edited by clare benson, mike martin and wesley till

third international primary design and technology conference

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DEDICATION

The publication is dedicated to Arthur Cotton, South Africa, who in many different ways did so much to support the development of technology education for primary children.

Introduction

Time has passed so quickly since CRIPT hosted the first International Primary Design and Technology conference and we are delighted to have hosted this third conference from June 29th-July 3rd 2001 at the Quality Hotel, in Birmingham, UK.

In the intervening six years much has happened. There are many more countries that have introduced design and technology into their primary schools; there has been a trend world wide for primary children to focus more on language and mathematics than on creative subjects; and issues such as assessment, designing and links to science continue to stimulate debate. Moreover, even though it has been discussed, technology education has not been removed from any primary curriculum worldwide.

This publication contains Keynote addresses, research and curriculum development papers from the Conference. The contributors, who were from every continent, were from a variety of backgrounds, including teachers, policy makers, teacher trainers, industrialists, students and manufacturers, and they brought with them a wealth of experiences and viewpoints to share with colleagues. The proceedings are intended to be an invaluable resource for all those connected with, and have an interest in, primary design and technology education.

Clare Benson / Mike Martin / Wesley Till
June 2001

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Design and Technology in Primary Schools – Developing its Future

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This paper seeks to analyse current curriculum provision and how it was developed, acknowledging the constraints imposed on the curriculum by changing priorities. It suggests that the promise of the early 1990s has not been maintained, but the subject has managed to remain intact through a challenging period in primary education. The paper then goes on to offer two ways for developing its future. The first sets out a revised structure based on a radical approach that could bring new impetus to this area of the curriculum. The second approach looks at incremental change over the coming years. The paper then suggests that one major hurdle to the future development of primary design and technology is the development of clear understanding of how children learn in design and technology.

Introduction

Design and technology is a dynamic and exciting area of the curriculum. It relates extremely well to the world outside the classroom and it can and does effectively support, enhance and bring meaningful practical learning to many other areas of the curriculum. When taught well it is one of the most valuable learning experiences in the primary curriculum, drawing together and integrating skills and knowledge like few other subjects can. It has the capacity to engage children in an exciting way, which makes children take ownership of their learning. This is why it is a vital element of pupils' learning in the school curriculum. David Hargreaves speaking at the Institute of Education in London on 22nd November stated:

'In the school curriculum, design and technology has a notable place in this regard, as a domain in which different bodies of knowledge and skill come together. Design and technology is not only a bridge linking the arts to science and mathematics in the interest of curriculum coherence; it is also a highly fertile ground for activities that support innovation. It is a subject that has over recent years gone through a very rapid and at times painful evolution.

Today, as the preface to the Programme of Study explains:

'Design and technology prepares pupils to participate in tomorrow's rapidly changing technologies. They learn to think and intervene creatively to improve quality of life. The subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems. They combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices. As they do so, they reflect on and evaluate present and past design and technology, its uses and effects. Through design and technology, all pupils can become discriminating and informed users of products and become innovators.'

Design and technology is moving from the periphery of the school curriculum to its heart, as a model of the combination of knowledge and skills that will be at a premium in the knowledge economy, and it is from the best practice that other subjects can learn about effective teaching and learning for innovativeness.'

David Hargreaves' comments surround one of the most powerful statements ever written about design and technology education. The statement was written in collaboration with the profession and there is almost universal agreement with the statement from within the design and technology profession. However, the challenge for design and technology is to translate that statement into practice in our schools. The challenge could have been achieved, or at least have been well on the way to being achieved, if the government over the last 10 years had understood and funded some key elements identified through the Science and Technology Education Support Grant (ESG) programmes in the late 1980s and early 1990s. These programmes provided quality training linked to the development of curriculum support materials, resources and in school, support working alongside teachers who lacked confidence. These programmes led to the provision of 20 and later 10-day courses through focused funding for subject co-ordinators in design and technology. These courses had real impact and HMI have repeatedly commented on the value of such courses and their impact in schools. Schools that have such staff, trained in the subject, show good practice and an understanding of the subject. The task, however, remained huge. The DATA Annual Survey of 1995 showed a coordinator remained responsible for the subject little more than two years before moving on to take responsibility for other curriculum areas. One of the strengths of the work in the first two years of the National Curriculum was that science and design and technology worked closely together and good collaborative work was developed. However, as the National Curriculum became settled, two factors emerged that influenced developments. Firstly funding, especially for training, was dramatically reduced; some would argue it was removed totally for primary design and technology and the emphasis on testing pupils in core subjects (maths, English and science) was given much greater emphasis. Thus primary teachers began to focus on what was being tested and what formed the basis of the league tables; it also leads to the close links between science and technology disappearing.

On reflection, the first five years of the National Curriculum (1990-1995) was a time of survival for design and technology in all key stages. At secondary level this survival was helped by three national projects: the Technology Enhancement Programme (TEP), Nuffield Design and Technology Project and the RCA/TC Schools Technology Project. These programmes all brought distinctive contributions to the subject, however, in primary there was no new thinking emerging and little development work at a national level and local advisory services were declining rapidly.

Supporting design and technology

In 1995 DATA took the decision to play a major role in supporting primary design and technology. It had its own magazine, Primary DATA, which was launched in the autumn of 1991, but no other materials for primary schools. To coincide with the New Orders of 1995, DATA produced Guidance Materials for Key Stages 1 and 2. These were a series of 30 units of work covering all aspects of primary design and technology. These were built on good practice determined by those active in the development of design and technology in primary schools through ESGs and long courses. These were supported by the DfEE and had a major impact with vast sales. Thus it clearly had a value and made an impact, as the teachers were more confident knowing it was supported by DATA and the DfEE. Although not a 'single route' scheme of work, as it provided choice and interpretation, it was in fact the first scheme of work endorsed by the DfEE; a number of years later they produced their own schemes of work. The enthusiasm, led by DATA's excellent Primary Advisory Committee, encouraged DATA to expand its work in this field. The following list indicates how DATA built the support for primary design and technology:

- DATA Guidance Materials Key Stage 1 & 2 (1995)
- Technical Vocabulary for Key Stages (1995)
- Primary Co-ordinators' File (1996)
- Guide for Teacher Assistants (1996)
- Planning into Practice (1997)
- Primary Teacher Training Standards (1997)
- DATA Primary leaflet – Bringing Learning to Life (1998)
- National Framework for Supporting Design and Technology in Primary Schools and Resource Guide (1998)
- Design and Technology for Pre-School Providers (1998)
- Primary School-based INSET Manual Vol. 1 (1998)
- Primary School-based INSET Manual Vol. 2 (1999)
- QCA/DfEE Scheme of Work* (1999)
- DATA Helpsheets (2000)
- Developing Language through Design and Technology (2000)
- Developing Numeracy through Design and Technology (2000)
- Developing ICT through Design and Technology (2001)
- DATA's Complete Lesson Plans for Design and Technology (2001)

* This is not a DATA publication but was written for QCA by members of DATA and is based on DATA Guidance Materials and Planning into Practice.

The whole basis for these materials was to support teachers and give them confidence in their work. Although the momentum of the early 1990s has been lost, there was evidence of growth in the subject after the 1995 revision of the National Curriculum. However, the action of the Secretary of State in January 1998 when he intervened and changed the emphasis of the primary curriculum with the focus on literacy and numeracy did great damage to the subject and its growth. The decision, without consultation, may have addressed literacy and numeracy standards, but its influence on the remainder of the curriculum will be seen in retrospect to have been very damaging. There is little published research on the impact on the whole curriculum, although there is significant data showing how standards in literacy and numeracy have improved. Many young teachers were given responsibility for design and technology on entering the profession. Sadly, changes in initial teacher training have led to these newly qualified teachers having limited or no design and technology experience.

Reflecting on the strategy

It would be good to think there has been a coherent, well thought out, strategy for developing the subject at the DfEE or NCC/SEAC/SCAA/QCA, but sadly there is little evidence of this. Reflecting on this period illustrates the strategy that has pervaded the last decade in primary design and technology, one of maintaining the subject, providing stability and supporting teachers to give them confidence to undertake the challenge of teaching what teachers consider is a new subject. In terms of curriculum development very little innovative work has taken place other than within the prescribed Orders. This does not recognise the work of individuals and the work of Nuffield Primary Design and Technology, but these have had little national impact at this stage. It may be reasonable to conclude that innovative curriculum development has not been necessary because we have got the essence of primary design and technology about right. There is little doubt that we have managed to captivate within primary design and technology many of the key principles that underpin the subject and these are generally understood by teachers. There are, generally speaking, three principles for curriculum development to take place and be successful. These are quality training, availability of appropriate resources, and the willingness of staff to embrace the changes. In countries such as England and Wales with a very prescriptive education programme, we also need national prioritising. The teacher's role has fundamentally changed over the last 10 years from that of an individual or small team who determine who and how he/she will teach, to now highly directed programmes of work from the Government and its agencies. Teachers look to follow prescribed government endorsed materials as a form of protection if, and when, inspected. Because design and technology has not been a priority at the national level it is fair to say its development has been minimal. Within the pressure on the primary curriculum in the last three years it is amazing that design and technology has remained in the primary curriculum of our schools.

Developing in the future

In looking forward there are a number of approaches that could be suggested. To polarise the argument this paper proposes two distinctive approaches. One is a radical approach setting a new structure and agenda for design and technology based on the premise that design and technology changes, and the current underlining framework is based on 1970s and 1980s subject matter. The second approach is much more pragmatic, seeking to illustrate small step incremental changes. It is clear that whatever we do there is a need for much greater expenditure. In 2000 the average expenditure for a primary school pupil in design and technology was £1.91 according to the DATA Annual Survey of Provision.

Radical development

My aspirations in a non-constrained context would be to generate a new paradigm for the subject, which recognises that different aspects of design and technology need to be addressed at different levels. In some cases this will lead to practical design and make activities, but not all cases. It could be debated what language we use to express our terms. There are many terms now in use such as technological literacy – US standards, to technological capability to technological competence. The 'level one' form of activity is when primary aged pupils are introduced to technological concepts. These would be concerned with knowledge about design and technology. This could be called design and technology knowledge because you cannot apply technological knowledge and concepts if you are not aware of them – not knowing what you don't know – is one of the basic problems for technologists. Some argue that you only acquire knowledge as and when you need it; however, you have difficulty choosing to use a technological concept if you don't know it exists. The second area I would be concerned about is application of knowledge in the made world and its influence on society. This could be called design and technology issues. Recognising the social and environmental impact of technological change is a crucial part of design and technology education and it must be emphasised in the curriculum. This category would involve pupils looking at how things work and analysing their functional, aesthetic and environmental impact. The third category relates to design and technology innovation. This category is about developing the skills for improving products and innovating to generate new ideas for the application of knowledge and skills. However, the pupil or a group of pupils should not always focus their work on the view that it must be made. This is why it has been separated out in design and technology – to allow for creative thinking and innovation without some major constraints, especially in the primary sector. It should mean that software simulation and novelty designs could have the chance to flourish, thus increasing creative thinking. The innovation may recognise a need but could be a set challenge. The final category that integrates the whole subject is design and technology application. This is concerned with designing and the creation of models, prototypes and the making of a product.

The reclassification of the subject and the splitting of the learning experiences into four categories may be deemed unnecessary and unrealistic, especially the separating of design and technology innovation from design and technology application. Many would argue that the holistic nature of designing and making in design and technology should not be split up and I have significant empathy for that view. However, it is important to separate out those learning experiences, which can be an activity in its own right. Thus some activities, which could start within the teaching of some basic knowledge as principles, then see how these principles are currently used in an existing product or environment, then seek out some innovations, using some innovation technology and simulating or modelling theoretical solutions. Then to product could be designed and made through the application of previous knowledge and experiences. If established with the correct concept and methodology, this would be a rich educational experience. However, it may not be the only way and some short experiences will help build the pupils' overall design and technological competence. There has been a tendency to limit the teaching of design and technology to areas of work in which a quality outcome can be physically generated. This should not be the case in the 21st century and this could free the subject for innovation, a new software model and a broader curriculum.

A debate about the subject's structure and classification would be healthy in reappraising the subject's future direction.

