study support tools by pupils, we gave a list of 14 objects to 50 pupils (25 boys and 25 girls) aged 13 and 14 in two different middle schools. The listed objects are chosen beforehand in accordance with « standard » ones used by technology teachers. The objects are a CD rack, a miniature basketball hoop, an office set, a small alarm, a bicycle speedometer, a pen holder, a telephone answering machine, a humidity detector, a reminder, a clock, a bike alarm, a folder, a keyring, a pedometer.
Pupils had to give their opinion about each object by choosing one of the following three options: primarily « feminine » object, primarily « masculine » object, primarily « neutral » object (both feminine and masculine).

Questionnaire analysis and results
The graph below shows the range of answers given by pupils regarding what gender they attribute to the different objects.
Of the 14 objects frequently used by teachers as teaching aids, half are heavily gendered (feminine or masculine), while the other half are neutral. Hence the pedometer, the mini basketball hoop, the bike speedometer and the bike anti-theft alarm are deemed more masculine. The office set, pen holder and humidity detector are more feminine. All the others are considered to be primarily neutral.

The masculine objects are linked to play and sporting activities (game of basketball, going running, biking). The feminine objects relate to indoor activities in the bedroom, and scaled up to the garden or the balcony (office set, pen, humidity detector for potted plants). The stereotypes are persistent and long-lasting.
Technology teachers choose as many neutral objects to pass on knowledge as they do heavily gendered ones. The choice of neutrality is indicative of the taking into account of the range of gender groups to be educated. These teachers reduce aspects linked to gender, by choosing objects of which the social use is just as feminine as it is masculine. On the other hand, the choice of objects in terms of feminine or masculine uses is indicative of the non-consideration of their social uses. For them, all the objects are “good mediators” in passing on knowledge.

**Observation in class**

The experimental setup consists of putting girls and boys into a teaching learning scenario one after the other, with an artefact which is seen as typically “masculine” as a study aid, then another typically “feminine” object. Note that these objects were chosen based on the classifications obtained in the pre-investigation.

The study is conducted in two 4° classes in two different middle schools in the middle of the school year (2° term). The pupils are between 13 and 14 years old. The sample comprises 48 pupils (24 girls and 24 boys).

**Teaching setup**

The sequence of events takes place in the context of a « product improvement » scenario (BOEN, 1995). It targets several learning aims: the first aim is to lead the pupils to answer a commercial request, in the aftermath of dissatisfaction having been voiced with regard to the use of a product. In terms of knowledge, pupils will learn to integrate the usage and technical constraints from the specification and learn to think of new forms, new ways of assembling the product, new materials to provide solutions.

The sequence is comprised of three phases, the first of which is observing a prototype and identifying the problem it poses from a commercial point of view. Two study supports are offered, neither of which comply with the aims targeted in the market study. Hence, these products in their current form cannot satisfy the target clientele. The next phase is suggesting solutions to improve the product, and then developing one of them.

Task: Find solutions for functions failing to meet the commercial target. Each study support has a corresponding specification indicating areas/functions that fail to meet the target, as shown in the illustrations below.
### Illustration 1: Characteristics amelioration

The task is sub-divided into two smaller tasks.

**Sub task A:** In writing, suggest a maximum amount of solutions capable of meeting these functions (targets).
- Organisation: 8 teams of 3 pupils no mixed. A secretary is charged with writing down the group’s suggestions in a single document.
- Material: Specification for areas/functions to be improved, paper, pencil, choice of study support.
- Duration: 20 minutes.

Once the task is complete, pupils are asked to develop one of the solutions.

**Sub task B:** Choose a solution out of all those suggested, and develop it by means of drawings, diagrams, sketches, texts, key, and paper models, to allow everybody to understand your project.
- Organisation: same teams (8 teams of 3 pupils, non mixed).

#### SPECIFICATION

<table>
<thead>
<tr>
<th>Function</th>
<th>Criterion</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP1</td>
<td>Be assembled and disassembled</td>
<td>quickly</td>
</tr>
<tr>
<td>FP2</td>
<td>Be transported easily</td>
<td>Back pack</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function</th>
<th>Criterion</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP1</td>
<td>Storing and transporting jewelry</td>
<td>transportable in travel bag, suitcase…</td>
</tr>
<tr>
<td>FP2</td>
<td>Open and close</td>
<td>Easy</td>
</tr>
</tbody>
</table>
- Material: Paper, pencil.
- Duration: 20 minutes

All the groups (girls and boys) accomplish the task on the study support of their choice to begin with, then on the other. Thus, the task is identical for the two supports.

The study support objects

The masculine study support object is a mini football goal for playing football in a group of three without a goalkeeper and in a reduced space.

The feminine study support object is a jewellery box which can be carried in a suitcase or a travel bag.

Illustration 2: Study supports « Mini football goal » and « jewellery box »
Data collection
Two types of data are collected: the first kind corresponds to pupil behaviour and the manner in which they go about the task with regard to the feminine or masculine study support object. The other data concerns the group's ability to suggest solutions and develop one of them.
The speed of getting down to work, discussion, concentration, curiosity is indicators of pupil involvement. A previously drawn up grid/chart, one for each study support object and each group, means that boxes can be ticked to show whether each of these indicators are present as the task progresses.
To examine solutions: the amount of solutions produced, the amount of solutions developed and their relevance to the specification made available are collected from written accounts provided by each group.

Analysis of teaching-learning scenario and results
Influence of study support on pupil behaviour.
The graph below shows: the number of feminine and masculine groups who started working in the minute following the instructions being given, the number of groups in which discussions between the different group members were frequent or even permanent in carrying out the task and participating in the work, the number of groups concentrating on the task and finally, the number of groups having shown curiosity, surprise, investigative qualities. Notably through experimenting, demonstrations and questions.
Graphic 2: Gender of study aids for pupils

This graph shows that the 8 feminine groups get to work quickly with a feminine study support, compared to only 3 masculine groups. The pattern for the masculine study support is less obvious, only 5 masculine groups get to work quickly compared to 3 feminine groups. As for exchanges and discussions, the feminine study support leads to discussions in all the feminine groups, and only half the masculine ones. This is not the case for the masculine study support, for which discussions remain half as frequent in both groups. The concentration of girls on the feminine support is twice as high as that of boys, a tendency which is inversed for the masculine support, but to a lesser degree. Indeed, 7 groups of girls concentrate on the task with the feminine support, whereas only 5 groups of boys are concentrated on the masculine support.
Both study supports (feminine and masculine) provoke almost as much curiosity for boys and girls, with 7 groups of boys and 7 groups of girls, with the exception of the feminine support which provokes curiosity from the 8 feminine groups.

**Analysis:**
The higher work rate, discussion, concentration and curiosity for girls in relation to the feminine study support, compared to the average score obtained by boys, shows that the feminine object is highly attractive to girls. They know the question well, seem interested in it, and grasp the problem to be solved, discussing it amongst themselves.

Pupils' behaviour on the masculine support is not as clear. Indeed, on the one hand, scores for boys in work rate and concentration, significantly higher than those for girls, lean towards the attractiveness of the study support shown above, but this time for boys. On the other hand, the masculine study support object is less conducive to discussion and exchange for all concerned (just as much for girls as for boys). This is possibly due to the parts l (pipe) and the only material (grey PVC) of which the football goal is made. The kind of support has almost no effect on pupils' curiosity.

**Remark:**
Girls appear to be more sensitive than boys to the kind (gender) of study support. Boys appear more consistent, regardless of study support gender. The support gender influences the pupils' concentration, but not their curiosity.

*Influence of the study support upon the pupils’ ability to suggest solutions.*
Examination of documents completed by the pupils reveals that they found a total of 93 solutions. The graph below shows the number of solutions offered by groups according to gender.
Graphic 3: Number of solution proposed in function of gender and aids

The groups of girls offer 38 solutions in total, 17 for the masculine support and 21 for the feminine support. Boy groups suggest 55 solutions in total, with 23 for the masculine support and 32 for the feminine.

Analysis: Pupils' work rate is shown by the amount of responses for both study supports. This result follows the trend shown above. Scores for masculine groups are higher than those of the feminine groups. But both follow the same trend/pattern/curve. The most common solutions for the jewellery box are boxes, storable tins, bags, drawers, hooks, velcro, laces, magnets. Most common solutions for the football goal are parts to be fitted together, covered or interlocked using springs, elastic, or telescopically. The emphasis on gender of the study support objects does not seem to influence the accomplishment of the task in finding technical solutions to a functional problem.
Qualitative analysis of the pupils' work shows that the solutions suggested for the feminine support are highly original, inventive and realistic, especially where the girls are concerned. They suggest, for example, a corrugated base or a base with small pegs to hold jewellery securely. Their male counterparts, however, hardly thought about acting upon the bottom of this support object. Just one suggests a suctioned or magnetic bottom which is uncommon. Suggestions made by girls with regard to the masculine support object are comparable to those made by boys. Both groups suggest systems which can be dismantled (parts fitting together or telescopic). The groups of boys combine solutions more than girls, they think of a structure with different systems for the top and bottom parts of the football goal. The girls offer more solutions that are completely different to the presented product (a blowups goal, for example), which shows a tendency to be less pre-occupied with the strict project outline.

Remark: Boys generally offer more solutions. The qualitative analysis of pupils' suggestions reinforces the idea that the gender of the study support object which quantitatively did not seem to have an effect on the accomplishment of the task actually does have one: boys and girls are both more inventive when working with study support objects of the same gender as themselves.

*Influence of study support object upon pupils' ability to develop a solution*

The graph below shows the relationship between the number of solutions developed and their suitability with regard to the specification, based on gender and support.
Graphic 4: Number of solutions developed in function of gender and aids

The amount of solutions developed is the same in the feminine and masculine groups (8 each). But not all the developments comply with the specifications. On the masculine study support, the groups of boys have 6 projects which comply with the specification, compared to 2 for girls. On the feminine support, the boy groups develop 5 suitable projects, compared to 5 for the girls.

Analysis: The identical number of solutions developed by groups of girls and boys holds no surprise in an academic context, with the pupils doing what the teacher asks of them. This figure shows that generally, everybody respected the instructions. If one looks at the instructions in more detail, the pupils had to work to a specification. The scores obtained by groups of boys indicate that they develop more ideas compliant with the specification than groups of girls. For the football goal, they develop a telescopic or stacking system. The girls develop systems with flexible structures which can be put up on their own, as in the case of tents used by hikers, or blow-up ones, which modify the product and move away from the specification. For the jewellery box, girls develop inventions such as an undulating bottom, winding lids, pockets which fasten together at the bottom and allow for the carrying of a single piece of jewellery.
Remark: The boys fulfil the teacher's expectations and get on with the set task. This is not the case for the girls, who are more inclined to totally re-invent the product (goal) and move away from the prescribed task strictly speaking, or just develop solutions which do not exist elsewhere (jewellery box). The study support 'gender' has little influence over boys. It has lots of influence over girls in this kind of task for finding new solutions.

Conclusions
In this study we attempted to find out what impact can be produced by a study support object which is socially given one gender or the other in middle school technology teaching. The results indicate that half the study aids normally used in technology in college are neutral. They also show that study supports which are not neutral have an important effect upon pupil behaviour. Furthermore, girls prove to be more sensitive than their male counterparts to the study aids they are working with. They show imagination and inventiveness, taking more risks than boys on the feminine supports that they are familiar with. They act in a similar way to boys when working with masculine supports. Feminising technology by opening it to more feminine fields such as habitat, clothes or the table, whilst not taking anything away from learning for boys, who are adaptable, would probably be a means of reuniting girls with technology, by ensuring that this subject area allows them to make the most of their inventive and creative skills.

It seems therefore important to educate teachers on this issue during their training. Indeed, generally, it gives too little attention to artefacts supports used to mediate the activity of pupils in class. They refer, however, so as to underlying social practices (Martinand, 1995) which themselves are rarely neutral in terms of gender.

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INTRODUCTION TO SOME CASE STUDIES

Exploring issues related to gender in technology education

John R Dakers and Wendy Dow

Introduction
A fundamental aim of UPDATE is to have an impact on learners’ (especially girls’) views about themselves as users and developers of technology. The project hopes to develop a more holistic approach to the learning and teaching of technology education by attempting to move away from the embedded ‘skills acquisition’ model that tends to prevail in the secondary sector. The consortium aims to act collaboratively to this end by combining the expertise of a network of complementary universities, research institutes, schools, and partners from relevant public and private organisations. Research suggests that, in general, girls are less inclined to be attracted to a technology education paradigm that is focussed upon fabrication and the development of procedural knowledge related to fabrication (see Murphy, 2006 for example). To this end, UPDATE has set out to encourage teachers and student teachers to view technology education conceptually as well as procedurally.

Previous research has indicated that technology lessons across the developed world and in the upper school sector, have tended to orientate around the concept of craft skill development relating more to the perceived needs of industry (see for example Dakers, 2006; Dow 2006). These skills, such as those related to woodwork, metalwork, working in plastics or technical drawing skills, whether by hand or using computer aided design or computer aided manufacture, tend to emphasise the development of procedural knowledge over the development of conceptual knowledge. Even where more complex technological areas such as electronics, pneumatics, structures or computer control are studied, they tend to err towards the development of procedural knowledge. Procedural knowledge development in technology education is more concerned with teaching young people to become proficient users of technology in the form of using tools,
machines, CAD packages etc., rather than becoming proficient in understanding the underlying conceptual issues resulting from technology use. In simplistic terms, the development of technological knowledge is more related to how to use technologies to achieve some required end, such as the development of a new technological innovation, fabricating a cloth pencil case or developing a nuclear bomb for example. The development of knowledge about technology, on the other hand, might consider the ethics of whether the development of cloning sheep might lead to human cloning or whether the skills acquired in the fabrication of a simple mechanism are internalised and so transferable (One author has argued elsewhere that they cannot.)

**The female as subordinate to man in the history of science and technology**

“A man never begins by presenting himself as an individual of a certain sex; it goes without saying that he is a man. The terms masculine and feminine are used symmetrically only as a matter of form, as on legal papers. In actuality the relation of the two sexes is quite like that of two electrical poles, for man represents both the positive and the neutral, as is indicated by the common use of man to designate human beings in general; whereas the woman represents only the negative, defined by limited criteria, without reciprocity...She is defined and differentiated with reference to man and not with reference to her; she is the incidental, the inessential as opposed to the essential. He is the subject, he is the absolute – she is the other” (de Beauvoir, 1949: 15-16).

In order to fully understand issues relating to gender in science and technology it is perhaps useful to start from an historical perspective. It was in late sixteenth and early seventeenth century England that the man, sometimes considered to be the architect of modern science, offered us the metaphor of the ‘marriage’ between knowledge and power. Sir Francis Bacon envisioned this marriage as “a chaste and lawful marriage between mind and nature” (Keller, 1995: 31). The aims of science were, for Bacon, the domination and control of nature, and nature, in Bacon’s metaphor was unequivocally feminine (nature as ‘she’ or ‘mother’). Given that Bacon, who was a student of Oxford and had a strong leaning towards Puritanism (he was tutored by a future Archbishop of Canterbury), it is perhaps no surprise that his views that man (sī) should dominate nature follow biblical canon: Man (sī) was not only given dominion over the earth, He (sī) was also instructed to ‘subdue’ it (Genesis 1: 26-28).
It is further interesting to note that at and around the time of Bacon, as a new unambiguously ‘masculine’ scientific rationality was beginning to set about dominating nature, women were considered to be irrational and have uncontrollable sexual appetites which were widely viewed by men as being problematic. Indeed witches, who by being seen to invoke the spiritual, sexual and non-rationale side of nature, continued to be feared by man. “The reality of witchcraft effectively attested to the gravity of the dangers represented by women – dangers against which reason and the new science promised protection” (Keller, 1995: 60).

Keller (1995) argues that during the seventeenth and eighteenth century’s, ideologies about gender shifted dramatically. Definitions of male and female became more and more polarised as evidenced in the woman’s role as ‘housewife’ and the man’s role in the workplace. Even as recently as twenty years ago boys studied technical education at school whilst girls studied home economics (and still do many argue). Over time as we approached the industrial revolution, this polarisation of genders resulted in a “severe curtailment of the economic, political, and social options available to women of all classes, and especially to women of the middle and upper classes” (62). By the nineteenth century the wild and sexually rapacious female of the seventeenth century had become completely dominated and domesticated in the service of man. Keller (ibid) argues that whilst the scientific revolution was not directly responsible for the domestication of the female, it did support its manifestation.

“In sympathy with, and even in response to, the growing division between male and female, public and private, work and home, modern science opted for an ever greater polarisation of mind and nature, reason and feeling, objective and subjective; in parallel with the gradual desexualisation of women, it offered a deanimated, desanctified, and increasingly mechanised conception of nature” (63).

Not only was nature subject to mans will, so too was the female: “with one reduced to its mechanical substrate, and the other to her asexual virtue, the essence of Mater could be both tamed and conquered; male potency was confirmed” (ibid: 64).

This separation of subject and object follows the Modernist paradigm which, we would argue, continues to be integral to Western thought to this day. Modernism, in line with Platonism seeks to categorise and classify the world by separating the “ideal and the real, the original and the copy, the conceptual and the material, and, ultimately, the opposition between man and woman” (Grosz, 1993: 169). Woman and
nature in this masculine world become something ‘other’ from ‘man’. Paechter, citing Morgan (1972), offers an amusing but significant anecdote as a representation of ‘otherness’ in terms of the female:

“There is a line in an old folk song that runs: ‘I call my donkey a horse gone wonky’. Throughout most of the literature dealing with differences between the sexes there runs a subtle underlying assumption that woman is a man gone wonky; that woman is a distorted version of the original blueprint; that they [men] are the norm, and we [woman] are the deviation” (in Paechter, 1998: 7). The ‘otherness’ of the female in terms of education is realised in multiple forms one of which is the sexual metaphor. Branches of knowledge like science and technology which are represented as factual and objective are considered to be ‘hard’ whereas those branches which are more normative in nature, those that are synonymous with hermeneutics and subjectivity are considered to be ‘soft’. The innuendo requires no explanation. “A woman thinking scientifically or objectively is thinking ‘like a man’; conversely, a man pursuing a non-rational, non-scientific argument is arguing ‘like a woman’” (Keller, 1995: 77). These stereotypes have potency, especially for the young. Writing in 1972, and I would argue that the stereotype still remains today, Hudson argues that:

“The arts are associated with sexual pleasure, the sciences with sexual restraint. The arts man is seen as having a good looking, well dressed wife with whom he enjoys a warm sexual relation; the scientist as having a wife who is dowdy and dull, and in whom he has no physical interest. Yet the scientist is seen as masculine, the arts specialist as slightly feminine” (83).

Substitute the word technologist or engineer for scientist and, I argue, the meaning will be consistent. Masculinity, like science and technology is considered to be related to notions of independence and objective thought whereas femininity is more related to notions of collegiality and intersubjectivity.

**Gender roles**
The difference between male and female from an anthropological standpoint is relatively obvious, unambiguous and biologically determined. The difference from a cultural standpoint, however, is fraught with problems. The cultural norms for gender behaviour vary
across communities and countries. These norms also vary over time. “The roles of males and females are almost always socially constructed and not biologically determined” (Slattery, 2006: 150). As we have discussed earlier, the gender role of a female changed considerably from the late medieval period to the industrial revolution and the rise of capitalism. This was socially constructed by men seeking to dominate nature which was (and is) considered female. Today, gender role is appropriated through the medium of corporate advertising, fuelled by capitalism. The dialectical roles discussed above have now been conflated. The female is expected to act as housekeeper, (co-) breadwinner, mother and highly sexualised partner, whilst simultaneously being virginal and deferential to masculine authority. Slattery (2006) offers us the example of the De Beers diamond company from South Africa as proof that corporate capitalism can shape gender stereotypes. In terms of Western marriage rituals, the idea that the female gives herself to the husband forever (a diamond is after all, forever) is still a potent ritual that serves to classify the roles of husband and wife. The offering of a diamond ring (an external symbol denoting ownership) from male to female demonstrates the status and power of the male provider. The bigger the diamond, the higher the perceived status of the man. Moreover, as a result of corporate advertising, a celebration of true love and happiness is explicated in the giving from the male to the female a 25 year anniversary diamond necklace. This is the social shaping of an idealised society, however, upon closer inspection it becomes apparent that De Beers “actually manipulated the market to create an artificial scarcity of diamonds” (151). The role of the female in relation to the male is effectively being ‘engineered’ in the interest of corporate greed which is predominantly masculine in its constitution. The important lesson to be learned here is that if gender is socially constructed, and if, as Norton and Freire (1990) argue, “the act of [technological] knowing has historicity, then today’s knowledge about something is not necessarily the same tomorrow. [Technological] Knowledge [and gender related knowledge] is changed to the extent that reality also moves and changes…it is not something stabilized, immobilized” (101), then both technologies and their functions change and develop over time, as does the gender role of the female and the male. This is not to say that the gender role of the female should become more orientated to that of the male. Rather, the whole concept of technology, both materially and metaphorically must be reconsidered and reconceptualised.

**Implications for technology education**

It is a generally held assumption that technology education (like all school based education) is gender free. However, it is Layton (1993) who observed that technology is understood as a “masculine preserve, not a place for women, who are relegated to the role of users and
consumers” (35). The technology education curriculum follows this understanding. In the United Kingdom in 1963, the technology education curriculum underwent a significant change. Whilst the content and delivery remained mostly unaltered, the vocationalisation and link to industry of technology education became law. A report called ‘Half Our Future’ was presented by Newsom. In it, he argued that “…all schools should provide a choice of programmes, including a range of courses broadly related to occupational interests, for pupils in the fourth and fifth years of a five years course” (in Dakers, 2008: 98). This occupational orientation situated working class girls in their domestic roles studying home economics, whilst the boys studied “workshop skills traditionally associated with male working class occupations and crafts, skills that have been associated with forms of hegemonic masculinity” (Murphy, 2006: 221). Whilst there may be subtle changes in the reasons for this Platonic form of gender separation occurring in late twentieth century technology education, the resultant separation of gender roles is, nevertheless, almost unchanged from over two hundred years ago. Education so conceived, follows Adam Smith’s notion of a ‘civilised’ society predicated upon a division of labour. Technology education in this model is consequently justified in terms of its utility (Dakers, 2006).