The next stage involves defining the content. There is currently an interesting series of concepts emerging with regard to the knowledge-based society. Some argue that in a knowledge-based society what you need is the skills to identify the knowledge and then apply it. Others believe that without understanding some basic concepts in areas like maths, science and technology, you cannot hope to know where to look and how to apply that knowledge. In schools, we need to identify those concepts that fundamentally need teaching and experiencing. Defining in this area either looks too much or you get accused of missing out vital fundamental elements of the subject. This will at least generate a debate and the list has been defined by examination of classifications from a number of countries including the USA, New Zealand, Finland, Japan, Scotland, Holland, Belgium and the various versions of the English National Curriculum. The suggested list of content for primary schools is as follows:

- Resources
  This will include natural and synthetic materials, food ingredient and components
- Energy
  This will include its forms and storage as well as its conversion and efficient use
- Systems
  These will be static such as structures and dynamic such as mechanisms, as well as electrical and electronic systems

- Control technology
  A means of controlling input, feedback and output
- Techniques and processes
  These are methods that can be used to create products
- Aesthetics
  This should cover basic concepts of shape, colour, form as well as smell, taste and feel
- Innovation and designing skills
  These will involve the creative as well as procedural skill related to innovation and design, using software where appropriate
- Making skills
  The skills needed to make the product from measuring, cutting, combining and joining resources to processing and manufacturing using machine tools where appropriate
- Communication skills
  These will include the use of ICT as well as traditional drawing skills
- Cultural, social and environmental effects
  This should look at impact on society, our culture and other cultures. Should include the idea of risk assessment and matching needs and wants in a society.

The above establishes two parts of a design and technology matrix. The other two are also important. One concerns strategies for teaching such as group work or individual work. It seems that group work with emphasis on working as a team is a vital component in the subject and with this will also come assessment strategies. In this paper I do not want to address these issues because if you take the argument that to restart design and technology in primary education we need new thinking and new strategies, we can only determine the assessment once the skills and content are defined and levels assessed.

The final dimension is the context in which design and technology works. In 1990 the National Curriculum for England and Wales identified context in terms of home, school, recreation, community, business and industry. This, although useful, must be changed to tackle a broader range than in the traditional contexts. These need reclassifying and to provide a more natural focus for the work they should relate specifically to the technology around. So contexts such as electronics and communication technology, transport technology, food and biotechnology, medical technology and construction technology may be better contexts. Many teachers now use these contexts so designs about the Channel Tunnel or the Dome or London Eye are not uncommon. However, others are not so simple because they may appear difficult or traditionally have not been covered.

These contexts would provide the themes for design and technology education but further they would provide the crucial elements of focusing the work in the 'real' world and providing a context that children can relate to. This element cannot be undervalued. Increasingly, technological issues are going to challenge our democracy, ranging from GM foods to the effects of excessive use of mobile phone technology. If in school we do not expose children to these learning experiences then we are likely to be governed by newspaper editors and their views. Now more than ever before we need intelligent citizens who can weigh up the advantages and disadvantages and make an informed risk assessment of the particular technological development. Virtually all new technological developments have consequences for some part of society if implemented, and children need to be aware of the possible implementation.

The above may be considered a radical proposal for developing primary design and technology; however, the radical nature has a number of benefits as well as the consequence of destabilising the existing approaches. However, it provides an opportunity to reconstruct our thinking. It could break the subject out from its traditional context and bring new challenging technologies into the curriculum in the name of motivating able young people. It will of course require new materials, new training and a 'fresh' start.

Incremental development

The second approach was to make minor evolutionary changes to the design and technology curriculum in a step-by-step approach. This slow incremental approach means there is no platform for curriculum innovation and without major stimulus it may continue to drift towards obscurity. The only reason for briefly setting out this approach is to compare the radical with the slow incremental approach. If this approach is adopted, we will need to address more effectively the role of kits as components for designing and making and software for design and simulation activities to reduce the making issues. Much valuable learning will continue to take place through handling materials. However, the limited range of materials have often been recycled and are not particularly appropriate for the use to which they are being put. In the hands of a skilful and resourceful teacher they can be very valuable. However, all too frequently children are frustrated by poor resources leading to designs led by resources available that do not reflect their thinking. The current curriculum needs the use of design software to simulate their thinking. This will not replace drawing by hand but it will bring a new dimension to the work. This may stimulate older aged primary pupils and expand their creative thinking. The use of construction kits needs to be further developed and this, combined with simple electrical and electronic kits, is vital to broadening the range of activities. Simple circuits, sensors, lights and simple control systems, excite children in primary schools; sadly staff lack confidence in this area. Another popular experience is working with food. Sadly this remains focused on cooking in many schools. However the work needs to be broad and address healthy eating, balanced diets and the whole food cycle from raw materials to food products on the shelves of the supermarket to eating that food. A key area must be food safety.

A further area for development is structures; this was left out of parts of the current primary curriculum by civil servants who don't understand design and technology. Building and evaluating structures is a valuable educational experience. Finally there is a case for introducing work in energy into the curriculum. The phasing of these developments needs planning but all are feasible within the next five years. However, training and new resources will be required, and a primary curriculum that is receptive to new materials.

Concluding comments

Design and technology in primary schools has had a period of stability and loss of momentum in terms of development. There is a need to capture the initiative again and this paper seeks to challenge what needs to be done to achieve this. One approach is to look at small incremental changes that update and increase the relevance of the subject. This is probably the most likely outcome if we are to get movement; however, there is a case for a much more radical approach which seeks to redefine the area of work and then use that to set a new agenda for the subject. This may be difficult to achieve but it is difficult to see how the primary curriculum could be tackled without a radical approach, which gains political acceptance. This latter approach needs much research and development and some new thinking that relates design and technology to the curriculum of the 21st century rather than the 20th century.

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The State of Primary Design and Technology Education in England – Past Successes, Future Developments and Comparisons with the Mathematics, Science and Technology Project in New York State'

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Introduction

This paper reports on the latest findings of HM Inspectorate in England and I will relate these to some observations from my visit to New York State in March 2000 to observe the work there. The USA references will only be presented orally during the lecture since it would be unfair to publish references. Sufficient to record that some excellent developments are to be found in many schools in widely differing contexts.

Main findings from inspection in England in 1999 – 2000

There have been significant improvements in D&T in nearly three schools in ten since their previous inspection.

Pupils' achievement in D&T is good in one school in five but unsatisfactory in one school in eight in Key Stage 1, and one in six in Key Stage 2. Pupils' achievements in both key stages continue to be better in making than in designing. Pupils' knowledge and understanding of materials, components and processes are steadily improving.

Most of the teaching of D&T is satisfactory, though seldom is it very good. However, teaching has improved considerably in Key Stage 2 this year.

The depth and breadth of design and technology activities have reduced this year. In a minority of schools D&T has almost disappeared. In about one third of lessons constructive links have been made between D&T and other subjects, mainly art and science. Many schools have improved their curriculum planning, often using the DfEE/QCA Scheme of Work.

Trends in D&T, 1999 – 2000

In one quarter of schools standards and the quality of work in D&T have risen markedly since the previous inspection, but in one school in six D&T provisions have deteriorated.

An encouraging feature of pupils' achievement in D&T is an improved understanding of concepts and their success in communicating ideas. For example, increasingly pupils use annotated drawings to work problems out for themselves. When this is encouraged, particularly by discussing such drawings, pupils make rapid progress.

However, even where pupils enjoy D&T, most fail to make the progress that should be expected of them. This is particularly true where pupils are not encouraged to think through a problem for themselves or to evaluate the effectiveness of their products. Too often, pupils are content simply to be told what to do.

Information and Communication Technology

The majority of designing and making tasks have required pupils only to use paper, card or wood; little work with food or textiles takes place. There is, however, a slight increase in work with systems and control – mainly using simple mechanisms – but there is very little use of ICT in designing. However, an increasing proportion of schools use Information and Communication Technology (ICT) as an integral part of their making procedures, usually with a printer, and a much higher proportion use ICT to record results of their investigations. Within this overall picture, some schools are employing ICT more regularly in D&T contexts. For example, pupils use graphics applications to form the net for the superstructures of model vehicles with applied text and decoration, and word processing/desktop publishing for presentation of design ideas. Although much of this work is at low level, there are examples of outstanding work. For example, in one school pupils in Y6 used a digital camera to capture images of selected objects and manipulated them using graphics software. They then printed the images on transfer paper and used this in the surface decoration of textiles for a bag for storing the objects they had photographed. In a few schools pupils use computer control of mechanisms that they have made themselves.

Quality of teaching

There have been slight, but significant, improvements in the quality of teaching of D&T, continuing the trend of recent years. Good teaching, is built upon thorough planning of long, medium and short-term objectives. It involves the careful choice of resources to provide not just a rich variety of experiences, but also to ensure that pupils have the tools, utensils, equipment and materials that are best for the work in hand. Teachers watch pupils closely during the lesson and constantly ask them questions about their approach to the work. At best, pupils are given responsibility for organising their own work, but their plans are frequently questioned and checked by the teacher who has a clear idea of what pupils are doing, and knows when to intervene. They achieve a good balance between directed and self-chosen activities.

Many teachers are showing increasing familiarity with National Curriculum requirements and their implications, and having access to better schemes of work. Some schools, particularly those that have received OFSTED reports critical of D&T, are beginning to use the DfEE/QCA Schemes of Work extensively. Many others select elements of these schemes to cover aspects of D&T with which they are not familiar or to improve the general scope of their own schemes. In addition, when the teaching of the subject has been identified as weak in a previous inspection, schools have usually made the improvement of D&T a whole-school priority. A consequence of such action has been a marked reduction in the proportion of poor lessons, although teaching issues remain to be addressed in a significant minority of schools.

Classroom assistants

In many schools where pupils' achievement is high, teachers make good use of classroom assistants and adult volunteers to help in D&T lessons. These additional adults make a valuable contribution to pupils' achievement, progress and the quality of learning. In an increasing number of schools, teachers prepare short written guidance notes, drawings or demonstrations for classroom assistants and parent-helpers so that they all work closely to ensure consistency in their approach, and learning objectives are achieved. In one school, for example:

- Teachers and assistants are very clear about the purpose of both designing and making activities and discuss the aims fully with the pupils. This ensures that pupils know precisely what they are expected to do. Pupils are then encouraged to try out several designs and experiment with different materials to make them work. A good supply of tools and materials plays an important part in the process. Questioning is used very effectively to help pupils to formulate their ideas. When pupils meet with difficulties, the assistants' good subject knowledge is always available. For example, one pupil needed a light but strong axle for his vehicle and was surprised and delighted to learn how effective tightly rolled up paper can be. By recording the designs and stages of making as they go along, pupils assess their own success and teachers have a very good means of tracking their progress.

Resources and accomodation

One quarter of schools have good resources and accommodation for D&T, but in one in ten schools these are poor, the main problem being insufficient space for working or storage. In one third of schools there is excessive reliance on recycled materials, which constrains the range and quality of work undertaken.

Issues in D&T

Improving the teaching of designing

D&T teaching remains weaker than that in other subjects because teachers' subject knowledge and understanding are less secure and there are very few opportunities for them to improve these through INSET. Where teachers are themselves uncertain about subject content they do not know what they should expect of pupils. They frequently accept work of too low a standard and do not set sufficiently challenging tasks. The teaching of designing within D&T has been identified as an area of particular weakness. In schools where the teaching of designing is successful, teachers:

- Have higher expectations of pupils' ability to think, solve problems and design for themselves, encouraging creative ideas
- Employ productive strategies to help pupils to overcome the problems with their designs, by group discussion as well as individual justification and evaluation
- Make greater use of product analysis and of probing questioning to help pupils investigate both existing products and their design tasks
- Make skilled use of whole class teaching with, for example, the teacher noting design criteria suggested by pupils on the board so as not to hinder the flow of pupils' ideas by requiring them to write them down as they occur
- Undertake systematic teaching of practical skills through clear instruction and demonstration, so that pupils know what is possible.

Improving the quality and effectiveness of planning for D&T

A continuing weakness in teaching D&T is the quality of long-term planning and, closely related to this, a failure to build on earlier learning, for example because of the repetition of work undertaken earlier in the key stage. Poor planning has been compounded in those schools where, in response to the relaxation of the National Curriculum requirements, teachers simply removed some units of work from their D&T Scheme of Work to match the available time. Similarly, some teachers tend to rush pupils through investigation and evaluation stages in an attempt to ensure that pupils have some experience of a making activity. The topics which teachers find most difficult, which cost the most or which take most time are the aspects that are ignored, that is, systems and control or food technology. Such strategies lead to an unbalanced and in some cases impoverished curriculum.

However, in a small but encouraging number of schools the D&T curriculum and D&T lessons have been planned much more carefully and effectively, minimising the effects on pupils' learning of the reduction in time. Increasingly, schools are experimenting more with different ways of organising D&T activity such as whole-class teaching, as opposed to group work, and the use of blocks of time each term or year, in order to make better use of time.

Improving subject leadership

D&T is at its weakest where senior managers do not understand the subject. For example, some schools have stopped teaching D&T altogether or only pay lip service by the inclusion of one or two simple activities each year. These tend to be more 'craft' activity with a 'follow-my-leader' style of teaching that precludes pupils from thinking and designing for themselves, or even learning about materials and processes.

The role of the subject co-ordinator is also central to the quality of D&T in a school. Leadership is good in one third, but unsatisfactory in one fifth, of schools, and overall is weaker than for other subjects. Effective leaders develop a coherent policy and progressively more demanding tasks set within a clearly structured scheme of work; provide whole school and individual INSET and support; and give colleagues confidence in their teaching. Such responsibilities need time, yet only one quarter of co-ordinators have any non-contact time to complete such tasks, particularly those involving working with colleagues.

Developing D&T alongside literacy and numeracy

The teaching of the basic skills of literacy and numeracy through D&T is weaker than in most other subjects. There are few 'big books' with overt technological content for use in literacy lessons. However, teachers are generally aware of the value of linking pupils' non-fictional writing to their designing and making activities and they teach their pupils well to use technological vocabulary related to these activities. When the work is at its best, pupils are taught to select and use a variety of communication techniques, often judiciously mixing drawing and writing in annotated sketches. They also frequently emphasise sequencing in both predicting and reporting their D&T work.

Teachers are realising that numerical skills and understanding can be reinforced, or even introduced, through D&T activities to support pupils' learning, such as measuring materials and weighing ingredients accurately, working to a budget and sequencing activities.

The very nature of design and technology means that it must both draw from, and contribute to, other areas of knowledge. Links with other subjects, mainly art and science, are increasing and are apparent in a third of all lessons, helping pupils to make connections between different aspects of their learning.

Using the Nuffield approach to secure a place for design & technology in primary schools

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Background to the Nuffield Primary Design & Technology Project

The Primary Nuffield Design & Technology Project began in 1997 and was highly compromised from the beginning by the introduction of national literacy and numeracy strategies. (Department for Education & Employment 1998 and 1999b) This put considerable time constraints on the curriculum with the result that the teaching of design & technology was put 'on the back burner' by many schools although in theory it was still a statutory obligation to teach the subject. One of the rationales for the Project was that it would provide a coherent approach throughout the primary years leading to design & technology in the secondary school. Although the Nuffield Foundation had already funded a highly successful secondary design & technology project (Barlex 1995 a – e) a basic premise of the primary Project was that it would be developed from the primary perspective; there would be no downward creep.

It was immediately clear that the major focus should be providing materials for teachers rather than pupils. So the Project developed a pedagogic model that it thought would be appropriate for primary schools and produced units of work utilising this model. The model was similar to that developed for the secondary Project but with two very significant differences. Each unit of work was based on a task structure that involved a Big Task in which pupils were required to design and make a product supported by Small Tasks which set the scene for the Big Task and taught specific knowledge and skills needed to be successful in tackling the Big Task. This is of course the task structure required by the National Curriculum (Department for Education & Employment 1999a). There were two key differences between this approach and that adopted in the secondary Project. The first was that the Small Tasks were dedicated to a particular Big Task; they were not free standing as was the case for Small Tasks in the secondary Project. The second key difference was that the units of work contained detailed lesson plans which ëhand held' the teacher through each session.

Initially I had been concerned that the structure would be seen as too restrictive although teachers trialling the materials indicated otherwise. To dispel any doubts the Project commissioned two independent evaluations by an experienced research team led by Patricia Murphy of the Open University. She found that inexperienced teachers really valued the lesson plans, subject co-ordinators found them very useful as it enabled them to easily help colleagues, and experienced teachers were happy to adapt them to meet the particular needs of their pupils. The research helped the Project to identify those elements in a unit of work which are important; particularly a clear articulation of the design decisions that pupils will be expected to make and the need for experiential small tasks to inform that decision making. As yet the detail of this research has not been published in an academic journal but it has influenced considerably the structure of the units of work, the content of the teacher handbook and the tutorials that will be available on the Project's website.

The Project was unable to find a commercial publisher willing to publish the materials; not because the publishers found the materials wanting but because they felt that in the prevailing climate with the considerable emphasis on literacy, numeracy and to a lesser extent science and ICT, plus the average primary school 'spend' on design & technology being so low it did not make commercial sense to publish the materials.

The Project has since its inception been concerned about how it would reach the large numbers of primary schools in England. There are 20,000 primary schools as opposed to about 4000 secondary schools. The dissemination problem is considerable. The Project decided that a website might provide the answer particularly at a time when the government was promoting the use of ICT by teachers through nation wide in-service provision. (www.nof.org.uk) The Project website can be found at www.nuffieldfoundation.org/primarydandt and has been in operation since 1998. The Project sees the website as both a means of involving teachers in the Project as a curriculum development activity and also as a means of supporting and growing a community of good practice once the curriculum development is finished and the Project moves into aftercare mode. The Project made trial materials available as free downloads and in a 16 month period (September 1999 – December 2000) almost 8000 units of work had been downloaded. This indicated a possible strategy for making the reformulated units of work available; simply give them away from the website. From September 2001 teachers will be able to purchase a short teacher's handbook plus CD ROM containing the units of work and a guide to the website for under £10.00. This has been possible because the Project is using DATA (the Design and Technology Association) as the marketing agency for these materials. This is an interesting example of a partnership between an educational charity (which does not need to make a profit) and a professional association (which from a small investment might actually make a profit) to provide curriculum materials and professional support at a time when commercial publishers are unable to do so.

Models for implementing design & technology in primary schools

There are two issues associated with implementing design & technology in the primary school. The first is in finding time for the subject. The second is in providing the teachers with the expertise to be effective in the classroom. The active involvement and support of the head teacher is crucial in engaging with both of these issues. The Project was fortunate to be able to work with

Phase 1	Phase 2
– Year 5 Design and produce tourist maps for Liverpool and Keswick using ICT – Year 1 Design and make a textile tree for the classroom and use fabrics to design and make a large woven class picture Taught by Kellie and Tracy	– Year 5 Design and make a pop up book with an environmental/recycling theme – Year 6 Design and make a large sculpture of a creature to act as a guardian or welcomer to the classroom Taught by Kellie and Denise
	– Year 1 Design and make a monster alphabet book for the reception class – Year 2 Design and make a multi layered fridge magnet Taught by Tracy and Sharon

Table 1 The first two phases of developing design & technology at St Monica's primary school

two head teachers in Liverpool who were concerned about the imbalance in the curriculum caused by the introduction of the national literacy and numeracy strategies and were committed to improving their schools' design & technology curriculum. They were able to look at their school timetables and find time for design & technology without compromising literacy and numeracy work or that of other subjects. They opted for very different models but each was envisaged as a powerful means of providing professional development for the teachers involved.

Brian Mulroy, the head teacher of St Monica's school, opted for a flexible one session a week model in which two teachers (the design & technology co-ordinator and one other) were paired in order to support each other. As these teachers worked together and became confident this 'buddy' system would be extended to involve two more teachers and then four more so that within a relatively short space of time (one academic year) there would be seven teachers plus the co-ordinator who could work with other teachers in the school in providing good design & technology lessons for all pupils.

Margaret Lynne, the head teacher of Our Lady's school, opted for a three day immersion in every term. In these three day blocks each class teacher would teach just design & technology to their class. There were two design & technology co-ordinators in the school and Margaret reasoned that this approach would give them the opportunity to focus their efforts in supporting the staff and also allow the staff to focus on developing good design & technology teaching without the distractions of teaching other subjects.

Both head teachers saw the availability of Nuffield units of work with the detailed lesson by lesson guidance as the sort of resources that would enable their teachers to be effective in the classroom with only minimal additional guidance from co-ordinators.

Feedback from St Monica's Catholic Primary School, Bootle, Liverpool

The design & technology work being carried out at St Monica's is summarised in Table 1. Kellie Ryan is the design & technology co-ordinator and a year 5 teacher; Tracey Obey is a Year 1 teacher. The head teacher organised supply cover so that they could teach each of their design & technology units together. This provided an incentive for joint planning and gave the opportunity for co-operative teaching and on going dialogue.

To provide feedback on these development activities the head teacher and the teachers involved in Phase 1 answered a series of questions designed to discover the efficacy of the approach. Questions and answers are presented below.

- **What were the issues surrounding the teaching of D&T in your school before you became involved in the Nuffield Primary D&T Project?**

  Brian Mulroy comments

  – The introduction of 3 new national initiatives placed enormous pressure on time allocated to the foundation subjects especially design & technology

  – Confidence and expertise of the staff was limited and therefore the delivery was erratic

  – The practical nature of the lessons presented difficulties in resourcing, planning and delivery e.g. open plan aspect of the infant departmen

  – Schemes of work were not written in sufficient detail.

- **How have you used the Nuffield approach and materials to develop D&T in your school?**

  Brian Mulroy comments

  – They have provided a framework for teachers to develop their competencies for planning and delivery using the approach embedded in the Nuffield units of work

  – The units of work fit in with the QCA schemes of work

  – Major elements of planning are completed by the Nuffield units

  – The roll out and ripple approach enables school to start with a confident staff and gradually impacts on the whole school in a planned way. This will result in a whole school approach that is understood and implemented by everyone including teaching assistants

  – They have become a major element of the continuing professional development provided by the school, which links directly with the School's Improvement Plan.

- **To what extent do you think that this approach has been successful in developing a team capable of helping all staff teach D&T in your school.**
  Brian Mulroy comments
  – Collectively we have been delighted with the Nuffield strategies. The commitment and enthusiasm of the staff involved reflects their professionalism and dedication
  Kellie Ryan and Tracy Obey comment
  – The co-operative and collaborative teaching removes the threat of the subject as support is at hand. It provides a staged programme for development and doesn't present an intolerable workload for all staff. At the same time, the programme will be developed and phased in over a period of time in a structured and supportive way.

In teaching Textile tree and Class loom
Kellie Ryan and Tracy Obey comment

- **Had you taught anything like this before?**
  – No
- **How easy was it to organise the lessons?**
  – The Nuffield units of work were extremely useful when planning the lessons. The learning objectives were explicit and the resources needed were clearly stated
  – However each part of the lessons had to be scaffolded in the year 1 lessons and therefore extra adult supervision was required.
- **How did the children respond?**
  – The children were inspired from the outset; they were able to clearly see their objective and purpose; they often brought resources in from home without prompting as they recognised that certain materials would be useful in their designs.
- **What important learning do you think took place in D&T and other subjects?**
  – The children developed their fine motor skills and were able to see the links with science in the varying uses of different types of materials.

In teaching the tourist map using ICT
Kellie Ryan and Tracy Obey comment

- **Had you taught anything like this before?**
  – No! It was a new experience for both the class teacher and the children.
- How easy was it to organise the lessons?
  – This unit involved two out of school trips with linked follow up work using ICT facilities so a considerable amount of time was needed to plan the logistics of the lessons; co-ordinating the differing elements to ensure continuity and progression were difficult. Guidance from the Nuffield units of work was of paramount importance in the preliminary stages and therefore proved invaluable.
- How did the children respond?
  – The children, as ever, were enthusiastic and embraced the new challenge with vigour. Their insatiable desire to know more about their local area and how they could potentially keep tourists in Liverpool rather than Manchester fired their thoughts.
- What important learning do you think took place?
  – The children now understand that scale is fundamental to designing plans; accordingly, they had to modify their original plans several times to ensure that they were accurate and relevant
  – The children are now suitably equipped to plan a map for a specific purpose; they are acutely aware that Design and Technology should always have a focus and a purpose.
- How do you think this learning might support future work in D&T?
  – The children are now suitably equipped with transferable skills which will make the delivery of subsequent Nuffield projects easier.
- To what extent has being 'paired' helped in preparation and professional development? Are there any drawbacks?
  – Pairing aided the preliminary thought processes regarding planning and logistical classroom decisions. Moreover, a consistent support mechanism often allowed increased freedom to go beyond the limited parameters of the lesson and raise the ceiling on the children's learning by integrating extension activities, that maybe couldn't have been supported otherwise.

Feedback from Our Lady of Compassion Primary School, Formby, Liverpool

The design & technology work being carried out at Our Lady's is summarised in Table 2. To provide feedback on these development activities the head teacher and the co-ordinators answered a series of questions . Alison Cole is the design & technology co-ordinator for Key Stage 1 (years 1 and 2) and a Year 1 class teacher; Suzanne Murray is the design & technology co-ordinator for Key Stage 2 (years 3 to 6) and a Year 3 class teacher. The questions were designed to discover the efficacy of the approach. Questions and answers are presented below.