The last twenty years have witnessed a change in policy for the delivery of technology education. Girls and boys are no longer streamed into either domestic science or technology subjects on the basis of gender or sex. These boundaries have, it would appear, been dismantled. Now, both girls and boys are encouraged to study both subject domains. This does not mean, however, that girls will automatically become more attracted to technology education as it was conceived for boys

**UPDATE in Scotland – the study so far.**

It was the original intention to use student teachers from initial teacher education systems to partake in the study. However, since writing the proposal, the educational system in Scotland has undergone significant changes, particularly in relation to student teacher placement in schools. It was formerly the case that the University selected the school that the student would be placed in for their school experience. The new Scottish Government decided, however, to devolve that decision to each of the 52 Local Authorities responsible for educational provision. This meant that it was no longer possible to gain the approval of selected schools that would be willing to take part in the project. School cooperation at both department level and Head Teacher level is an extremely important component of the UPDATE project ethos. It was decided, as a result to enlist the help of teachers across a broad range of experience. In consultation with the
University of Strathclyde, nine willing teachers were interviewed and selected, including two Principal Teachers and four beginning teachers. The Head Teacher and Department head at each of the participating schools were interviewed by the authors and agreement was reached that the teachers undertaking the project would be given a larger degree of freedom in designing the subject material than might otherwise have been the case. It was agreed, nevertheless, that this had to be done in consultation with the head of department. An intensive weekend workshop was organised in Glasgow. Patricia Murphy, a world-renowned authority on gender issues in technology education was invited to speak along with David Barlex, a leading curriculum developer in technology education. These presentations were video taped and are available on the UPDATE website. Books were given to each participant that were considered relevant to the project. For the first part of the study, we adopted a democratic process whereby the teachers were given free choice in the type of intervention they would implement in their classroom initiatives. We also worked with the teachers in order to produce an initial questionnaire for pupils. This was intended to establish the perceptions of technology and technology education of pupils in the first stage of secondary school (aged 12 and 13). These questionnaires were intended to establish a base line against which any changes affected by interventions could be measured. A case study approach was adopted in which teacher participants in the project could consider their department, or class or a group within the class in relation to changes brought about by changing the pedagogy to make the subject more engaging and attractive to girls. Whilst several case studies were implemented in the first phase of this project, this paper will concentrate on one in some detail. In the issues it raised and the problems it identified, this case study is, nevertheless, representative of them all. The teacher in this case study is a relatively new teacher of technology education. She has, however, shown a great deal of interest in the subject. She is a leading member of the Technology Teacher’s Association in Scotland and was very keen to take part in this project. She was keen to investigate whether or not, a single sex class would change female pupil perception. For a more detailed account of her project, see appendix 2 and 3. The authors of this paper were invited out to the event that Lindsey had organised and our observations are as follows.

**Case Study version 1**
In an attempt to change perceptions and increase the interest of girls in Design and Technology, various outside agencies related to engineering and technology had been invited to visit the school and work for the duration of one day on various activities with an all-
girl group of S2 pupils. The intention was to give the girls the chance to experience technology education without boys being present and to give them an intensive and continuous experience of what were considered to be activities which they would find interesting and engaging and which would alter their perceptions of both engineering and Design and Technology education. Observation of the group was made during the day by both authors of this paper and data collected by the class teacher relating to their perceptions of Design and Technology before and after the day’s activities.

17 girls, all from S2 had been selected to participate because of their perceived ability in Design and Technology. Although 30 girls had initially been identified and agreed to participation in the day’s events, 13 had, perhaps significantly, later opted to take the opportunity provided by the Home Economics Department to ice their Easter cakes!

The seventeen girls were seated at tables, mainly in pairs although there were some seated in groups of three. One girl sat at a table on her own.

Before the day’s activities, the girls were asked to produce drawings illustrating their perception of a scientist and an engineer. While four girls depicted the scientist as unambiguously female, only one depicted the engineer as female, with all others clearly depicted as male. Even in the case of the female depiction of an engineer, it is interesting to note that the figure drawn was not unambiguously female. The figure in the drawing had short hair and wore overalls, but was identified as female by the attachment to the drawing of a caption containing the pupil’s female teacher’s name. Almost all the scientists were depicted as wearing white coats and spectacles and holding, or surrounded by test-tubes. Engineers were depicted as wearing overalls, hard hats and holding a variety of tools including screwdrivers and wrenches. Engineers were perceived to fix machines (in particular cars) and while some of the girls identified them as ‘important,’ two girls stated explicitly that engineering was ‘not for them’ Thus engineering was clearly perceived as a male oriented preserve which involved using tools and getting dirty. It was clearly an unattractive and irrelevant option for this particular group of girls.

A short questionnaire was also given to the girls before and after the activities to determine whether these had any impact on their views of D & T. These findings are presented later in the paper.
The intervention

While the aim of the intervention was to make technology education more interesting and relevant to girls by involving outside agencies, it was clear from observation of the tasks that the necessary changes in pedagogy were not addressed. This was particularly evident from the first session.

The first task of the day was presented by SETPOINT which is a government sponsored agency set up to support technology education. The task was to make a “jitter bug” from a kit provided to the pupils. Along with the kit, pupils were given a carefully itemised list of step by step instructions. These instructions were reinforced orally by the (male) instructor who, along with an assistant and the class teacher, circulated among the pupils offering help and assistance with putting together the components. The class mainly worked at the same pace as the instructor took them stage by stage through the process. At times, those who finished a stage quickly were allowed to follow the next instruction for themselves. Although the task was intended to promote collaboration by presenting building as a team activity, all the pupils worked individually to produce their own jitter bug. Although pupils sitting beside each other would occasionally confer and help each other, approval was constantly sought from one of the adults that the correct procedure was being carried out.

The task involved cutting out a bug shape from a choice of four (this was the only part of the task which involved any element of choice) then fitting legs and a battery which when switched on caused the bug to vibrate. All pupils ended up with a bug that was identical in all aspects other than it’s ‘cover’

The pupils worked quietly and diligently, although without any obvious degree of enthusiasm. When the task was complete, there was little interest shown in the finished article.

At the end of the task, the pupils were asked only one question- what the artefact had in common with a mobile phone. The pupil who answered ‘correctly’ (ie both vibrated, was given a reward in the shape of a highlighter pen with different colours of highlighter) When pupils were asked if they had enjoyed the task, they were non committal. There was no attempt to either share learning intentions or to
establish what indeed had been learned by pupils in completing the task. It was not clear what the purpose of the task was. There was no element of design or creativity, nor was there any discussion of circuits or electricity.

Because the task had been completed more quickly than the instructors had anticipated, kits of plastic building materials were handed out. Pupils were given the instruction that they were to build a bridge, able to span a certain distance and hold the weight of a buggy. This task was clearly more novel and resulted in a much higher level of collaborative learning. This task appeared much more suitable for the age of the pupils involved but because it was used as a fill-in activity, there was insufficient time to test the bridges, which rather defeated the object of the exercise. Once again there was no attempt to share learning intentions or establish what had been learned. Although kits were distributed to ensure sharing, the girl who sat alone extracted pieces from the kit she was to share with others and built a bridge on her own. Others worked by trial and error, unsure whether appearance was more important than function. No discussion of structures took place.

The second task of the day, the was led by a leading construction company sponsored skills development project as part of the Construction Industry Training Board (CITB). This task required pupils to work collaboratively in groups of 4 to build a tower meeting certain specific criteria. Although the task came with a fairly detailed written remit, this remit was delivered orally to the pupils with only one sheet of the remit actually given out for reference while another sheet for supplying a drawing, and dimensions of the tower was also given out. All groups were given boxes with exactly the same amount of lego bricks comprising one base, 95 small black bricks, 95 larger grey bricks and 10 flat bricks of varying sizes. Each group was told that they were a company who had been asked to build a tower for a client, thus setting an authentic context for the task. A competitive element was also included in that the group who made the greatest profit would be the winner. Thus the emphasis was on the economic rather than the aesthetic aspects of design. The task was divided into a planning and construction phase. The planning phase consisted of trial and error building and rebuilding of the tower. The construction phase took part under controlled conditions in which the time taken to build the tower and the height of the tower was measured. Profits were calculated according to the height of the tower, the number of bricks used and the time taken to build the tower. No profit was made for towers under a metre high. Beyond this point, profit increased with the height of the tower. Profit diminished with the number of bricks being used with profits dropping with every brick beyond 100 used and profit also dropped for times beyond one
minute taken for construction. Groups therefore had to balance the various elements, to try to build the highest tower possible, with the smallest number of bricks in the shortest time. The structure also had to stand for long enough to be measured.

All groups were clearly engaged with the task and the degree of collaboration in this case was high. Time was taken at the planning stage, and various combinations of bricks were experimented with. There was a high level of engagement and persistence in the face of failure evident, both at the planning and construction stage. One group in particular, practiced their construction over and over again, despite the tower continually collapsing, in order to reduce the time taken for building.

One problem observed, however, was that once a group had devised a creative solution, other groups noticed this and quickly copied the idea. Although this is not necessarily a problem *per se* in terms of design, it is a pity that the group who first thought of the novel idea was not given extra credit for this. Significantly, the group who had the most creative ideas, and clearly resented being copied, started thinking right out of the box and came up finally with a completely original idea. They worked out that if they ignored the height and concentrated on using the smallest number of bricks and building the tower in the shortest time possible, then the profit lost in height would be largely compensated for by speed of construction and savings on materials. Bonuses and penalties which were outlined, were, however, not actually used. This would have changed the outcome. If the bonus provided for saving time, had been given, the strategy adopted by this group would have largely worked!

Again, although the task was designed to foster collaboration and team work (and in this it succeeded) there was no discussion of, or reflection on this. The theoretical underpinnings were not sufficiently thought out.

Although the task was also clearly intended to introduce pupils to potential careers in the construction industry, it failed in this respect. Although the presenter was a young female architect who highlighted the variety of careers which the area afforded, none of the pupils when given the opportunity to express an interest in a construction related career, did so. When questioned about their perceptions, one girl stated that these types of careers were much more interesting to boys. This reflected the responses of all pupils in the initial questionnaires.
The third task was presented by ‘Formula Schools’ – a title designed to conjure up formula one racing - an activity which is entirely male dominated (in terms of active participation at least)

Although the activity involved the construction of vehicles (eg remote controlled cars and boats, gravity racers etc) there was also, as with the tower building activity a strong emphasis on the cross cutting skills of collaboration and problem solving through team building and innovation

The questionnaires issued before and after the intervention were intended to identify any change in perceptions resulting from participation in the activities.

Before the intervention, 76% of the class regarded Design and Technology as ‘fun’. 6% did not think it was fun and 13% were undecided. After the intervention, the number regarding it as fun had risen to 89% with 11% still undecided, but no-one stating that it was not fun. Similarly perceptions of how exciting the subject was had generally risen with 56% considering it exciting before the activities and 75% considering exciting at the end of the day. Perceptions of the relation of engineering to Design and Technology education had also changed with 56% perceiving a connection between the two before the activities and 85% making the connection afterwards.

The activities also had some impact on how the girls preferred to learn. Although none stated a preference for working alone, after the activities a higher number stated a preference for working in groups rather than in pairs (although significantly, one girl worked alone on almost all activities) Confidence in working as part of a group in Design and Technology also increased from 62% to 82%. Perceptions of the importance of Design and Technology to future employment had also shown an increase with 41% considering it important at the end of the day, compared to 12% at the beginning.