- **In what ways has the approach adopted been of benefit to the co-ordinators?**
  Alison Cole and Suzanne Murray comment
  – It has given us both an overview of each year's design & technology topics and objectives
  – We have been able to recognise the progression and skill development in the triple blocking
  – It has created a much clearer awareness and identification of resources by both staff and pupils
  – It has been much easier to organise targeted parental help in an immersive experience
  – We both feel professionally more fulfilled as design & technology is being covered properly in its own right, not tacked on to another subject as sometimes happens e.g. with art & design
  – Teachers who are less confident in the subject feel able to ask for support and guidance as all the teachers are involved

Year	Immersion 1 November 2000	Immersion 2 February 2001	Immersion 3 June 2001
1	Design and make a fruit salad	Design and make a monster calendar	Design and make tops, spinners and whizzers
2	Design and make a serving of toast Design and make a fridge magnets	Design and make a roly poly	Design and make summer hats and T shirts
3	Design and make a cold drink Design and make a party hat	Design and make a class display	Design and make musical instruments
4	Design and make a jam and pastry product Design and make a treasure box	Design and make a game for someone in bed	Design and make a Pop up book
5	Design and make a hot drink Design and make a carrier	Design and make a toy buggy	Design and make a chewy beast
6	Design and make puppets and a puppet theatre	Design and make a lighting device	Design and make a classroom creature, or Design and make some multimedia software

Table 2 The three design & technology 'immersions' at Our Lady's primary school

– On the downside the co-ordinators can find themselves with a lot to organise if other teachers aren't prepared to become involved and prepare thoroughly.

- **In what ways has the approach adopted been of benefit to the class teachers?**
  Margaret Lynn comments
  – It has increased everyone's subject knowledge
  – Organisation of lessons has improved due to the highly focused nature of the experience
  – Teachers are more motivated
  – Adopting a central resourcing model (more akin to secondary practice) has helped teachers organise the resources needed
  – It has enabled teachers to concentrate on a neglected area of the curriculum.
- **In what ways has the approach adopted been of benefit to classroom assistants?**
  Margaret Lynn comments
  – Giving the assistants a copy of the Nuffield unit of work in advance of the lessons increased their subject knowledge and enabled them to adopt a better defined and focused role in the classroom.
- **In what ways has the approach adopted been of benefit to pupils?**
  Alison Cole and Suzanne Murray comment
  – The subject is no longer a mystery; they can talk about it with confidence using terms such as specification and evaluation
  – The children have developed better group work skills
  – The approach enables them to experience the whole process from initial ideas through to evaluation; making a finished product in a time period that is just long enough to hold their concentration and enthusiasm to the optimum
  – The quality of the work is higher as the children are more focused
  – Performance in other subjects has improved e.g. excellent writing from KS1 pupils and improvement generally in speaking and listening skills
  – We were concerned that they would be unable to maintain good behaviour throughout the experience but our fears were groundless. They rose to the occasion, acting very sensibly. We think this is because the experience is motivating, practical and engaging so there is little time to become bored or distracted.
- **In what ways has the approach adopted been of benefit to parents?**
  Margaret Lynn comments
  – By being able to let them know exactly when design & technology will take place and when they can be of most help we can involve parents in the life of the school through the design & technology curriculum. The parents feel they are making a contribution to their children's education. One father became so involved that he took his daughter to the local DIY store to buy tools. Many parents reported that their children so enjoyed the experience that they talked of little else.
- **How do governors view the exercise?**
  Margaret Lynn comments
  – The governors are receiving positive feedback from their own children and from their visits during the 3 day events
  – The governors support the approach by approving its inclusion in the school development plan and allocating additional funding.
- **How does the head teacher view the exercise?**
  Margaret Lynn comments
  – The approach has been highly successful
  – It is easy to see that the children are making progress
  – It focuses everyone's teaching and planning so all staff undergo professional development
  – It is an approach which will have impact on the whole curriculum in that it can be used to develop other neglected subjects
  – However staff workshops in which teachers had the opportunity to work together in carrying out the unit of work before they taught it would have made the exercise much less stressful.

Discussion

In this section we consider the professional development embedded in the methods adopted by both schools in developing their design & technology curriculum by using the materials and approaches of the Nuffield Primary Design & Technology Project.

For professional development to be effective i.e. lead to positive change in the classroom it must involve four crucial elements. First, professional development must provide a challenge to teachers' frames of reference (Carney, 1998). Ball (1996) argues that teachers must use an inquiry and problem-solving paradigm that results in their producing new knowledge, rather that a training paradigm that results in their consuming knowledge. The Nuffield units of work utilised a pedagogy new to the teachers in both schools so this represented a challenge but the units themselves provided support which the teachers could adapt to meet their own circumstances preventing the challenge from becoming daunting.

Second, Carney (1998) suggests that new knowledge will not be learned and applied unless it is situated in relevant contexts. Vukelich and Wrenn (1999) believe that professional development should be based on the participants' interests and needs. Cameron (1996) suggests that professional development must be relevant to actual classroom work and to what students need to know and be able to do. The work carried out by both schools is completely embedded in the context of the classroom. The results of the classroom activity are seen very positively by the teachers and the head teachers.

Third, collaborative support from other teachers greatly increases the likelihood that changes in practice will be sustained (Fullan and Stiegelbauer, 1990). Teachers need colleagues with whom to focus on problems of teaching and learning, to work out how to deal with new subject matter, and to engage in innovative work aimed at curriculum reform (Olson, 1997; Shanker, 1996). Both schools use collaboration as an important part of their approach. Indeed at St Monica's the development is explicitly predicated on this. At Our Lady's the pairing of teachers in year groups and the support for all teachers from the co-ordinators involves extensive collaboration.

Fourth, professional development must provide opportunities for teachers to form 'communities of practice' (Lave & Wenger, 1991) that encourage them to reflect on the content and contexts of their pedagogy. Schön (1987) demonstrates the importance of reflection-in-action and reflection-on-action for the development of professional practice. Louden (1991) argues that reflection is a basic source of learning and change. In both schools there is clear evidence of the development of communities of practice. At Our Lady's the entire school becomes a community of practice dedicated to design & technology with intense reflection before, during and after the immersive experience. At St Monica's the approach is less intense but the involvement of teachers in (to use their words) the 'roll out and ripple' approach through a buddy system is clearly the development of a reflective community of practice.

The approaches adopted by both schools clearly meet the criteria for robust professional development likely to result in changed and improved practice.

Conclusion

From the comments made by the teachers and head teachers it is clear that both schools were able to use the Nuffield materials and approach to design & technology as the basis for considerably improved practice although they opted for seemingly quite different ways of doing this. It is apparent that the involvement of the head teachers was a crucial element in the success of the endeavours. Without their active support and encouragement neither of the approaches would have been at all feasible. The work of both school constitutes considerable professional development for the teachers involved. Although the means by which the schools were successful appear to be different it has been possible to show that they each embody four features known to be needed for effective professional development to take place. It is hoped that these examples will enable other schools to take the Nuffield approach and materials and use them as the basis for the professional development that is needed to secure a place for design & technology in the primary school curriculum.

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  This training will ensure that teachers and school librarians are equipped with the necessary knowledge, understanding and skills to make sound decisions about when and how to use ICT effectively in teaching.
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Creating the future

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Introduction

The theme of the conference relates to the future and it is the intention of this paper to highlight possible futures not only in this country but worldwide. Of course, many of the presentations focus on work that has been, or is being, undertaken, but it is always necessary to build on what has gone before. From the collection of conference papers we have a picture of practice around the globe and whilst this in incomplete, it gives a valuable insight into many directions and trends that are occurring.

An English perspective

From 1989, when design and technology education was introduced as a mandatory element of the primary curriculum (DES 1989), the subject has been constantly changing, and sometimes evolving. Some of the changes have come about through decisions seemingly taken 'on a whim' (the exclusion of energy and structures as clearly identifiable parts of the content) whilst others really have evolved as a result of consultation, trial and evaluation (the more focused and jargon free 1995 document).

Of course, it would be difficult to argue that a curriculum that is being introduced for the first time should not evolve. The world in which we live changes and evolves rapidly and it is important that young people are aware of this and of the fact that their curriculum needs to change to take into account the situation, not only of the day, but more importantly, the future.

Creating the policy

There are at least two ways in which future policy can be created. Firstly we can put to one side all that has gone before and make radical proposals for a curriculum that is in essence, a new beginning. Secondly we can examine, the present curriculum and continue to identify areas for change and inclusion. Whilst it may seem appealing to 'take the clean slate' approach, in reality, if we are to ensure that teachers are able to cope with the future, small, consistent, steps forward might appear to be the better option. The financial implications are huge for the first way, and without this investment change would be impossible. In addition, it would be necessary to convince majority of primary teachers that this was the best option and this seems an unlikely outcome. Many now see the value of the subject, if only because the children are so enthusiastic, and would be prepared in the future to change a little and often. Certainly, I would wish to see the increased appropriate use of Information and Communication Technology (ICT) in areas such as research, communicating ideas, control and communicating practice. But there are also areas that were included in the 1989 document (DES 1989) that have been marginalized and I believe should be highlighted in the future.

The statement

'consider the needs and values of individuals and of groups, from a variety of backgrounds and cultures' (DES 1989, p.27) is a vital area if we are supporting young people to gain an understanding of a range of cultures, and the world in which they live. Areas such as story telling, food, textiles, puppets, masks and toys provide relevant contexts for such work. By using this information in their own work, the children have, to not only have knowledge of other cultures, but to use and apply it.

'Extend the range of techniques used in their drawing and modelling' (DES 1989 p.28) focuses on aspects of designing that are often overlooked in the rush to get to 'the making'. 'Plan a simple budget' (DES 1989 p.29) offers real links with mathematics, together with opportunities to understand that resources are limited and costly and these factors need to be considered by every designer. Environmental issues, including those of alternative energy and sustainability, are rarely pursued although they are obviously integral in future developments. Children are given few opportunities to look at design and technology from an historical or cultural perspective, both of which will help to make sense of future developments.

Much of the school curriculum that is now developing is based on the Qualifications and Curriculum Authority (QCA) Scheme of Work (QCA 1989). This document provided a much needed basic framework for primary design and technology. However it was only ever intended as guidance, and this is sometimes forgotten. Many of the important issues just raised are at best implicit in the document as it and it was the intention that school subject leaders would adapt, extend and include those aspects that are of particular relevance to their children. It is therefore important that this document together with the National Curriculum, is kept under constant review to ensure that not only the present, but also the future is considered.

Providing the support

However good the policy, without support, implementation will fail to make a difference to practice. At school level, Local Education Authorities have been in decline for many years and there are now few people nationally who have a specific brief to support teachers in school. It seems unlikely that this will change in the future and alternatives need to be sought. From research, such as Benson et al 1998, it is clear that inservice work does bring about positive changes, including the all important building of practitioners' confidence. This needs more funding and funding in a different way. At present, all courses funded by the Department for Education and Employment (DfEE) to provide continuing professional development (CPD) have to be delivered at Masters level. Whilst this is appropriate for some, many teachers want a more practically based course, with less emphasis on the assignments that have to be completed More independent consultants need to be updated and identified across the country, and higher education could also play a greater role in providing inservice opportunities.

Few Initial Teacher Training courses (ITT) give much time to design and technology as a generalist subject (and this is so for other foundation subjects History, Geography, Physical Education, Art, Music and Religious Education). Students can leave their training with as little as five hours study of the subject and are then expected to teach it to a whole class. Subject specialist students have had a reduction in time, since 1998 when new regulations were introduced, and few now spend the equivalent of 50% of the course studying their main subject. If future teachers are not given adequate training and there are inadequate opportunities for further development, the future development of the subject will, at best, be limited.

However, QCA, the Design and Technology Association (DATA) and a range of easily available, affordable resources all contribute positive support and need to continue to do so. QCA have a series of ongoing projects to monitor and evaluate practice, address specific issues and provide support through its website. It can give a national perspective and as such is useful to a wide audience. In the past, lack of resources was identified as an area that was holding back practice but suppliers together with DATA and some publishers, have, and are continuing to provide materials which are proving invaluable to all involved in the subject. For the near future, DATA's development of lesson plans to support the QCA scheme of work should save hours of planning time for teachers and they will be able to adapt them for their own particular needs. Moreover it is essential that materials that help to broaden the curriculum, such as those provided by Nuffield, are used in a creative way. Nevertheless, we must not be complacent and at least two areas that need to be addressed in the future are the provision of practical ideas for assessment, for addressing the issue of 'bridging the gap' for 11-12 year olds and for supporting the teaching of designing.

Communicating the message

Despite the fact that design and technology is ten years on from its introduction, there is much to be done to spread the word. There are areas of the country where teachers have no, or little, opportunity to communicate with those who have an up to date knowledge of practice, national developments and support systems. These areas need to be identified and a course of action determined to provide much needed guidance.

Whilst DATA has an advisory group for Initial Teacher Trainers, a wider network needs to be established, courses and personnel identified and opportunities provided for students from different Universities and Colleges to interact and to share experiences. They will be the future of design and technology and it is vital to equip them with information, skills and a network that they can turn to.

The creation of leading teachers in mathematics has met with some success, and this idea is just beginning to be developed through DATA. It is hoped that in the future there will be a group of leading teachers throughout the country that will be able to provide support to others in their area and offer visitors to their school an opportunity to see good practice in action.

Much needs to be done to disseminate the value of design and technology to those who work outside schools, colleges and universities. Parents, governors, politicians and industrialists for example, still struggle to understand what this subject is about, especially as they will not have had their own experiences at primary school upon which they can draw. Obviously, this will change in the future but it will take time. Open days, brochures, projects linked to industry, displays of work in public places, newspaper articles are all ways in which the word can be shared but it does take time and effort to achieve.

If children are to continue to have their entitlement to this valuable subject then it is up to all of us to make the effort to communicate the message.

An international perspective

Now that it is possible to identify an increasing number of countries worldwide that have introduced, or are engaged in debate about the possibility of the inclusion of, design and technology into the primary curriculum, there are a number of immediate steps that can be taken to promote the subject's growth, to support developments and to communicate activities to a wide range of people that are connected with the subject.

To date, there has been a sharing of ideas and practice through, for example, previous CRIPT (1997, 1999), IDATER (1988-2000) and PATT (1983-2001) conferences, through Socrates projects (Peters and Heath 1999), through projects based in Universities (Barlex, Welch et al 2000), through personal contacts, study visits and teachers' exchanges. The international community was galvanised into action to support S. Africa last year when the Education Minister and colleagues were reviewing the primary National Curriculum. Many key players from across the globe communicated their support for the continued inclusion of technology education in the curriculum, outlining its value and highlighting its importance to young people worldwide. Of course, it is difficult to evaluate just how much influence these messages had, but technology education remains, and the Education Minister personally communicated with at least some of the overseas respondents.

With the continuing growth of the subject, now is the time to provide a framework within which support can be organised and offered. It is important to ensure that no one person, organisation or country is excluded; nor is there a wish to hinder 'adhoc' developments. However by creating a framework that anyone can access, it can only serve to strengthen to provide open access to developments at all levels, worldwide.

Of course, the use of Information and communication technology (ICT) will play a key role in gathering and disseminating information. But we must not forget that there are still enormous areas where access via ICT will not be possible, particularly among practicing teachers. There is still a real place for the printed word.

Promoting growth

It is now possible to identify three levels of growth within the international community. Firstly there are those countries, such as Brazil, China, Poland and the Netherlands that are beginning to engage in the debate relating to inclusion. Interested parties are exploring the nature of the subject and its development in different countries and are beginning to outline a philosophical rationale for inclusion and implementation. It will be possible to follow progress from debate to inception when it occurs. Secondly there are those countries, such as Bahrain and Chile, which have very recently incorporated the subject into their curricula. They have developed their own documentation and are beginning to provide curriculum support and inservice training for primary teachers. Pilot studies have been carried out and evaluated, and findings are being used to give guidance to trainers who are supporting teachers in the classroom. Thirdly there are countries, such as England and Wales and New Zealand where technology education has been mandatory for some time. Already there have been many changes to original documentation, policy and implementation, often as a result of evaluation. Resources are now well developed and getting easier to access, some inservice training is available and research is beginning to take place.

It would seem appropriate to create a database of countries worldwide, identifying the level at which they are operating. Moreover, it will be necessary to identify those countries that have not taken the first step. Such a database will prove invaluable in different ways. Through interrogation, it will be possible to liaise with countries that are at a similar developmental stage and perhaps are experiencing similar concerns and successes; it will be possible to follow the ways in which the subject develops from its inception; it will be possible to identify different rationales and philosophical reasons for development; and it will be interesting to follow the various avenues of development, in those countries that already have a history of inclusion.

Supporting for developments

As the subject emerges in the curricula of different countries, certainly, for all personnel involved, including policy makers, teachers, teacher trainers, industrialists and parents, there are similar areas of concern, and successful strategies that have been trialled and adopted. Whilst it is often the case that learning only takes place through making mistakes and rectifying them, nevertheless it would be valuable to have information available and personnel identified that could be used as necessary. By having access to, for example, national documentation, teacher training frameworks, inservice course outlines, resources and the monitoring and evaluation of these, it would be possible to at least gain an insight into what has been successful, or otherwise, in different countries. Through, for example, ICT, conferences, study visits, projects and personal contacts, hopefully support will expand in the future and learning from each other will be a reality.

Communicating activities

As developments take place and there is more activity showing what design and technology education looks like in practice (in schools, during teacher training and inservice courses) it is essential that this practice is not only shared within a country but worldwide. From first hand experience, I know that teachers on courses at UCE have valued input on activities taking place overseas. In evaluations they have indicated their interest in discovering that other countries 'do technology'-something that we may take for granted; that teachers often share the same concern-lack of training, resources and time; but that children enjoy and value their lessons and gain many skills that are important for their future lives, including the world of work. Obviously, sharing practice can be done in a variety of ways but at this point in time, it is limited, especially with activities that are classroom based. It is possible to access documentation through the Internet, research papers through Proceedings and the Internet and individual projects through reports and personal contacts. Practical activity, in its widest sense, can be accessed through written reports but images, video and the spoken word are better media for this information, to bring it alive.

A way forward

There will be many ideas as to how it is possible to share practice worldwide. Moreover it is an ongoing debate and will not be solved at this conference. However there are some suggestions that CRIPT proposes to work on during the next two years.

Firstly we can create a database of the position of all countries engaged in the debate about the inclusion of design and technology education in their primary curricula. This can include information about national policy and documentation, national associations, implementation, resources, teacher training, school practice and key personnel. CRIPT website will then become a gateway, that provides links to sites around the world that are really relevant to primary design and technology. It would be possible to link to case studies of classroom practice, teacher training sessions and inservice courses. The information could be downloaded and sent out to those on the CRIPT database, every six months so that those without Internet access will not be excluded.

Secondly, we want to launch again the project World Wide wheels. We have sponsorship so that now we can provide financial support for those involved in the project. We would like to include case studies from both the 3-7 and 7-11 age group, and are providing a framework to enable projects to be written up in a similar way. It will then be possible to make some comparisons in the methods of delivery and the learning outcomes and the findings can be disseminated through both the Internet and a paper publication.

It is anticipated that there will be many other suggestions from delegates around the world and it is hoped that this will generate discussion, suggestions and action in the intervening two years before the next conference.

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  Design and technology
  a scheme of work for Key Stages 1 and 2
  QCA

Moving Monsters – A First attempt at Design and Technology

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Introduction

Over the last few years, the Qualifications and Curriculum Authority (QCA) and the Department for Education and Employment (DfEE) have jointly published exemplar schemes of work for all primary National Curriculum subjects. The Design and Technology edition was first published in 1998 and updated in 2000 to comply with the revised National Curriculum. The document contains four units of work for each year at both Key Stage One and Key Stage Two.

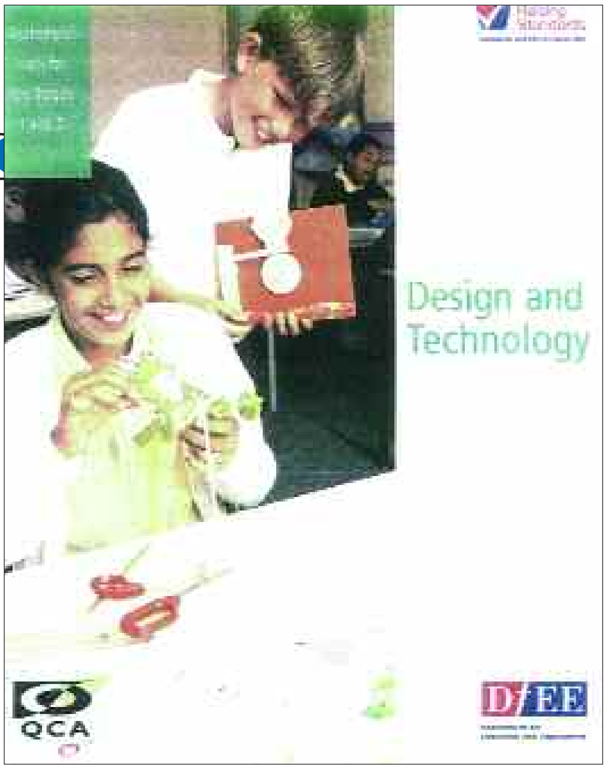


Figure 1 D&T Scheme of Work

The pull-out sheets for each unit of work provide plenty of ideas for activities relating to a theme, enabling teachers, both inexperienced and those looking for new ideas, to select appropriate ideas for use in their own schemes, or to develop schemes based entirely on the document. The Design and Technology Association (DATA) have published 'Helpsheets' to support the QCA scheme, and these contain lots of suggestions which teachers can use to help implement the activities from the units of work.

As a Design and Technology specialist on a four year BA QTS course, I was eager to tackle teaching the subject on my very first teaching practice in the Summer of 2000. My placement school was using a revised version of the scheme of work's Unit 3c *Moving Monsters*. Due to my own inexperience, I chose to teach this scheme because I could take advantage of published materials and other's experiences, rather than producing my own scheme entirely from scratch. I began my planning by highlighting and revising Unit 3c to develop my own 5-week (11 hour) scheme of work.

My class, thirty-four seven and eight year olds, had little experience of Design and Technology; especially IDEAs (Investigative, Disassembly and Evaluative Activities) and FPTs (Focused Practical Tasks) due to the strain put on their timetable by the pressure to incorporate literacy and numeracy hours everyday. This was a prime concern in my original planning as I did not want the children's learning held back by my inexperience in teaching or their inexperience in learning about this subject. I decided to teach pneumatics, and the IDEAs and FPTs as whole class activities and then give more individual control over the design of their monsters.

Getting Ready

I chose to produce a workbook for the children to record their work in. I designed the booklet with one or two pages to complete each session, with the intention of keeping the children focussed on what they should be doing. I left it up to the children whether they answer questions in writing or by drawing with the intention of minimalising the problem of some children being held back in the learning of Design and Technology due to a literacy problem.

Figure 2 Moving monsters project book

Ever the nervous student, I was terrified of not being able to deliver my teaching due to a lack of resources. All who know me were hounded for washing-up liquid bottles and an array of boxes! I also produced an eye-catching letter for the children to take home so they knew exactly what to collect.

I was then inundated with more problems: washing-up liquid bottles that had nozzles too small to fit the plastic tubing that I had found lurking in the resource cellar and cardboard boxes far too large for our needs. The first problem I solved by forcing a screwdriver through the nozzles to widen the holes, whilst the second problem was solved by a very nice manager in the nearest McDonalds who donated 40 burger boxes!

Figure 3 'Wanted' poster

Week by week summary of activities and learning objectives:

Week One (IDEAs and FPTs)

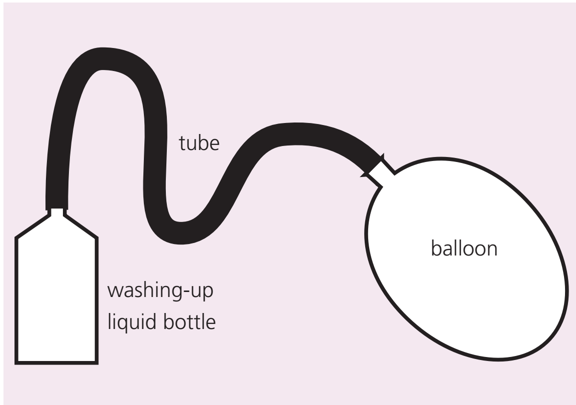
1 (IDEA) Look at familiar objects that use air to work. Why is the air needed? Could you make it work without air?

2 (FPT) Construct a pneumatic system using tubing, a balloon and a washing-up liquid bottle. Can you use it to make things move? How could you improve it?

- Objectives
  - To explain how simple pneumatic systems work using appropriate vocabulary
  - To investigate how air is used in different objects, suggesting how they work
  - To compare the effectiveness of simple pneumatic systems.

As my first introduction to pneumatics, I had gathered together a selection of pneumatic objects such as bicycle pumps and blow-out whistles for the children to investigate. At lunchtime, I had a sudden inspiration of how to demonstrate pneumatics in the real world: I made the quickest model dumper truck ever from an ice-cream carton and two syringes. Because it was thrown together so quickly, it was easy to take apart and show the children how it worked.

I had been particularly worried that the higher ability children would race ahead in their work and the lower ability children would need more support than I had time. To try to avoid this, I seated the children in mixed ability groups. This really helped the lesson to run smoothly. The children gave each other support, and other than a few exceptions worked really well. Some lower ability children surprised me with the amount they did and understood.



The focused practical task (FPT) pneumatic system

Week Two (FPTs)

1 Modify the system. Try using different resources at either end of the tube, eg. balloons, syringes, washing-up liquid bottles, plastic drinks bottles, etc. How can you connect the resources? Which way is best?

2 Decide on the best system to use to create a monster with an opening mouth.

- Objectives
  - To construct effective pneumatic systems
  - To use a variety of techniques for fixing components
  - To decide on a system that best meets the agreed criteria.