Despite these evident changes in perceptions effected by the day’s activities, there was no increase in the number of girls who were considering taking the subject as an option in S3. Indeed the number who had decided not to take Design and Technology after the events had in fact risen slightly from 50% to 52% and those undecided had risen from 23% to 31%. 
Reflections
Although the activities could be in some respects be considered a success, they did not address the problem of making technology a more attractive option in the long term for girls. There were a number of problems that clearly have to be addressed in future phases of the UPDATE case studies.

Theoretical underpinnings/ pedagogy
One issue identified was the need to consider the theoretical assumptions underlying the type of pedagogy adopted in the various tasks. Although all the tasks presented were designed to be engaging and fun, there was little evidence of them being informed by a clear underlying theoretical framework. Little thought in any activity was given to what the learning intentions were to be. While the intention of the tower building was to promote team work, communication and problem solving, at no point was there any reflection on whether this was achieved, and if so, to what extent and by what means.

While the tower building task could be considered to have social constructivist underpinnings, in that it encouraged the girls to work together to solve problems with scaffolding provided by the instructor, the jitter- bug task used a total expert transmission model. Instructions given were prescriptive, the task was broken down into stages; the pupils were led through the task at the same pace, and there was an absence of agency or choice. The epistemological assumptions underlying this task, were, moreover, that there are right and wrong answers to problems and right and wrong ways to build. Helplessness in this particular task was further encouraged by the fact that the instructor did all the clearing up of surplus material while the girls sat passively.
In none of the tasks was it made clear how the nature of it enhanced the learning of girls. Although team work was encouraged, and achieved successfully in two of the tasks, the focus on competition led to a tendency for ‘team work’ to result in the development of an ‘assembly –line’ in the tower building activity.
Vocationalism
There was clearly a problem with the vocationalisation of education in general and of technology education in particular. The pupils were unable to make the connection between their enjoyment of and engagement in the activity and related careers in the area. They tended to have fixed but narrow perception of the types of careers which design and technology education can lead to. Although the pupils are not yet at the end of their second year of secondary education, they are already having to make important decisions about careers, which in turn impacts on choice of subjects. One girl, for example, wanted to be doctor. This meant that she would have to take the three science subjects which precluded her taking technology education. Another wanted to be a police officer and again there was a perception that certain subjects would be more suitable for this. Technology education was clearly associated with apprenticeships in plumbing, joinery, bricklaying and other industry related skills- areas which were perceived as much more suitable for boys.

Technological literacy
The tasks observed all comprised practical hands-on activities. Although problem solving and team work was encouraged, there was no discussion or consideration at any point of the technological impact on society of the building of bridges or of high tower blocks. Both activities lent themselves well to such reflection but the opportunity to introduce the concept of technological literacy was overlooked.

Gender issues
Although an argument can be made for having an all-girls technology class where there is greater likelihood of risk-taking and less likelihood of boys hogging equipment or making decisions without consultation or collaboration, when questioned, the girls expressed a preference for co-educational classes. It was not their perception that boys were more dominant. Indeed, they enjoyed the interaction with the boys and the opportunity to share ideas.

Conclusions
Several studies conducted by the European Union (e.g., Eurostar 2004, Implementation of “education & training 2010” work programme) demonstrate that women and girls are continuously dramatically underrepresented in science and technological education, areas, and jobs. This is highlighted in the Joint Interim Report “Education and Training 2010” by the European Commission under
domain of Maths, Science and Technology (MST). The joint report points out the persistent shortage of women in scientific and technical fields and calls on Member States to encourage the development of a scientific and technical culture among its citizens. In particular, action was recommended in order to motivate young people, especially girls, to undertake scientific and technical studies and careers. This is the task in hand that the UPDATE project has under consideration. It is evident, however, from both the literature and the workshop 4 UPDATE project, thus far, that gender stereotypes in schools retain a strong potency. Other research supports this view: Paechter, as recently as 2007, observes that schools as institutions offer countless opportunities for pupils to develop masculinities or femininities and these gender stereotypes are deeply rooted in the subject matter. Citing the Equal Opportunities Commission, Paechter (2007) highlights the fact that technology education as a vocational subject is conceived very much as a masculine working class domain. This, she argues, leads “young women overwhelmingly [to] opt for pathways that lead to poorly paid jobs with little possibility for advancement or the development of their skills, in contrast to young men, who tend to favour these courses leading to recognised trade qualifications with the potential for self employment and good rates of pay” (129). Murphy (2007), also writing in 2007, reports similar findings. She highlights the fact that pupil’s choice in the technology subjects follows gender stereotypes; a significant majority of boys elect to take the workshop based or electronically orientated subjects whereas a significant majority of girls elect to take food or textile orientated subjects. This is in exact contrast to the performance indicators in examination results. Statistically and paradoxically, more girls achieve higher grades in examination results in virtually all technology subject domains, it is not therefore a question about ability. Murphy observes that that these gendered roles in technology education offer us clues as to pedagogies that might be better employed in the delivery of the subject. In one set of observations (2007) she notes “When playing with construction kits young boys were observed to focus on making structures that moved whereas girls were more likely to use structures as part of their social play…Girls’ concern with the social context dominates their designs and they are more likely than boys to consider aesthetics and user needs” (245). Murphy (2007) offers us some bullet points that should be given serious attention, some of which are reproduced below:

- the assumptions we [teachers] hold about what girls and boys can do;
- what tasks are selected and how the relevance of what they offer pupils and their learning is made explicit [shared learning intentions];
- treating girls and boys as individuals and not homogeneous groups;
• what girls and boys bring to their [technology] lessons, i.e. their learned priorities and ways of working;
• the support needed for pupils to develop new learning habits;
• extending subjects to include a broader view of technological practices which embrace a wider future orientated conception of technological activity and careers.

Whilst these issues are extremely important in helping to redress the balance in terms of pedagogy, it is not possible to simply consider issues relating to gender in isolation of other overlapping issues such as class, values, pedagogy and technological assumptions to name but a few. In a recent research project, Dow (2006) found that student technology teachers emerged as holding on to the belief that technology education was still very much based upon skill mastery and was vocationally orientated. Dakers (2008) in his recent study and in concert with Dow’s findings, found that technology education classrooms continue to hold on doggedly to the types of learning spaces described above. Moreover, he found that teachers and student teachers saw their role as experts passing on prescribed skills linked to economic development. Given that technology education continues to be delivered as a trades based vocational subject, this will have a negative impact on girls take up of the subject. Moreover, other overlapping issues such as class, values, pedagogy and technological assumptions to name but a few must be taken into consideration. What appears to be emerging from our study, and from former studies, is that any explicit intentions or interventions such as those carried out in our preliminary investigations are appearing to be problematic. They seem, in our initial investigation, to be attempting to redress the imbalance in girls taking up technology education by attempting to give girls equality with the boys. This follows early feminist arguments that “focused upon the unfairness of the fact that women [are] excluded from some central activities crucial to humanity – the defining activities of modern political identity – which men appear to be granted by natural fiat” (Chanter, 2006: 8). However, postmodern thinking takes a different view. Chanter poses the question that if women are to be given equality with men, or boys in this case, then what boys are they to be equal with? Certainly not “oppressed, disenfranchised, or disadvantaged [ones]” (ibid: 8). Both Murphy (2006, 2007) and Paechter (1997, 2007) argue that technology education spaces in schools are not only masculine preserves but trades based vocationally orientated, working class, masculine preserves. Girls, we argue, do not want equality with boys in this domain.
Our future intentions, influenced from the work carried out thus far by all partners in UPDATE and from our reading of the literature, now leads us to reformulate the pedagogy by designing teacher continued professional development opportunities where, a partnership between us as researchers, teachers, schools and pupils will work together to design and implement new and more radical interventions in the delivery of technology education. These interventions will seek to adapt the subject matter already existing in schools, by incorporating a more critically orientated pedagogy that will serve to problematise conceptual issues appertaining to any given technology.

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CASE STUDY 2: FROM A TEACHER’S PERSPECTIVE

Project Perfume Project
Lynsey McNamee: St Mungo’s High School, Scotland, and Wendy Dow

I conducted this case study using a group of students in a Scottish comprehensive school. The class comprised nineteen pupils (10 male and 10 female). All pupils were aged 11-12 and had experienced 6 weeks of a common course within Technology education. The case study was conducted within the context of a period of significant change in Scottish education with the development of new policy, guidelines entitled ‘A Curriculum for Excellence’ (ACE) These represent a move away from an objectives based curriculum towards one which focuses on the processes of learning and the holistic development of all young people. There is an emphasis the establishment of cross-curricular working and ACE also promotes fundamental capacities that all pupils should develop before the completion of compulsory education. The Scottish Government is therefore asking for a change in teaching approach and this requires a cultural shift on the part of Scottish teachers.

Methodology
I used a variety of different methods of data collection. The main one was my close observation of the pupils. Triangulation was achieved by comparing my observations with those of the different teachers with whom I worked on the project across several curricular areas. I also used questionnaires to evaluate the perceptions of pupils before and after the intervention strategy. These were analysed to highlight the differences brought about by the intervention. Interviews and questionnaires were also used with the other teacher participants to establish how they thought and felt about the collaborative approach to learning involved. I also wanted to gain an appreciation of what the other teachers felt about technology education and whether their opinion of technology education had changed during the case study.
**Intervention Strategy**

The project that I designed for pupils to undertake was entitled ‘Project Perfume’ I felt that the use of alliteration would make the title memorable and that it would glamorise the project by echoing the titles of popular TV shows.

Project perfume asks pupils to design a fragrance for one another. The twist in the task is that they had to design the fragrance for the opposite sex, with girls designing a fragrance for boys and boys designing a fragrance for the girls. (It is important here to note the use of the word fragrance as it has no gender connotations and is equally accessible to both male and female pupils.) Pupils were given the brief of designing and manufacturing the fragrance, bottle, box and advertising for the fragrance.

Within the technology department pupils were divided into single sex groups and given an initial brief. This brief was open to the pupils’ own interpretation. They were given the freedom to make all their own decisions relating to the tasks. I divided the pupils randomly into single gender groups and each group then established what they needed to find out and how they were going to proceed. At this stage the type of knowledge development was lower order conceptual knowledge as pupils were making links between the different aspects of the subjects, establishing connections between these areas and thinking through the consequences of particular actions. Pupils were also using their knowledge of different fragrances and considering the ethical issues that using some fragrances might entail.

A critical aspect of the project was its promotion of collaboration with other subject specialists. This particular case study was designed to establish links between the Design Technology department, Science, Media Studies and Social Subjects. By doing this I hoped to demonstrate to pupils that school subjects do not operate in isolation and that life after school requires a complex mix of different types of knowledge and skills. This area is something that schools traditionally struggle with and I hope to be able to further expand on links developed in this case study and to establish further links with different subject areas in future projects.

In addition to working with different subject areas in the school, links were established with the University of Glasgow Chemistry Department. A lecturer from the Chemistry department came into the school to deliver a lesson to the class and to the teachers about how fragrances are created. This involved the declarative and procedural knowledge necessary for pupils to make informed decisions and
complete the tasks of producing their own fragrance successfully. As chemistry and fragrance creation were not areas of expertise of any of the teachers involved in the project, this had the effect of making teachers learners along with the pupils and a community of learners was established (Lave and Wegner 1991; Wegner 1998). The fact that the teachers were also learners in this situation led to an improved atmosphere in the class as pupils developed more responsibility from the confidence they experienced through having the same knowledge as their hitherto supposed ‘expert’ teachers. Pupils were observed to demonstrate a high degree of enthusiasm and motivation during this lesson and were clearly delighted to be involved in the project. The pupils were keen to use the knowledge gained and some of them subsequently conducted their own independent research without being directed by any of the teachers involved in the project. Pupils were also working with the teacher of social subjects, discovering more about the history of fragrances and why they were created and used. Interesting aspects of the social studies lesson echoed areas from the science input and this reinforced the pupils’ interest in the series of lessons. In social studies they also considered in greater depth the ethical issues relating to fragrance creation, thus engaging in higher-order conceptual knowledge development. Pupils were, moreover, able to bring their own prior knowledge to the subject, thus bridging the gap between the different types of knowledge and skills that the class teachers were attempting to develop.

Within the Design Technology department, pupils were given a very quick introduction to a software package, which is more commonly used with senior pupils. I wanted the pupils to explore the software themselves and to begin to apply the skills and qualities that were being developed in the research element of the project in order to learn more about the unique features of the software on their own. This was more successful with some pupils than others and it was interesting to watch the different reactions of the pupils in this situation. As they were used to prescriptive, expert-transmission modes of delivery, some clearly lacked confidence in the more constructivist type of teaching which I was attempting to promote.

After completing their own computer models of bottles for the fragrances, pupils then engaged in further research and evaluation by class mates of the opposite gender to comment on the developed ideas. This led to further refinement of the designs. Pupils were observed to be eager to seek the opinions and advice of other pupils. They also consulted me, less as a teacher and more as a woman consumer. Other members of the Design Technology department were also approached to seek their opinion as male consumers. This
marked a significant change from the pupils’ behaviour in previous projects where they had displayed a constant need for approval and made frequent requests for work to be checked.

With the bottles designed, initial fragrance recipes created and ideas for the boxes drawn, pupils were invited to Glasgow University to manufacture the actual fragrances. At this point pupils were clearly developing higher order conceptual thinking skills and making links to the other aspects of knowledge they already had - and establishing what was right and wrong for them.

Pupils’ personalities and attitudes were observed to change during the project and this was clearly evident at the university where they became more confident and assertive and displayed a maturity beyond their years. My role as expert teacher became unnecessary as pupils demonstrated sufficient confidence in the processes necessary to measure, mix, create their product and conduct research with their target market on their own. At this point we teachers again also took on the role of learners and designed and made fragrances for one another - a task which proved harder than it first appeared! We were again no longer needed in our traditional role as experts and were simply consulted on our opinions as consumers - male or female. Although as a teacher I admit that I found it hard to adjust to the feeling of no longer being the centre of the classroom, the intervention strategy highlighted how pupils’ learning approaches can be transformed with changes in pedagogy.

It is also hoped that the pupils will be able to link with the Department of Design, Manufacture and Engineering management, at the University of Strathclyde which has a rapid prototyping centre that will manufacture the prototype bottles designed by the pupils. It is intended to visit the rapid prototyping centre in the near future to allow pupils see their creations turned into professional and real products.

The media studies department within in the school also looked at the advertising of fragrances and how these are focussed across gender differences as males often buy fragrance for females and vice versa. At the time of writing, the focus of the media studies lessons was still being explored.
Reflections

I feel that in carrying out this project, the pupils and I both went on a journey. For me as a teacher, it was the journey of letting go of the constant need to control everything that was happening by rigid prescription and direction of pupils’ ideas and activities. Establishing that the pupils no longer needed me to make all the decisions for them and giving them the confidence to complete tasks on their own was a powerfully positive, but initially frightening experience. Although a more social constructivist model of teaching is being introduced into the Scottish curriculum it can be hard for us as teachers to adjust. Giving pupils greater control of, and responsibility for their own learning can be a hard concept for some teachers to embrace and working with my colleagues, problems and concerns did indeed arise. If the journey of the teacher was difficult one, an even more fundamental change occurred in the pupils, who had recently started secondary school and had limited experience of Design Technology. Pupils arrived at secondary school at the beginning of the year in need of constant reassurance that whatever they were doing was correct. I can clearly remember how pupils used to follow me around the class seeking reassurance about every aspect of their work. During the project, however, I observed marked changes in pupil approaches to learning. They consulted each other, reviewed their opinions and came up with solutions on their own. Instead of focussing on me as class teacher, and what I had to say, the pupils displayed a high level of independence and were happy to accept that I was no longer the expert in some areas of the situation. I feel that I created a class of pupils who were focussed on the goal and on devising their own strategies on how to achieve it. All pupils regardless of gender displayed a level of maturity beyond that expected for their age in all aspects of the project. There was a high level of motivation and engagement evident throughout.

The project was clearly defined from the outset as gender neutral, and I feel this is critical to its success. All pupils, regardless of gender, attempted the task with the same degree of enthusiasm. Both appeared equally engaged in the project and adopted very mature attitudes. It was clear that both genders gained a great deal of independence and confidence as learners from being encouraged to make decisions themselves.

The traditional mode of delivery across the curriculum in Scotland is expert led, and very prescriptive in nature. Some pupils initially found it very hard to adapt to having the flexibility to use the software in any way they wanted. Initially I looked for a gender link in this problem but could not establish one as the number of pupils in this category was small and comprised both genders. Interestingly,
however, I found that these were the same pupils who needed most reassurance during more traditional methods of delivery. Lack of confidence seemed to be the main issue facing these pupils and over the course of the project this eased as the pupils gradually became more independent and in control of their own learning.

All the other teachers involved also noted an increase in motivation of all pupils, regardless of gender and they were surprised at the level of enthusiasm and involvement in the different aspects of the project. The other teachers also observed that pupils were keen to share information gained across the various subject areas, thus making important conceptual connections.

**Conclusions**

All pupils displayed a very high level of maturity during the project and constantly proved that they are more than capable of achieving very high quality work. Pupils became responsible for their own learning and took on responsibilities within the group.

Working across four different subjects and with different organisations helped pupils to understand the broader themes of both science and technology education, and how other areas of life also relate to these subjects. By giving the project a real-world context pupils were more engaged and worked harder to produce an outcome they were proud off, and not just for my approval. By linking subjects, pupils experienced a greater depth and breadth of knowledge of the topic. These both enhanced their learning experience and fulfilled the criteria of ACE.

The intervention strategy showed that -although girls and boys may sometimes learn differently and tackle tasks in different ways, all were equally invested in the process.

The results of observation and pupil responses have demonstrated how important changes can be achieved with changes in strategy and pedagogy. The intervention strategy suggests that perhaps by removing the historical links that technology education has to trade based careers, both girls and boys can become more engaged. Because pupils can see links to real life contexts, technology education becomes more relevant to every member of the learning community.
Hottie:
A fragrance for girls designed by boys
Illustration by:
Cactus Creative Consultants Ltd
Web:http://www.cactushq.com
Frrresh:
A fragrance for boys designed by girls
Illustration by:
Cactus Creative Consultants Ltd
Web:http://www.cactushq.com
CASE STUDY 3: FROM A TEACHER’S PERSPECTIVE

A Community Project
Nerys Hughes: Blackwood Primary School, South Wales, and Wendy Dow

The following case study was carried out with a class of pupils in a Welsh primary school. The pupils had had not previous experience of technology education. I had been appointed to the school as Depute Head teacher and part of my remit was to develop the technology curriculum within the school.

Methodology
The principle means of data collection was by observation. Pupils were observed when working on the project and a note made of any comment. Triangulation was achieved by interviewing a student teacher and a teaching assistant who were also present in the class when the project was being carried out. After the project, pupils were interviewed to determine what their perceptions of technology were and to determine any influences of gender.

The Project
The project was designed to be interesting and motivating for both genders. This was achieved by setting the project within a real life context that I hoped would be meaningful to all pupils regardless of gender. Throughout the project, I used a range of different pedagogies designed to promote different types of knowledge development. In particular, a social constructivist pedagogy was introduced which was designed to give pupils greater control of their own learning and to facilitate the development of lower and higher order conceptual thinking. Although declarative and procedural knowledge were both essential in technology education, they tend to be the predominant model and I hoped to increase both motivation and knowledge development in both genders by moving beyond these.
The project began with an email that had ostensibly been sent by Mr Park, an architect from Caerphilly County Council requesting the help of our children. It stated that some money had been put aside to further develop Blackwood community (the real community where the children live) Mr Park informed them that he was interested in what they felt would improve the community for all its users.

We began by brainstorming what a community meant. By doing this, I meant to build upon the pupils’ prior learning and the focus at this stage was on declarative knowledge only. I was, however, very surprised to find that none of the children could describe for me what a community was. I therefore used this as an opportunity, not to provide what I felt was the right answer but to introduce reflection and discussion, thus introducing lower order conceptual knowledge to the task. I therefore recorded all the children’s ideas of what it might be and they reflected upon one another’s answers. Once a shared understanding of the concept of community had been reached, the children were asked to discuss what they felt a community needed and what people might need from their community. By this process, higher order conceptual knowledge was introduced as pupils reflected on various possibilities and engaged critically with the different ideas which were presented.

I believed that active engagement in the process increased motivation in both genders. To further develop this, I arranged for the class to take an urban walk around the community, during which they took a note of the various shops and facilities in their local area. A homework task was then given for the children to follow this up at home with their parents. They were asked to walk through their town noting all the facilities and consider who might use them. When this information had been gathered, they were asked in class to consider what they felt was missing from their community and if they were to be given the power to re-design it what would they include. At first the children were hesitant with answers. I told them to put on their Edward de Bono Green Hat (which is their creative hat) and to think of exciting facilities with no limits that residents of the community would benefit from. At this point I put them in small groups to discuss ideas before presenting their ideas back to class. This inspired and motivated the children and their ideas became very creative. It was at this stage I noticed a difference in gender issues. The boys were very much focused on football stadiums, rugby clubs, and skateboard ramps, a graffiti wall. The girls were suggesting dance studios, hairdressers, a beauty parlour, and ice cream shops. This bought us to a discussion about the needs of the community as a whole. We held a discussion about what they felt the people in the community needed. What would make it a better community? They were asked to consider the bigger picture, one that went beyond their personal
wishes. Again discussion and critical reflection was used to develop higher order conceptual knowledge as pupils considered the needs of particular groups and addressed potential conflicts of interests. All groups then presented their final ideas to the rest of the class. In order to address individual differences and introduce an element of choice and autonomy, groups decided for themselves how to present their final ideas. Some chose to talk, some just to hold up mind maps of their ideas on large sheets of paper and some chose to do a PowerPoint presentation. While completing this task, a high degree of engagement and collaboration was observed.

I was interested to note that when I first told the children to form groups of 3 to 4, they all opted for single sex groups. I tried therefore throughout the project to encourage mixed gender groups so that ideas are varied. We have since had conversations as to why they choose single gender groups when given a choice. These conversations are hopefully helping them to address gender stereotypes which are clearly well embedded from an early age.