For the lesson, I set the classroom up as a circus of activities. There were three activities for each group to do during the lesson, each with a slightly different focus. The aim of the lesson was to use interactive tasks to encourage the children to think of their own ways to alter and improve the system. It was a successful way to get the children working individually to develop their ideas and experience using different materials. Most children got on with the tasks well, although a few would have benefited from individual support. It was a very hectic and noisy session (and I was being assessed by my link tutor – favourably, fortunately!), but I would definitely recommend it as a way of organising Design and Technology activity, even with an inexperienced class, providing the class know exactly what is expected of them and what is acceptable behaviour.

Week Three (DMA)

1 Design a Moving Monster and decide what equipment will be needed.

Children proudly demonstrate their moving monsters

- Objectives
  - Produce a design
  - Choose ideas and resources carefully, taking into consideration time, size and constraints of resources.

Week Four (DMA)

1 Begin constructing monster.

- Objectives
  - To use skills and knowledge gained through FPTs and IDEAs
  - To work safely and accurately using a range of tools, equipment and resources.

Week Five (DMA)

1 Complete and evaluate monster.

- Objectives
  - To present a completed monster and explain how it works
  - To evaluate own work against design criteria.

Designing their monsters proved to be more of a problem than I had anticipated. Producing designs for products prior to making is a substantial requirement of the national curriculum. From my experience on teaching practice and from my book-based research I know that this can be a hard concept for children to understand. It is easy to explain this to a classroom of children as drawing their ideas, but many did not relate the drawing activity to making their monsters. As a teacher it is essential to teach the process of designing and why it is important, children need to know how their designing relates to what they are going to produce – they need to be clear about the purpose behind the task (Egan, 1999). The children seemed to understand their task, and most started eagerly to record their ideas. In looking at their workbooks, I realised that some children did not understand the relationship between their drawings and what they were going to make. Some did not realise that their design had to be based on a burger box and would therefore need a square base. We discussed this and I showed the class some good examples before they continued to design. This is probably the main point of my scheme that needs improving. Ive (1999) discusses erratic progress as being due to 'weaknesses in long term planning and a failure to build on earlier learning.' I knew that the class was fairly inexperienced, so I should have included a session on design, the children needed more input on how to draw a design and include labels and notes as many of them were simply drawing monster pictures.

Display of final products

All of the children produced their final monster with an opening mouth and the overall response to the scheme was good. The biggest complaint from the children was the amount of recording. After looking through the project booklet again I agree that there probably are things that could have been done differently, but with a class this size, written evidence is always going to play a major part in most subjects as it is so difficult to find enough time to talk to and assess each child during the lesson without neglecting someone else who needs help.

Next Time

In delivering this scheme of work I have discovered that being organised is probably the greatest asset a primary Design and Technology teacher can have. The hardest problems I had were organising the resources and finding time to see each child during the lessons. The most important lesson I learned from this teaching practice was that children need to be trained to the way the teacher wants to work

The class usually sit in the same ability groups. When I came in and moved them around for Design and technology, not all of them were keen on the idea, but by the end of my practice they were working well and benefiting from peer support and working with different people.

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Deconstructing the Task: Practical Planning Strategies Design and Technology in the Primary Classroom

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Introduction

This paper explores planning and teaching approaches that enable teachers to examine the practicality of implementing a design and technology project in a primary (children aged between 5 and 11 years) classroom. In it I discuss how teachers can identify the key teaching inputs and develops classroom organisation strategies that will alleviate the stress points that often occur when teaching this subject.

The evidence for the paper is drawn from an extended 'action research' (Lewin 1946) project undertaken with four primary schools in the UK. Bassey (1990) described the action research 'paradigm' (further exploration of the notion of 'paradigms' can be found in Kuhn 1962):

The action research paradigm is about actors trying to improve the phenomena of their surroundings. Inevitably different people define it in different ways but the universally agreed characteristic is that it is research designed to improve action. (13)

Within this context the approach used to gathering data was pluralist in nature. Walker (1985) argued the case for the power of multiple methods.

The power of multiple methods flexibly used should not be underestimated. What at first sight appear to be not very rigorous methods, such as open interview and unstructured observation, become much more powerful when used in conjunction with each other. (83)

The data generated by the above methods was then analysed through a technique called 'reflexive critique'. This process has three phases:

1 Accounts will be collected such as observation notes, interview transcripts, written statements from participants, or official documents.

2 The reflexive basis of these accounts will be made explicit,'

so that

3 *…claims can be transformed into questions and a range of possible alternatives will be suggested, where previously particular interpretations have been taken for granted.* (Winter 1989: 43)

I then illustrated the findings through vignettes:

A vignette has the status of a sketch as compared to a fully worked picture. Invariably interpretative, it is founded on the act of selection of a subject for the vignette which itself constitutes an interpretation, and the illumination of the observation, situation or event by the selection of features whose meaning is determined by the author's interpretative stance.
(Stenhouse 1978: 26)

Within this paper I use some short vignettes to exemplify some of the point that are made. These are intended to give a flavour of the research.

Preparing for the Classroom

In England, despite considerable government support through the development of the national 'Schemes of Work' (DfEE/QCA 1999) and internet based support materials (see, for example, the National Grid For Learning – www.ngfl.gov.uk), many primary teachers still struggle to plan and implement effective teaching for design and technology activities (OfSTED 1999). My work has shown that this is often caused by a failure to recognise the importance of 'deconstructing' the activity for the children by 'backward chaining' (Stones1968). Through this process it is possible to identify which aspects of a project need tight teacher control and direct teaching through 'Focussed Practical Tasks' (FPTs) (DfEE/ QCA 1999a), and which aspects of a project (the Designing and Making Assignment (DMA) (DfEE/ QCA 1999a) can be left more open for children to explore freely for themselves.

The 'conceptual planning' (I use the term conceptual planning to refer to the decisions made before working in the classroom) necessary to achieve these ends requires the teacher to develop notions of 'professional artistry' (Schon 1983: 13), which includes abilities to:

- Deconstruct a project into associated FPTs by backward chaining and, consequently determine the nature and sequence of teaching inputs
- Plan the organisation of the children into whole class, groups, pairs or individual activities based on the learning intentions; recognising that whole class teaching can function well for aspects of design and technology teaching
- Organise and provide resources that support children's learning
- Interact with the children and resources to provide a dynamic learning environment that stimulates children to be creative whilst ensuring that that they progress at the limits of their expertise.

Deconstruction and Backward Chaining

Deconstruction requires teachers to make predictions about the their own activity and the children's activity in relation what they plan. The reality of the classroom is that these plans never run exactly as envisaged. Teachers then need to be reactive and plan actions spontaneously to meet the demands that children place on them (I use the term operational planning to describe this kind of activity.) Calderhead (1987) in exploring the decision-making processes of teachers, describes similar experiences:

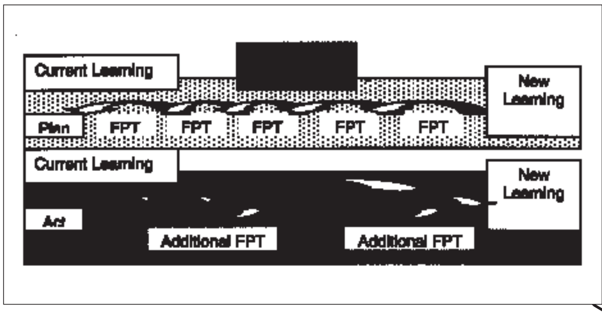
Schools and classrooms are complex environments in which teachers are called upon to play an active, central part. In order to carry out their profession function, and interact meaningfully *with pupils and colleagues, they must develop ways of understanding this environment that enables them to make decisions, and guide their everyday actions. Teachers' decisions again vary in nature. Some are reflective. Decisions about the selection of appropriate teaching methods and curriculum content may be made over a fairly long period of time, require consultation with staff, and involve considerable thought and evaluation. Other decisions are immediate. In the classroom, teachers meet a variety of unexpected situations: lessons don't go as well as expected, children experience unforeseen difficulties, the activities of the classroom are interrupted by sudden events. Such situations demand immediate and appropriate responses to minimise classroom disruption, pupil's loss of interest and failure to learn.* (pp 3 – 4)

It is my view, therefore, that there is a need to plan for the important imposition of a clear structure on the teaching and learning process; this planning needs to address the knowledge and skills to be learned at a specific time. However, when exploring this idea I was initially concerned that imposing such a structure, whilst making the teaching more manageable, would detract from the children's creative experience. This proved not to be the case. The research work evidenced that tightly structured planning enabled children to make creative responses in their design and technology activity. For example, a vignette taken from a post teaching review illustrates the point:
they were being creative …you gave them a lot of input …and they took it as far as they could. I don't think it was a case of 'well I'll just have that' they really thought about it. …it was a very practical and creative lesson.

Further, my work illustrated that an approach which envisaged the UK National Curriculum of FPTs and DMAs as a structure in which a series of FPTs is related to a DMA, was both enabling and practical for the classroom. I used the term deconstruction to describe this process.

I began to feel more confident in taking this idea forward. I found that the ability of children to be creative was due to a number of factors, all of which could be influenced at the conceptual planning stage. These included planning for children to have the resources of subject knowledge and skill, gained through the teaching (FPTs), and the physical resources to hand (an obvious necessity in a practical subject like design and technology); planning for the development of procedural knowledge alongside subject knowledge (FPTs). To deconstruct requires the teacher to examine all of these factors in relation to children's previous experience. Here, backward chaining comes to the fore. There is a need to identify the new learning children are intended to attain and to build links backwards to where they are now, hence the notion of a 'chain' of inputs from the teacher. These FPTs need to planned in relation to a DMA. Without the context of the DMA the FPTs become meaningless. It was the combination of FPTs within a DMA that provided a practical approach for the teacher and the opportunity for children to express their creative abilities.

A diagram will, perhaps, help to clarify this idea.



The teaching plan is an important tool, but being willing to abandon it when it or the teacher or the children come up with something better is also a necessary attribute of a teacher of design and technology. To operationalise the conceptual planning requires teacher judgements that cannot be entirely thought through before engaging with the children. The 'active' section of the diagram illustrates additional FPTs. These are ones that the teacher recognised as being necessary to operationalise the planning. These are equally important in enabling the children to progress. Also, the diagram illustrates two 'blacked out' FPTs. This is intended to illustrate where the teacher has abandoned the original planning and replaced two FPT with a new overarching FPT. The dynamic nature of the subject means that this kind of reactivity is essential if the children are to progress. This is one of the notions of professional artistry discussed above.

The Importance of Subject Knowledge

It is my view that designing and making tasks in which children design and make products that meet previously identified need and wants are the essence of design and technology teaching, but children will be unsuccessful without a repertoire of appropriately taught skills and knowledge. Because of the lack of pupil subject knowledge and unfamiliarity with process knowledge there is a need to teach subject knowledge and procedural knowledge very formally. Further, it is my view that effective teaching in this subject area is built on clearly structured units of work that are developed through deconstruction by backward chaining. These units of work need to develop knowledge and skills in a coherent and progressive manner. OFSTED (2001) have also found this to be the case:
…few still have no coherent scheme of work. Where there are excessively long gaps between D&T activities at Key Stage 2 pupils do not always retain or make use of knowledge, skills or understanding developed in earlier years.

It may be that creative responses in design and technology occur within unstructured situations, but the experience of this research suggest that they do occur within a formal structure of well-taught procedural and conceptual knowledge. In my view, the role of the teacher is to provide such a structure. This is only possible in relation to the child's current level of experience and understanding of the processes involved. The teacher needs to initially identify FPTs that children will need to do to progress their designs, then follow this up with FPTs based on judgements of the children's ongoing needs.

The deconstruction of a task into manageable parts is crucial to effective teaching. It is my experience that where design and technology has been unsuccessful it is because short-term learning intentions are unclear and the management of the learning environment unstructured. To provide a child-centred environment requires more, and better, teacher organisation rather than less. A further vignette extracted from a post teaching discussion illustrates this point:

Children need to know what's expected of them and they need to do a little bit at a time. You have to plan (so that) the children can cope. My style tends to be question and answer, giving knowledge, showing then talking about it and working it through. I think …you give them a variety of things to do in the right sequence. …so they can build up what they are going to do.

The difficulty is that most primary teachers lack personal subject knowledge and skills to be able to make judgements about deconstructing the activity: judging the appropriateness of the activity, deciding which areas the skills and knowledge will be taught first and which will be inserted on a 'need to know basis' is important. My ability to do this was dependent on my subject knowledge and a clear ideological position. The teaching of suitable knowledge and skills, so that children can progress, as well as finding and exposing the children to resources in which useful information resides is a difficult skill and many primary teachers do not have the knowledge necessary to identify these appropriately:

You knew what was needed. Sometimes I think that teachers who are not experts do not realise all the things you do need. In design and technology you are not aware …of what sort of things (are available).