I then asked them what resources they felt they wanted to make a model of their ideal community? They went through catalogues and noted ideas down. I could see that they had never been given opportunity to plan ahead and make choices like this before and needed support and questioning to make them think ahead. Social constructivist pedagogy highlights the importance of providing scaffolding, and this was achieved by tailoring the support I gave to the individual groups whilst also encouraging them to support each other in the process. They were clearly so excited at this stage about what was going to be made and therefore initially found it difficult to think about HOW they were going to do it. I observed, however, that the girls in general appeared to be more systematic in their approach to this part of the task. They could see what materials would be needed and were talking about how hey could make, for example, a bridge and water. I just sat and listened to the groups and observed them closely at this stage. The were asking so many questions of each other and coming up with so many different ideas of how to do things and where to put items. Overall the boys were focussed on, for example, where the football pitch should go and that it should not be too far from the housing estate, but little attention was paid to the materials they would need to make it and how it would be constructed. Interestingly, the focus of the boys seemed to be more on lower-order conceptual knowledge, while the girls were more clearly focused on procedural knowledge. As both types of knowledge development were necessary for the project, I encouraged groups to engage with both. The children also used laptops and an ICT package called SPEX to design their community. This allowed them to do a virtual tour and to go inside buildings etc. From this they transferred their ideas onto A1.
I gave the children the choice of how they would like to make the community - one large class one with everyone contributing with each group focusing on one particular area and then putting it together as one, or smalls groups each making their own community. They were given time to discuss what they wanted and they decided to make a community in their groups. Again, motivation was clearly greatly enhanced by giving pupils opportunities to discuss the issues and come up with their own decisions. The children were absolutely buzzing at this stage, they were clearly so excited about doing what they had decided. Comments were heard such as "Can we really do what we want? Can we really include anything that we want?" Creative ideas were now coming thick and fast. I have actually never seen children who were so excited and so fired up about any project. I believe this was probably because they were in control of their learning and they were guiding where they wanted it to go. I also believe that they thought the email from Mr Park was real, so it put things into a meaningful and authentic context. The boys at this stage were slightly more excited and were talking louder, faster and in a higher pitch. One boy was actually flapping his arms with excitement as he was telling me his ideas. When I asked if he was enjoying the project his response was "Enjoying it? This is the best day of my life? I can't wait to make it. Mine is going to be so cool." The children wanted to stay in school at playtime and lunchtime to work on their projects. That proved to me exactly how motivated and inspired they were.

We used a block of time to develop the project. During this time I had a student teacher and teaching assistant in the classroom alongside me and we worked collaboratively to provide support to groups as needed. The children were incredibly focused in their teams and it was noted that there was not one cross word or falling out, which for my class was particularly impressive! Working in groups is something that the children generally find particularly challenging and something I had been aware. All resources were laid out on a table and they were told to be independent in collecting resources. I took a group to teach them the control technology skills using the Flow Go and clown. The children then taught another group these skills, whilst I worked with a group helping them make a net of a house. Thus while the focus was on procedural knowledge development, I was developing the notion that it is not simply a case of the teacher as expert demonstrating and transmitting skills but that pupils can also support each other in their knowledge development.

The project was also, at least to some extent, cross-curricular. In Science we studied electricity and I was delighted to see a group of boys apply the skills learned in science to make a set of traffic lights. Interestingly during this task, I observed, that even though they were in
mixed gender groups, two boys from each group had formed a separate sub-group. I just observed what was happening rather than ask why they had left their original group at this stage. It turned out that they had in fact delegated each other tasks after overhearing conversations with another group, where both wanted to make traffic lights. They had decided that they should get together to solve the problem and then go back to their original group to share ideas. They then taught the rest of the group. At one point as I stood back and observed the class I realised that no one needed me and I felt quite redundant! Every individual was on task and the children were really working together in groups. Talking and interaction was superb. It made me feel very proud and quite emotional!!

It is also pleasing to note that the children made some community models at home and brought them into school. It was lovely to see parents and children working on practical tasks together.

**Reflection**
This experience has really shown to me that you have to have the confidence to allow children to tell you what they want to learn about. Listening to learners allows their voice to be heard. I have learnt from this for a future project involving technology, I have asked the children to come up with some ideas and tell me what they want to learn and what tasks they want to do and how. I sent a note home for them to complete. I will then include their ideas in my planning.

When we have completed the current project I will question the children and interview them on their learning styles and how they worked in groups etc. It will be very interesting to see the views of girls and boys on this task. What I have found, however, is that although differences in approach between boys and girls sometimes emerged, it is not so much a case of finding a topic that is gender relevant that matters, it is how the knowledge, skills and procedures are taught. By changing my pedagogy and by considering different types of knowledge development, I feel that it has been possible to motivate and engage and therefore increase the interest of both girls and boys in technology education in my classroom.
CASE STUDY 4: GOOD PRACTICE FROM GERMANY

Course for Primary School Children about Renewable Energy

Dr. Martina Endepohls-Ulpe; Janine Stahl-von Zabern; Judith Ebach

In collaboration with Tatiana Herda-Munoz and Imme Schwenteit

University of Koblenz-Landau, Campus Koblenz

In the course of the EU UPDATE Project several pilot projects were planned and evaluated as Good-Practice-Examples for teaching science and technology. This was also done at the University of Koblenz – Department of Psychology. This article refers to the course “Renewable Energy” for primary school children.

The theme was chosen because the field of renewable energy is especially interesting to girls. Predominantly they have a positive attitude towards nature or biology. Thus, there is a very good starting point for acquiring knowledge and for an abiding interest in science and technology. The thematic implementation is a very playful one with experiments, appealing demonstration materials and many practical elements. This ensures a child-oriented approach. The children are free to practice actively during the sessions.
The topic also permits the presentation of a broad spectrum of subtopics from science and technology. The pupils get the possibility to construct things on their own and to work with tools and materials. They gain knowledge about forms of renewable energy through the course, e.g. wind and solar energy.

The concept about renewable energy for primary school children encompasses six units of each one lesson = 50 minutes. 10 children at the age of 8-9 years participated at the testing of the course. Female mentors from the Ada-Lovelace-Project, students of the field of “ecological impact assessment”, supported the concept development and led through the lessons. The project was carried out at the primary school of Plaidt in the Greater Koblenz area.

**Description of the course:**
The description is subdivided into the explanation of the aims of each session, a specific instruction for the procedure (Phase of the project, Content, Material, Method and Length) as well as an introduction to the respective topic.

**Structure of the course:**
Unit 1: Renewable energy
Unit 2: Conserving energy
Unit 3: Wind
Unit 4: Sun
Unit 5: Solar energy (here the children can e.g. construct a mini solar panel on their own)
Unit 6: Certificate of energy conserving & finalization
**Unit 1: ‘Renewable energy’**

**Aim:**
The children are to learn how to differentiate between various forms of energy. In particular they should realise the difference between regenerative and non-regenerative energy.

<table>
<thead>
<tr>
<th>Phase of the project</th>
<th>Contents</th>
<th>Material</th>
<th>Method</th>
<th>Length [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Introduction of participants / Game to get to know each other / Explanation of the upcoming topics</td>
<td>-</td>
<td>Circle time</td>
<td>~10</td>
</tr>
<tr>
<td><strong>Introduction to the topic ‘energy’</strong></td>
<td>Mindmap at the blackboard on the topic of energy (differentiation of regenerative and non-regenerative)</td>
<td>Chalk, Blackboard</td>
<td>Group discussion</td>
<td>~10</td>
</tr>
</tbody>
</table>
### Introduction to the topic ‘renewable energy’

At first the children are introduced to the field of natural science, e.g. mathematics, biology and physics. The leaders of the project teams create a mindmap at the blackboard and the children mention terms referring to ‘energy’. Besides, the question is answered why renewable energy is called ‘renewable’:

- **Forms of renewable energy** are sustainable forms of energy which are constantly available. Non-renewable forms of energy are only available for a limited time, e.g. kerosene.
Later on the children are divided into groups and get pictures of conventional and regenerative energy. They discuss about a classification within the group. The evaluation follows at the blackboard.

The children get ‘explorer’s folders’ to file their worksheets and materials in order to document the project and compile some sort of reference work. Afterwards each child can design their own cover page for the explorer’s folder.

**Unit 2: ‘Conserving energy’**

**Aim:**

After the children have learned what forms of energy there are, the aim of this unit is now to show them “WHY” we urgently need renewable energy and how we can conserve it.
<table>
<thead>
<tr>
<th>Phase of the project</th>
<th>Contents</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Repetition of the last session</td>
<td>-</td>
<td>Group discussion</td>
<td>~5</td>
</tr>
<tr>
<td>Introduction to the topic</td>
<td>Why do we need renewable energy?</td>
<td>Worksheet 'Why do we actually need renewable energy?'</td>
<td>First working in small groups, afterwards evaluation within the group</td>
<td>~15</td>
</tr>
<tr>
<td>‘Conserving energy’</td>
<td></td>
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</tr>
<tr>
<td>Getting practice with the</td>
<td>Gathering ideas on how to conserve energy</td>
<td>Blackboard</td>
<td>Group discussion</td>
<td>~10</td>
</tr>
<tr>
<td>topic ‘Conserving energy’</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Material</td>
<td>Filling in the energy conserver's licence and filing it into the explorer's folder</td>
<td>Copies / Energy conserver's licence / Explorer's folder</td>
<td>Individual work</td>
<td>~15</td>
</tr>
<tr>
<td>Reflection</td>
<td>Filling in a questionnaire / Parting</td>
<td>Questionnaire</td>
<td>Individual work</td>
<td>~5</td>
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</tbody>
</table>
Introduction to the topic ‘Conserving energy’:
The children name ideas and suggestions of how and where to conserve energy in their everyday lives. These ideas are listed at the blackboard.
- Switch off the standby mode
- Put lids on pots
- Always switch off the lights
- Don’t shower for too long
- Use the bike more often
- Energy saving lamps
- Turn down the heating, wear a pullover
- Use as little warm water as possible …

Afterwards the children design an ‘energy conserver’s licence’. The list at the blackboard is recorded into this certificate. Whenever a child conserves energy or influences someone to conserve energy according to this list, they get a tick mark at the corresponding activity. The ‘Master of Energy Conserving’ is elected at the end. This competition is to motivate the children to deal with the topic of energy conserving even ‘outside’ the project.

Unit 3: ‘Wind’

Aim:
This unit is to give the children a basic understanding of the topic ‘wind’. In particular they should understand the physical process of how wind picks up, which is explained in the form of an experiment. Furthermore the topic of ‘wind energy’ is presented in this unit.
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<td>-</td>
<td>Group discussion</td>
<td>~5</td>
</tr>
<tr>
<td>Introduction to the topic ‘Wind’</td>
<td>Wind as a source of energy, What is wind? How does wind pick up?</td>
<td>-</td>
<td>Group discussion</td>
<td>~10</td>
</tr>
<tr>
<td>Getting practice with the topic ‘Wind’</td>
<td>Experiment with a candle</td>
<td>Candles, Lighters</td>
<td>Group discussion with a mentor</td>
<td>~15- 20</td>
</tr>
<tr>
<td>Material</td>
<td>What is a protocol? Creating an experiment report which is filed away into the explorer’s folder</td>
<td>Protocol / Explorer’s folders</td>
<td>Individual work</td>
<td>~10</td>
</tr>
<tr>
<td>Reflection</td>
<td>Filling in a questionnaire, Parting</td>
<td>Questionnaire</td>
<td>Individual work</td>
<td>~5</td>
</tr>
</tbody>
</table>
Introduction to the topic ‘wind’

Group discussion:
- Where is wind used as a source of energy? In former times? Nowadays?
  = In former times wind was used in mills for grinding, but even more often in shipping. Nowadays wind energy is obtained through windmills and sometimes through tidal power plants.
- What is wind? = Wind is a directed rather strong motion of the air.
- How does it happen? = The physical process is one of altitude compensation between a high pressure area and a low pressure area. Parcels of the air from the area with a higher pressure flow into the area with lower pressure. Thereby, a mass flow is created, which means a stronger motion of the air.
  For the children it will be easier to understand this process through the following experiment.