There is in my view a clear need to develop these skills in the teaching community if design and technology is ever to be effectively taught. The latest OfSTED report also pursues this theme:

However, the lack of subject knowledge and experience amongst teachers remains the main reason for pupils' lack of progress. Day-to-day assessment is also a weak aspect of teaching. (OfSTED 2001)

Acting in the Classroom

Making judgements about appropriate levels of teacher intervention is difficult. Even with the most open of DMAs there is likely to be a need for FPTs. If the activity is challenging the children, the teacher's role here is clearly facilitating. As noted above, in open-ended situations, which design and technology as a subject must enable, the teacher often has to intervene to make the activity progress. An analogy is a useful way of explaining this role. If the design process is as an uneven and circuitous causeway that runs from the initial ideas of the child to the finished product – the ideal track is down its centre. In reality the child turns from side to side often getting off track, making false turns, tripping up and often ending up in the sea! The teacher is trying to pilot the child down the most effective route but often ends up as the first aid and sea rescue service. There are difficulties here, however, do you intervene to stop the child falling into the sea of failure, how do you know this turn leads to the sea and not to a better faster track. You do not! Design and technology teaching requires both the teacher and the child to act as arbitrator between various courses of action and making evaluations at every stage. The only way for the teacher to progress is to make a decision and live with its consequences. Just as the child is doing, teaching is a designedly activity relying on value judgements. It is a process in which the teacher is also learner becoming more expert by practising the art of teaching. This position is uncomfortable for somebody whose professional role is preparing the next generation of teachers. However, the experience of the research shows that the conceptual planning described above can aid operational planning.

It is a common experience that children's ability to ideate frequently outstrips their ability to make. There is often a degree of frustration, particularly amongst younger children, in that they wish to make the highly complex models focusing on their initial ideas without thinking through the reality of their situation. Design and technology brings with it the restrictions of the reality of the possible. It is only possible to design and make within the resources of personal skills, knowledge and available. I think that it is a positive feature of the subject as it makes children aware of the realities of the technological world in which we live – technology is not magic. The implication for teaching is that, whilst the thrust is to achieve the ideas from within the possible, there should be a spark in the work that generates creative responses from the children. I would wish children to be in situations where they are attempting to realise their more exotic ideas. A key skill in teaching is the ability to recognise where the critical threshold of frustration is being reached, there is not going to be a creative response, and to intervene appropriately to enable progression. The planning and reacting with FPTs as discussed above can alleviate this situation. These forms of teacher intervention impose the teacher's view of progress and influence the ultimate product. The reality of teaching design and technology is that decisions of this kind have to make, quality teaching comes from making them appropriately.

- *Was the teaching allowing the children to get these ideas out, strive to achieve things, whilst at the same time ensuring they didn't get ever so frustrated because they couldn't do what they wanted to do?* (RB)

- *I think that worked really well.* (Class Teacher)
- *So it possible to do that, to 'push the edge' (of the children's knowledge and frustration level) all the time, whilst not getting to what I'd call 'critical mass', where they (the children) go – 'well I'm not doing any more of that!'* (RB)
- *It worked very well, I was very pleased.* (Class teacher)

Conclusion

I hold an unclouded view that children's creative actions occur within a well-organised, supportive environment. The teacher's role in design and technology is to provide such an environment. The concept of deconstruction through backward chaining can be a useful aid for the teacher in creating this environment. This is one of the keys to professional artistry in teaching design and technology.

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Using Competitions to Promote Children's Design and Technology Skills

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Introduction

Competition-pitting your skill or knowledge against that of another person can either make you sweat in panic in the knowledge that you are going to be made to look a fool or get the adrenalin pumping as you anticipate pride and glory. Whatever feelings they inspire, competitions are all around us, in supermarkets, in magazines and on television, they are part of our way of life.

In school we try to encourage all children to succeed, and because of this competition has at times been given a negative press, you will always get winners and losers and nobody wants to be the loser. On the other hand how do you know how good you are unless you have a mark to measure yourself against? That mark might have to be the skill or ability of another person.

In school we measure sporting success through competitions, musical success is often celebrated too, but not everybody can be successful in these areas. We need to find as many opportunities as we can to allow children the chance to celebrate success and demonstrate their capabilities to a wider audience.

Over the last few years I have found that competitions with a technology bias can offer just such an opportunity for encouraging talents in children that might not receive recognition in other ways. They have also given the school recognition and success at both local and national level.

A Taste Of Success

The first competition that awarded some success to our school was organised by the local council. As part of an environmental awareness campaign they asked schools to design posters encouraging people to use litterbins. The challenge was presented to the whole of year 3 and year 6 who were involved in environmental topics at the time and we entered each child's poster. As a result the children won a litterbin for the school playground and several children won individual prizes of gift vouchers at a local department store. It later transpired that only three schools had made the effort to enter the competition! This started the ball rolling.

A Focus For Young Engineers

Competitions involving Technology are a good way of channelling the children's interest and they have been a useful focus for the Young Engineer's Club (YEC) that takes place after school each week. Apart from the obvious incentive of a prize at the end there is also the challenge of solving a problem in some way.

The club was initially set up with the help of the Science and Technology Regional Office (SATRO) At first we extended the technology activities already taking place within school but the children were soon asking to do other things.

The BMFA organise a model plane contest each year that is open to youth groups. There are three types of model aircraft that the children can make, and these are sold very cheaply in kit form by the association. We purchased several kits that the children made very carefully. We held our own competition in the school playground but decided not to enter the area competition. The children had just as much fun making the kits and competing against each other.

Each time when we seem to be having difficulty generating ideas for the club, a competition presents itself.

K'nex Challenge

Last summer the YEC was invited to take part in the K'nex challenge. The children had to design and make a fairground ride out of K'nex. On the day of the competition they would have to make their ride in one and a half hours and would not be allowed to use plans. We got into competition mode!

The children sketched their ideas on paper using ideas from rides they had seen at amusement parks in the UK and America. They looked at pictures of fairgrounds and thought about ways of incorporating a mechanism to make the ride turn around. This wasn't a requirement of the competition but we decided to make the best ride we could.

The children came up with two completely different ideas, one based on a Ferris wheel and the other, best described as two spinning rockets. Although the children worked in two distinct groups to develop their designs, they eagerly offered advice to each other. The older children helped the younger children to make their base more stable by strengthening the structure.

Once the children had completed their designs they worked on perfecting them and then began practicing building them from scratch to see if they could manage in the time limit. They built and rebuilt them, allocating different tasks to each team member so that it could be built efficiently. We even practiced against the clock one weekend.

On the day the children felt confident. They certainly appeared organised as they quickly and calmly built their models. They were interviewed by the judges and were able to talk about how their designs worked and how they had developed them. The group with the spinning rocket won, their innovation and their confidence in explaining the model gave them extra points on the day. The prize was a solar powered K'nex kit for the school and a place in the regional final, the winner of which would go through to a final in London.

At the regional final, the children did not fare so well. This time they had to build a time machine incorporating a mechanism.

They were not told of the subject ahead and found it difficult to work as well as they had before. However they were far from disheartened and enjoyed the day. When asked about not getting through to the final, they were pleased enough to have got as far as they did. In fact they were keen to enter other competitions.

Television Celebrities

Our most recent venture was even more exciting. Techno Games, a programme screened by the BBC was shown in March 2000. It really caught the children's imagination.

Techno Games is a competition where robots compete in Olympic style events such as swimming, sprint, climbing and jumping. The children were interested in entering but we didn't do much about it at the time. Later in the year around September time, one of the children in the YEC sent off for the registration form. The children needed an adult to be part of their team so I agreed, telling the children that as I knew nothing about robots they would have to do all the work! The Techno Games project became the focus of the Young Engineer's Club.

Initially we only had the rules from the previous year so began to look at the events that had taken place before. The children were keen to enter the swimming race but I wasn't very sure about getting a motor to work in water. I thought the sprint might be easier. As we couldn't decide, the children began sketching ideas for both.

When we received a copy of the rules we discovered that there were new events, one was the 'relay'. This event was recommended for junior teams and consisted of a team of three cars designed to carry a standard runner's baton. Entrants in the race could use commercially bought cars or cars made from kits. One of the children owned several cars and we had a couple at home so this race had a certain appeal already. The skill of the race would be the children's driving and the ingenuity of transferring the baton from one car to another. This was the event we decided to go for.

I was extremely impressed with the support offered by the production team at the BBC. On registering we immediately received a 'welcome' telephone call giving us various contact names and numbers, in particular that of the technical advisor who was available at any time for help and information. We were informed that filming would take place in December which gave us about 8 weeks to prepare but at that point we were still under no obligation to commit to entry, so there didn't seem to be too much pressure.

As a group we defined the tasks ahead of us: we needed three cars in good working order, we needed a way of transferring the baton and we needed to brush up on driving skills. From the collection of cars we chose the best two and used the funds in the club to purchase another kit. Building a car from scratch was one of the most useful things I did. It enabled me to gain an understanding of the workings of a remote control car in particular what a servo was and how it operated. When things started to go wrong with the other cars I was actually able to help the children repair them.

The Young Engineer's sessions divided into two parts, driving practice and developing a way to pass the baton. Ideas for the baton change ranged from a grabbing device to a tipping bucket. The grabbing device quickly proved complicated, so we kept it simple and went for the bucket.

First the children tried their ideas out in paper and card, after some trial and error the bucket developed into a slope with a hinged board at one end to stop the baton sliding off. The slopes were staggered in height on each car using gravity to help move the baton. When one car drove up against the car in front it would knock the hinged board allowing the baton to roll down onto the next car. To test the idea, the children tried it out in foam board first with the hinged board held on with masking tape and elastic bands allowing it to spring back. Amazingly it worked first time, we actually began to worry at this point that it was too simple and that something more complicated would be required.

The foam board proved to be too soft so we looked around school for a stronger material and found that corrugated plastic was the answer it was strong, light and also colourful also we had a good stock in school! We found some small springs in amongst the science resources, which were stronger than the elastic bands and at home I had a large box of Meccano, which we used to build the framework to hold the slope above the car body.

Once the idea was established the children spent most of the time brushing up on their driving skills. This was not as easy as they thought it would be and it soon became obvious that lots of practice would be needed. Cars started whizzing up the corridors after school, the hall was transformed into a racetrack; and when the weather was fine we transferred out onto the school playground. However, we couldn't make a race track the size of the 50 metre track of the competition so I approached the local leisure centre who generously offered the use of their large gymnasium free of charge.

The chance to practice so frequently had many advantages but there were also disadvantages; problems occurred and had to be solved each time. We found that the height difference between the cars had to be exact otherwise one car could not push the hinge down enough. To compensate for this we added small triangles of meccano which added leverage. On some occasions the baton fell off the slope when cornering so we added sides (the children suggested a jagged 'go faster' look to add more style). The switch on one car stopped working so all the switches were changed for electronic ones.

We had one serious problem that had worried me from the outset; the handsets for remote control cars are operated using interchangeable crystals so that each car can run without causing interference to another car. In the rules it was stated that the frequency for running the controls should be 40 MHz FM which offer a choice of about 40 crystals. This is less likely to cause interference when several cars are being driven at the same time, an important consideration when each team has three cars. However, most cars are run on 27 MHz Fm, that only has a choice of 6 crystals. We needed to change the handsets and servos over but at a cost of over £100 for each handset it was going to be prohibitive. At this point I contacted the technical adviser at the BBC he was very helpful and after some discussion agreed to allow us to use less expensive AM sets. The kit we had bought with the club funds ran on a 40MHz AM set so we only had to buy two more. Had this not been allowed we would probably have had to withdraw from the competition.

The Big Day

We had worried that we wouldn't be ready in time for the competition. However, when we arrived on the day we found that although there should have been 11 other entrants in the relay race only two other teams were ready to compete alongside us, a team of students from Hertfordshire University and a team of year 10 girls from a high school in Northern Ireland – we were the only junior team. The girls' team had worked on a similar idea to ours, they had used gravity to move the baton but had it sliding through tubes with a hinged 'gate' at the bottom. The university team had used the alternative idea of a grabbing hand to hold the baton. It also transpired that they were regulars on the BBC Robot Wars programme so we were definitely up against the experts.

The whole day of the competition was very exciting for the children. The two boys in the team are both relatively quiet and unassuming, but they rose to the occasion well. They were interviewed in front of a camera and were able to describe their vehicles and how the designs had been developed. They spent most of the morning talking about their robots to a variety of different people. After lunch we were called for our event. The rules had been changed slightly, the event was now to be timed and the fastest team would win. This gave the boys a better chance. I felt they would be under less pressure and as they were called first, it meant that they would be able to relax and enjoy the rest of the competition. We had decided ahead that the boys would do the driving, Richard the team leader was to drive the first and third car, Chris would drive the second. I was on stand by to place the third car in position on the track ready for the change over.