Deepening:

Experiment with a candle: All the children sit around a table. Eight to ten candles are arranged in a circle and are lit. The children are to describe their observations. In doing so they may hold their hands over the candles and tell what they feel.

Observation: All the flames point to the middle of the circle and there is an upward motion of the air.

Discussion: Why is that so?
= The air close to the flames is getting lighter and rises. A vacuum is formed, which is immediately filled by following colder air. This colder air again gets warmer and then rises. Thus, an air circuit and a motion of the air are created.

Challenge: Why do hot-air balloons soar? The children should realise here that hot air rises.
Unit 4: ‘Sun’

Aim:
The aim of this unit is to convey the idea what the sun is and what it can ‘accomplish’.

<table>
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<tbody>
<tr>
<td>Introduction</td>
<td>Repetition of the last session</td>
<td>-</td>
<td>Group discussion</td>
<td>~5</td>
</tr>
<tr>
<td>Introduction to the topic ‘Sun’</td>
<td>Basic information about the sun: What is the sun? What does it consist of? How hot is it? How big and how old is it?</td>
<td>-</td>
<td>Group discussion</td>
<td>~15</td>
</tr>
<tr>
<td>Getting practice with the topic ‘Sun’</td>
<td>The relations of ‘distance’ and ‘size’ of sun-moon-earth are drawn in the schoolyard</td>
<td>Chalk</td>
<td>Group work</td>
<td>~20</td>
</tr>
<tr>
<td>Material</td>
<td>Sun quiz (if necessary to be done at home through internet)</td>
<td>Worksheet ‘Sun quiz’ / Explorer’s folders</td>
<td>Individual work</td>
<td>~5</td>
</tr>
<tr>
<td>Reflection</td>
<td>Filling in a questionnaire, Parting</td>
<td>Questionnaire</td>
<td>Individual work</td>
<td>~5</td>
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</table>

Introduction to the topic ‘sun’

- Basics about the sun:
  - **What is the sun?** What does consist of? = *The sun is a star / it is a ‘ball of gas’ – it consists of the gases helium, hydrogen, and to small amounts also of heavy elements (metals). This means that we would actually ‘fall through the sun’ if we could walk on it.*
  - **How hot is it?** = *The temperature at the outer parts is 5527°C (9980.6°F), at the inner parts it is 15,599,726°C (28,033,977°F).*
  - **How big is it?** = *The diameter of the sun is 1,000,000 km (621,388,181,19679 miles). It is 109 times bigger than the earth, the earth would fit 1,000,000 times into the sun. The mass of the sun constitutes 98% of our solar system. On the sun you would weigh 28 times more than on earth.*
  - **How far away is it?** = *The sun is 150 million km (93,208 miles) away from the earth. If you could fly to the sun with a jet you would need 10 years. Light takes 8 minutes from the sun to the earth.*

Deepening:
The children are divided into the groups ‘sun’, ‘moon’ and ‘earth’ in the schoolyard. Each group is to draw with chalk in the schoolyard how the size and distance of the respective stars and planets relate to each other.
Afterwards they get the solution of the correct distance of ‘sun-moon-earth’ and their respective sizes.

= *The sun is 40 m (131.24 feet) away from the earth, the distance between the earth and the moon is 10 cm (3.94 inches). If the sun had a diameter of one metre, the diameter of the earth would be 0.9 cm (0.354 inches) and the moon could not be outlined with chalk anymore.*
Unit 5: ‘Solar energy’

Aim:
At first the children are to understand how much energy the sun could provide. Furthermore the topic of ‘solar panels’ is dealt with. Due to the complexity of a solar panel it is introduced only rudimentarily. Also the children are to find out where solar panels can be found in everyday life.

<table>
<thead>
<tr>
<th>Phase of the project</th>
<th>Contents</th>
<th>Material</th>
<th>Method</th>
<th>Length [min]</th>
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</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>How to do research? &gt;worksheet</td>
<td>Worksheet</td>
<td>Group discussion</td>
<td>~5</td>
</tr>
<tr>
<td>Introduction to the topic ‘Solar energy’</td>
<td>Basic information about the sun as a source of energy: How much energy does the sun have? What is a solar panel? Where is it used?</td>
<td>-</td>
<td>Group discussion</td>
<td>~10</td>
</tr>
<tr>
<td>Getting practice with the topic ‘Solar’</td>
<td>Functioning of a solar panel</td>
<td>Blackboard, chalk</td>
<td>Short presentation of the mentors</td>
<td>~5</td>
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<td>energy’</td>
<td>Material</td>
<td>Reflection</td>
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<tr>
<td><strong>Material</strong></td>
<td>Constructing a solar panel with a mini fan, testing it together in the schoolyard</td>
<td>Filling in a questionnaire, Parting</td>
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<tr>
<td></td>
<td>Solar panel (set with construction manual), pliers / explorer’s folders</td>
<td>Questionnaire</td>
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<td></td>
<td>Working in small groups</td>
<td>Individual work</td>
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<td>~25</td>
<td>~5</td>
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**Introduction to the topic ‘solar energy’**

- **How much energy does the sun have?** = The sun has a radiation intensity of 62,000 kilowatt per cm². That is the power of about 1,000,000 light bulbs. Only a fraction of this energy arrives at the earth, yet even this fraction is 80 times more than what humanity can even use.
- **What is a solar panel?** = It is a device with which you can utilize solar energy.
- **Where are they used?** = In calculators, on roofs, with parking meters, garden lights, ... 

**Deepening:**

Explaning the functioning of a solar panel at the blackboard = A solar panel works like a small greenhouse. The dark surface collects as many rays of light as possible. These are reflected on the panel, but are then ‘trapped inside’ and don’t get out anymore. The collected energy is conveyed to a heat transfer fluid in pipes. This fluid transports the heat energy to a reservoir.

Afterwards the children get an assembly set for a mini solar plant, which is constructed in small groups according to the construction manual and is tested later on.
Unit 6: Finalization and ‘Energy conserver’s licence’
Aim:
The aim of the last unit is on the one hand to repeat all the subjects and to prepare an overview on the topics. On the other hand the children (especially the girls) are to realise that all of this is about natural science, in particular about mathematics and physics. It would be interesting to have a short talk about possible new career aspirations or interests.

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<tr>
<th>Phase of the project</th>
<th>Contents</th>
<th>Material</th>
<th>Sozialform/Methoden</th>
<th>Length [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Summary of the project: What kind of renewable energy is there? Why do we need it? Where can we conserve energy? Were you interested in these topics?</td>
<td>-</td>
<td>Group discussion</td>
<td>~10</td>
</tr>
<tr>
<td>Evaluation of the ‘energy conserver’s licence’</td>
<td>The children report how they felt with the project of</td>
<td>-</td>
<td>Group discussion</td>
<td>~10</td>
</tr>
</tbody>
</table>
Finalization

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<tr>
<th>Finalization</th>
<th>The ‘Master of Conserving Energy’ is elected, the licences are handed out</th>
<th>Certificate / Explorer’s folder</th>
<th>Group discussion</th>
<th>~20</th>
</tr>
</thead>
</table>

Reflection

| Reflection   | Filling in a questionnaire, Parting                                  | Questionnaire                   | Individual work | ~10 |

**Evaluation of the ‘energy conserving licence’:**
Discussion: How did you conserve energy? / How did your parents, friends and relatives react?

**Finalization:**
A ‘Master of Conserving Energy’ is elected – All the children receive licences for conserving energy. The children may take their explorer’s folders home with them.
Conclusion and discussion:

The following criteria lead to success in all of our projects:

- High practical relevance and opportunity to active cooperation
- Motivation by a sense of achievement
- Working in small groups and/or with a partner
- Child-oriented and appealing selection of materials
- Flexible adaptation of the level of demands; differentiation
- In order to motivate the girls: positive role models via female mentors

- High practical relevance and active collaboration
  Due to the playful and very practical-oriented approach, the knowledge transfer is combined with a lot of fun. Technology education according to this concept is exciting, is organised playfully and offers the children the possibility to practice actively. This furthers motivation and pleasure in dealing with technology. Especially when the concentration of the children is getting less it is essential to enlarge the practical part and to quickly offer the children the possibility to work practically. In such instances the concept should be adapted flexibly to the preconditions and the capabilities of the group.

- Motivation by a sense of achievement
  The tasks allow for the children to get positive results within short periods of time, which enhances their self-confidence concerning their technical abilities.
  Since at the end of the courses the children got a certificate (Master of energy conserving) they were very proud of their their results.

- Working in small groups and/or with a partner
All courses are held in small groups. This guarantees a close collaboration between partners and within the group, as well as an effective communication. The method of group and partner work corresponds especially to the preferred method of girls. This contributes to motivate the female participants for the course.

- **Child-oriented and appealing selection of materials**
  All the materials are designed specifically for children and relate to their field of experience. The playful and practical implementation ensures a child-orientated approach. Furthermore life-oriented themes are chosen which correspond to the experience of children.

- **Flexible adaptation of the level of demands; differentiation**
  The concept can be adapted flexibly to the needs and background knowledge of the participants.

- **In order to motivate the girls: positive role models via female mentors**
The selection of the topics is equally appealing to boys and girls. The course is meant to especially attract girls to technical topics and to get them excited about science and technology. This is ensured through female mentors, which serve as positive role models, and through the selection of the right topics and material. Also the selected method of group work corresponds to the preferences of girls. This helps to motivate the female participants.

**Evaluation according to UPDATE criteria:**

- **Supporting positive attitudes towards technology / experiences / sense of success and accomplishment, strengthening of self-esteem, empowerment**
- With this course the pupils learn the basics about renewable energy. The thematic implementation is ensured through a playful approach with experiments and practical elements, which enable the children to participate actively during the sessions. The participants have a lot
of fun during the project. The materials used are designed in a child-oriented and appealing way. The children can e.g. construct a mini solar panel independently and keep it. The opportunity of actively doing something motivates the participants and they are elated at the results and accomplishments of the things they have worked out or created on their own. This sense of achievement promotes a positive attitude towards natural scientific topics. The little competition of conserving energy also motivates the children to deal with this topic in their everyday lives. After they have completed the project they receive a certificate, which attests their successful conserving of energy.

• **Promoting knowledge and understanding**
  • The participants of the course gain knowledge about regenerative and non-regenerative forms of energy. Here they learn how to differentiate both forms of energy and they get more detailed information on wind and solar energy. This happens by means of experiments and child-oriented visual aids, e.g. a mini solar panel. In addition, the children get information on the possibilities of conserving energy. The topics are deepened through a repetition of all the subjects in the last session.

• **Promoting equality through a differentiation of the tasks**
  • The course is geared towards children of the third and fourth grade. Due to varying levels of background knowledge the concept can be differentiated and adapted flexibly to the needs and knowledge of the participants. The concept particularly wants to appeal to girls and get them excited about technical and natural scientific topics. This is ensured on the one hand through female mentors who serve as positive role models, and on the other hand through appealing topics and materials. Moreover, during the project the children work primarily in groups. This method complies especially with the achievement motivation of girls (cf. Alfermann, 1996).

• **Collaboration and communication**
  • The thematic implementation happens primarily during group work. Short group-dynamic exercises can be carried out as needed to strengthen the cooperation and the community spirit of the group and to create a positive working atmosphere. The selected method of group work corresponds especially to the preferences of girls. This helps to motivate the female participants for the course contents.
Evaluation through observation sheets:
After each session the mentors in charge reflected on the results of the lesson with the help of an observation form (cf. the observation sheet for projects in primary schools). Unusual events, difficulties, gender-specific aspects and the overall happenings of the group are documented in this form.

A fundamental experience in the project was that the limit of 50 minutes per unit was too short to deal with the forms of energy more detailed or to deal with further regenerative forms, such as hydropower. Therefore, if it is possible, time should be lengthened in future courses.

The selection of topics was equally appealing to boys and girls. The girls, however, were a little more reluctant with their contributions. The boys had partly more prior knowledge about the subject matters, e.g. from children’s books that they had read in their leisure time. An option of differentiation could be to divide the boys and girls in the respective introductions to these topics. Thus, the mentors could react better to the knowledge of the children and not either expect too much or leave the children unchallenged.

Group work has proven to be of an advantage. The cooperation was in mixed groups as well as in same-sex groups.

The children were especially excited during practical activities. Here, they enjoyed in particular the construction of the mini solar panel. Through actively doing something all the children got excited about participating. The concept contains a balanced ratio of theory and practice, which corresponds well to the level of requirement of that age group.

Feedback from the children:

The children were also asked about their opinion at the end of each session (cf. The children’s questionnaire). Here, one can summarize the following results:
According to the answers of the children they learned a lot during the course, especially about the topics wind and solar energy and about conserving energy. Through the competition of the ‘Master of Conserving Energy’ with the ‘energy conserver’s licence’ the children were highly motivated to find ways of conserving energy at home. Thereby they fully realised the necessity and possibilities of conserving energy.

The children found the materials and visual presentations of the topics (e.g. pictures showing different forms of energy) very appealing. In the same way they liked designing and creating their explorer’s folder, which can serve as some sort of reference work. They especially enjoyed the practical parts of the sessions, e.g. constructing the mini solar panel.

References:

http://www.ellmitron.de/shop/index.htm


Material – Mini-Solar-Panel:
Ellmitron, Lehrmittel und Bücher, D-75334 Straubing, Im Eck 12/2, Telefon (07082) 793307 / info@ellmitron.de / www.ellmitron.de (= Bausatz für Mini-Solaranlagen - Lernprogramm Teil 7 / 10-821)
Worksheets:

1. Why do we actually need renewable energy?
2. Experiment report circle of candles
3. Quiz about the sun
4. What have you learned in this project?
5. Certificate

Evaluation instruments:

1. Observation sheet
2. Children’s questionnaire
Evaluation: Children’s questionnaire

Date:______________

Hello dear pupils,
We would like to know what the course was like for you. In order to find this out we would like to ask you to tick each question according to your opinion.

Thank you for participating!

1. Are you a girl ______ or a boy ______?
   Please tick whether you’re a girl or a boy
2. How old are you? _______years
   Please enter your age

3. How did you like the course?

<table>
<thead>
<tr>
<th>Very much</th>
<th>Medium</th>
<th>Not so much</th>
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<tbody>
<tr>
<td>🤩</td>
<td>😐</td>
<td>😞</td>
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</tbody>
</table>

   Please tick your opinion

4. Was there anything specific you enjoyed very much? 😊

_____________________________________________________

Please write down your opinion
5. Was there anything specific that you did not like at all?

Please write down your opinion

6. Did you enjoy working today?

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<tbody>
<tr>
<td>Yes</td>
<td>Medium</td>
<td>No</td>
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</table>

Please tick your opinion
7. Did you learn anything new today?
   Please tick your opinion

   Yes □       No □

   If yes, what was it?? Please write down what you have learned that was new to you

8. Was the course easy or difficult for you?

<table>
<thead>
<tr>
<th>Too easy</th>
<th>Just right</th>
<th>Too difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>😮</td>
<td>😊</td>
<td>🙁</td>
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</table>

   Please tick your opinion
9. What was it like to work together with the others?

<table>
<thead>
<tr>
<th>Good</th>
<th>Medium</th>
<th>Not good</th>
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</thead>
</table>

Please tick your opinion

Thank you once again for your cooperation
Observation sheets for projects

GENERAL QUESTIONS:

1. Date of the session:
2. Topic of the session:
3. Number of participating children: female _________ male _________
4. Chosen methods:
5. Were there any problems today? If yes, which ones and what could be done to avoid them / improve the concept?
6. Were girls and boys involved in equal measure? If no, for what areas not and why was this the case?
7. Were the contents equally appealing to boys and girls? If no, which ones were not and why was this the case?
8. Did the children cooperate rather in same-sex groups or in mixed groups, or did they cooperate equally in both groups?
9. Brief description of the procedure/course of action (Protocol from memory, ca. 2-3 sentences)
INDIVIDUAL OBSERVATIONS:
Please answer the following questions individually for each child:

- The child’s interest/motivation is ...
- The child’s enjoyment while working is ...
- The self-confidence with which the child approaches the tasks is ...
- The child’s active participation in the events is ...
- The child’s willingness to cooperate in group/partner work is ...
- The level of requirement of the session was ... for the child
Please record code, gender and behaviour for each child

<table>
<thead>
<tr>
<th>Code</th>
<th>Interest Motivation</th>
<th>Enjoyment while working</th>
<th>Self-confidence</th>
<th>Active participation</th>
<th>Willingness to cooperate</th>
<th>Level of requirement</th>
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<tbody>
<tr>
<td>♂</td>
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<td>Very high</td>
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WORKSHEET 1: Why do we need renewable energy?

- Our planet Earth is surrounded by a **mantle of air, the atmosphere**.
- This atmosphere keeps the harmful particles of the sunrays away from the earth.
- Thus, we live on this earth within a **safe mantle of air**.
- We breathe in this air and in it the oxygen.
- When we breathe out, the **carbon dioxide** that we have produced gets released into the air.
- This happens in the same way when animals breathe out.
- Just imagine: the plants around us breathe in this carbon dioxide – and they in turn produce **oxygen** out of it. We then again can breathe in this fresh air.
- People, plants and animals are quite a good team, don’t you think?
- However, it is not only us who consume oxygen.
- Wherever something is **burnt**, it uses up **oxygen**:
- This is the case with heating, in factories, when driving a car, flying a plane, …
- Therefore, there is **more and more carbon dioxide** in the atmosphere.
- This amount is very often too much for the plants.
- There is so much **carbon dioxide** in the atmosphere left that, although the sunlight still gets through to the earth, the **warmth** produced can’t get out anymore. Thus, it is getting warmer and warmer on earth.
- As a result, the **weather** is changing all around the world. This is called **climate change**. It can have severe consequences, for example:
  - There are more **storms**; in some regions is is getting **drier** than before and the plants can’t grow anymore.
  - **Flood catastrophes** are also a consequence of the **climate change**.
• What can we do? It is better for the **climate** if we use renewable energy such as solar energy, wind power, biomass and water power. These forms of energy don’t produce any further carbon dioxide.

**Have you read everything carefully? So do you know the answers..?**

1. How do you call the mantle of air that surrounds the earth?
2. What do we breathe in, what do we breathe out?
3. What is used up when we burn something?
4. How do you call the change of the weather?
5. Is it possible that there will be more storms in the future?
6. What forms of renewable energy are there?
WORKSHEET 2: Experiment report; Circle of candles

Date:
Researcher:
Experiment set-up draft:

Observations:

Conclusions:
WORKSHEET 3: Quiz about the sun

- What does the sun consist of?
- What thing is it of which you can have 1,000,000 and get enough power for them through the sun’s energy?
- Which one is the smallest: the sun, the earth or the moon?
- For how long do the supplies of the sun’s fuel last?
- How long does it take the earth to go round the sun?
- How hot is it in the inner parts of the sun?
- Where does the sun rise?
WORKSHEET 4: What did you learn in this project

1. Energy
   Which different sources of energy do you know?
   What do you understand by the term 'renewable energy'?

2. Wind
   What happens to cold air?
   What happens to hot air?
   What can help you in conserving energy?

3. Sun:
   How many light bulbs could be lighted through only 1 inch² of the sun?
   How long does the journey of the light last to reach the earth?
   What thing helps you to gain the sun’s energy?
SOME PLACES OF INTEREST

There has been a growing amount of research into technology education over the last two decades. Organisations exist that aim to promote technology education such as:

The International Technology Education Association (ITEA) available at: http://www.iteaconnect.org/
The Design And Technology Association (DATA) available at: http://www.data.org.uk/
The Centre for Research Into Primary Technology education (CRIP) available at: http://www.ed.ucc.ac.uk/cript/
Nuffield Primary Design and Technology available at: http://www.primarydanldt.org/
Nuffield Secondary Design and Technology available at: http://www.secondarydanldt.org/
Pupils Attitudes Towards Technology (PATT) available on the ITEA website.

A growing number of research publications are also available such as:
The International Journal of Technology and Design Education available at: http://www.springerlink.com/content/102912/
Design and Technology Association: an International Journal available at: http://jil.lboro.ac.uk/ojs/index.php/DATE/about/contact
American Standards for Technological Literacy available at: http://www.iteaconnect.org/
Book series on Technology Education available at: https://www.sensepublishers.com/
John R Dakers is a lecturer at the University of Glasgow in Scotland. His research interests are:

- Addressing gender imbalance issues relating to science and technology education
- Developing new forms of pedagogy for the delivery of science and technology education
- Developing a modern and relevant science and technology education curriculum for the 21st century
- Scientific, technological and environmental sustainability
- Continental philosophy of technology and phenomenology

He is interested in promoting the need for students to develop a scientific and technological literacy in order to better understand the impact that science and technology have upon society. He writes extensively on issues relating to technology and science education. His first book “Defining Technological Literacy” deals with this very subject and was published by Palgrave MacMillan in 2006. His most recent book, “Analyzing Best Practices in Technology Education”, published by Sense Publishers in 2007 won the prestigious “Silvius-Wolansky Award for the Outstanding Scholarly Publication in Technology Education”.

He sits on the board of several international journals and book series and has published widely on matters relating to science and technology education. He acted as a consultant to the European Commission for two years on matters relating to increasing recruitment to mathematics science and technology subjects. He continues to deliver invited keynote presentations and workshops around the world.

Wendy Dow is a lecturer at the University of Glasgow in Scotland. She has worked collaboratively on a range of projects in technology Education and has carried out research into a number of areas pertaining to the field. She presents papers on technology education on a regular basis at international conferences and has had papers published in both international journals and books around the world. She has worked collaboratively with John Dakers on a number of funded projects, including acting as an associate consultant and rapporteur to the European Commission for two years on matters relating to increasing interest in and recruitment to Mathematics, Science and Technology within a European context.

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