All seemed to be going well in the race. The first car, our biggest and most stable completed the circuit in less than 20 seconds, changing the baton quite smoothly. However the second car didn't quite line up as accurately and the third car took off too quickly resulting in the baton falling off. All was not lost, the boys were allowed to pick up the baton but were penalised with a 10 second time penalty. Losing the baton in this way had never happened in the practices so the boys were quite unprepared. However, they finished the race in 1 minute and 38 seconds but with the penalty added on it made the finishing time 1 minute 48 seconds.

The second team looked very good, but as their robots were very tall they made the vehicle quite unstable and therefore had to be driven slowly. They also had problems with one of their changeovers that resulted in a time of over 2 minutes. We knew then that we had at least earned a silver medal.

The third team were expert drivers they were also very accomplished at manoeuvring their robots. They managed a time of just less than 1 minute.

The children were extremely pleased and proud of their efforts they had achieved a great deal in a very short space of time.

The whole experience of Techno Games was a very positive one. The ethos of the competition was one of having fun and 'having a go' was emphasised. Whilst at the film studio, the children received constant praise for their efforts. Genuine interest was shown to them by a range of 'experts', and this was very rewarding for the children.

Back at school the children were instant celebrities. The success was announced in assembly where the children drove their robots in to show the rest of the school. They were featured in the local press but were unable to show off their medals or give away the place they had gained as the programme was not planned for broadcast until March 2001.

Of course when the programme was on television the whole school was tuned in. We had to wait until the end of the second week to see our event but the series of programmes generated so much interest from all the children in the school that they were coming up to me daily to talk about the events of the previous night.

The Effect on the School

Although only two children were able to enter this competition, it has inspired a tremendous amount of interest throughout all ages in the school. Suddenly technology is really rated. The quality of the models brought to our celebration assembly each Friday is wonderful. Children spend hours at home making models to share and we see every form of construction kit imaginable. There is a queue of children waiting to come to Young Engineers next year.

Competitions have definitely had a positive effect on the profile of technology within the school,

The day after the robots had been shown to the children in assembly one younger boy came to me with a sketch that he had done at home. He had thought of a way to improve the design to stop the baton falling off again and explained where he thought we had gone wrong. He had obviously spent hours thinking about the problem and sketched and labelled his diagrams to explain his solution. Look out for him on next year's Techno Games. I have a feeling he will be on the team!

The six year old child and the difficulties associated with choosing materials

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Introduction

Primary school teachers devote part of the school time to activities that involve making objects. These activities are introduced through small projects presented to pupils at key times of the school year: Christmas, Mother's Day, Father's Day, April the 1st, school fete, etc. The project starts with a dialogue. It enables teachers to pass on quickly to those questions of how to achieve it, even to look at it from different angles to focus the activity on the production that they have in mind. With regards to the teaching of technology, we prefer the notion of realisation to that of production, which is better suited to its anthropological – Leroi-Gourhan, (1994); Haudricourt, (1988) – epistemological – Perrin, 1988 – and didactical dimension – Ginestie, (1999); Hostein, (1998); Lutz, (1999). For indeed, the focus of the activity centred on production, does not allow pupils to free themselves of the constraints imposed by the teacher. They must make things as they are told and in the time given. The very limited contact does not give pupils enough time for them to give meaning to the activity – Chevallard, (1991). They carry out instructions more than think over, anticipate and understand what they are doing. The activity is positive in so far as it is manual and engages the children in play. However, it has no real value technologically speaking – Chatoney, (1999); Lutz, (1999).

The meaning is revealed in linking the activities of conception, production and usage in the process Ginestie, (1999); Lutz, (1999); Benson, (2000), Chatoney, (1999). To examine this question, we have chosen to focus on a concept which, from the very beginning, occupies a central place within the rapport between the CPU – conception, production , use and the materials. Traditional practice in France does not address that question of choice of materials. This is because materials are distributed at the time of production, just in the right quantity and chosen beforehand by the teacher. They are sometimes physically named and identified. Pupils come across the material during the production phase, that is at the time of using the material technologically.

The concept of material is enriched by technical knowledge. But the relation between the CPU does not take place. Some teaching objectives, such as the specifications, the choice of materials, the search for technical solutions, are reached through the management of the three components. The preliminary study of the project puts these objects in a different light, according to the direction the teacher has given to it. In this framework, the devolvement of tasks regarding the choice of materials forces the pupils to make a link between conception, production and use. Which techniques and which engineering allow the devolvement of this type of task?

During previous observations of how pupils tackle at first the concept of materials, we have observed that pupils recognise without any difficulty common materials, such as wood, soil, glass, paper, plasticine, plastic, textile, iron. If they show that they can recognise the main generic families, they cannot distinguish between the subtleties within a given category, eg. metals are all iron. The property of the surface, its reflections and its treatments are obstacles, for example china / porcelain is made of glass, the iron door made of wood. On the other hand, physical properties are a means of identifying the material – it does not hold together, it flows for liquidification, or it stretches and returns to its original form for elasticity. The function of use helps the choice, for example, the wooden spoon does not burn when used to stir with in a pan. Pupils refer more rarely to the technique of shaping it – "we have done something to this one" for its use, or "we made balls, we roll them up, and then we let them dry, for the process of shaping it. They give to this shaping of materials aesthetic and pragmatic reasons. What is it used for? for putting away, for capacity, etc.

Starting with those indicators, we have examined the way pupils, involved in a project of making something and put into a situation of interacting with its design and a choice of materials for artefacts, choose the latter. We will develop this second study in this paper. We will present the framework for this research followed by the different elements of the experimentation carried out, and the main results that have been drawn from it.

Making of technical objects at school

The introduction of the teaching of technology in the compulsory school programme aims at increasing the understanding of the world of technical objects by pupils from pre-schooling to the study of technology courses. At primary school (from the age of 5 to 11 years) where the distinction is made, it has the objective of distinguishing between disciplines progressively. The first two cycles put the pupils in a wide and general association with the world. This association groups together different subjects: human and social science, life and earth science, physics, chemistry and technology. The making of an object or of a model, the use of an object or of a system – IT – the acquisition of gestures and techniques, and the knowledge of the variety of common materials, constitute the focus of that teaching. In the school context, the world of objects can be introduced by the study of those existing objects, or of models, as well as by completing projects. In an epistemological perspective, through the research work of Leroi-Gourhan (1945) this indicates that, from its origin, the technical object answers a need and is associated to its practical use. The object completed at school has particular functions, called in technology, functions of use. Other functions, such as appreciation and technical functions, determine also its practical use. To identify them and to represent them through a first design of the project to be completed is the first stage that enables the child to define what is to be achieved. It is the first step that allows the child to think of that object. Once the object has been defined, it will have to be made. The rapport between the definition of its function and its actual production goes through the management of the pragmatic constraints with materials, and of the equipment used to make it. For psychologists the relations between the object, its function and the material used are not neutral. From a very early age, the child acts, observes, identifies and classifies objects per category Piaget (1927) according to criteria which are more or less intuitive, or other criteria which are more pragmatic – Carbonnel 1982, Andreucci 1990 – Our first experiments confirm the pragmatic criteria, such as physical properties and grouping by association that belongs to a particular category, and we add classifications by technical properties and by frequent associations with the functions of an object. This leads us to say that pupils, with regards to technical objects, weave a network of connections between object, material and function. They make a link between function and choice of material, without necessarily explaining the constraining in choosing the latter. Thus, they associate the properties particular to some materials and have a tendency to consider that glass is fragile because it is transparent and that it breaks easily, or that metal is more or less rigid, which is true. All those many properties are rooted in concrete and practical experiences and allow them to know that one cannot make an object, which is supposed to have a particular function, with just anything at all, for example the function of "driving a nail in" with the head of a hammer made of glass or that of "controlling a liquid" with blotting paper.

Materials

The concept of materials is widely used in technology. Materials are natural or artificial objects. They owe their existence to technical intervention. They are obtained by a series of reasoned actions that through successive transformations, owe also their existence to human intervention. Therefore, just as for the technical object, it is the meaning given to the techniques involved which enables to specify that concept of material – regarding size, cutting, intertwining. The material is determined by the shape already given to it and by its very property. This pre-determination is a constraint that the maker will have to consider at the time of choosing the material best suited to the situation. The maker cannot choose a material, already damaged and torn, to use as a wrapping, nor a conductive one to isolate a circuit without taking precautions and/or bring modifications. The choice of materials is a delicate stage in this process, a stage during which the person will have to consider the functions of the object, its use, techniques and value, the medium in which the object will be made, the materials and skills of the person, and the stock available, in accordance with his/her epistemological development.

Hypothesis and methodology

Our previous research show that on one hand Year 2 pupils identify materials by broad categories, such as wood, plastic, iron, if these are presented through palpable objects, found in nature or made by man. On the other hand, the identification of the material does not lie exclusively on its shape and colour, but on pragmatic criteria such as properties for its making and its use. These various observations have lead us to the following hypothesis. If one gives a task which involves the choice of materials, introduced by a situation that is rich enough and aimed at giving choice, in which the pupil will have to think about the object, to imagine and interact between the representation of the project and the pragmatic properties he/she attributes to the materials, then the situation is dependant on the artefact which promotes articulation, conception, production and use. The language of the objects available is a particular artefact that will help the pupils in their choice, as they do not read fluently yet. The experimental investigation was set up as follows:

- Place: the observation of pupils was carried out in two Year 2 classes in June 2000
- Sample: six girls and six boys were chosen at random in those classes, without considering whether they were 'good' or 'bad' pupils. But just according to those available and chosen by their teacher, while he/she carried on normally with the rest of the class.

Methodology of the operation

Those being monitored were invited to observe closely the drawing of a vehicle made by a pupil of a Year 3 class, as to be put in a situation of carrying out a project. The researcher explained what the experiment consisted of and noted down his/her observations on the techniques that were developed and on the propositions for choice.

The graphic representation was very figurative. It brought out many details: monospatial type, round body, side doors, roof aerial, bumper, driver and children at the back. It showed a wrong perspective for the bonnet, which is typical for children of that age.

The subjects were assigned two different tasks. All were invited to extract from a group of materials what they would need for making that vehicle and give the reason for their choice.

Experimental task 1 *"I am interested in what children like you know regarding what objects are made of. I am going to ask you to choose materials to carry out this project, but it is not a marked assignment, not a test. If you do not know how to do it, it does not matter. Just tell me that you do not know, instead of making anything at all."*

In this project, half of the sample was invited to observe closely the drawing and to feel the materials, then to select them and give the reason for their choice.

Experimental task 2: *"I am interested in what children like you know regarding what objects are made of. I am going to ask you to choose materials to carry out this project, but it is not a marked assignment, not a test. If you do not know how to do it, just tell me what you do not know, instead of making just anything at all".* In this second task, the other half of the sample was invited like the others to observe closely the drawing, to express verbally what the functions of the drawn object were, then to feel the materials and finally to select from the stock and give the reason for their choice.

The researcher noted the answers given, the procedure which was followed, the time devoted to the choice, and other observations.

The stock was put together in such a way that it offered a variety of materials from different categories. Plastic materials: PVC, Akylux, opaque plastic film, transparent film, moss, semi-rigid rush, drinking straws, rubber bands. Paper materials: corrugated cardboard, decorations, cardboard in a wheel and cylinder shape, thick ones, coloured drawing paper. Metals: brass threads, iron plate, wire, copper tube, pipe cleaner. Wood: swivel pin, tooth-pick, skewer, tile and board of balsa. Fibres: string, bits of wool, material. They all made up the basic stock. Contrasts were added with colour, thickness, length, etc. We deliberately avoided stratified materials and electric wires, which are made up of several different materials.

Results

Many findings appeared

Pupils agreed to participate in the task without any difficulty. Putting them in charge of it was very exciting as far as they were concerned. They carried it out very seriously. The idea of participating in a partial project – compared to the technological enquiry – was not a problem for them. They participated in the task knowing that they will not own the object made. What they liked was to be involved in it because the activity in view was different, probably less academic.

In the two experimental tasks, pupils had to explain the reason for their choice – see table1 – Explanations are not always given. In both tasks, six pupils only gave explanations, two boys and one girl in Task 1 and the opposite in Task 2. On the other hand, the researcher found that they were formulated at the time when the pupil felt, that is to say, was in contact with the material. To identify them by touch determined the final choice and produced the explanation. For the others, the choice is associated with the element of the vehicle itself. To name that element is sufficient to justify the reasons for their choice.

Two pupils reasoned out in the same way in Task 1 and only one of them in Task 2 – table 2 – all of them were boys. For them,

Table 1

Task		Explaination		Solution	
		Yes	No	1D	3D
	G	x			x
			x	x	
1		x		x	
	B	x		x	
		x			x
			x	x	
		4/6	2/6	4/6	2/6
	G	x			x
2		x			x
			x		x
	B	x			x
			x	x	
		x			x
		4/6	2/6	1/6	5/6

Table 1 Connection between explanation and solution

Table 2

Task		Explaination		Solution	
		Yes	No	1D	3D
	G				
1		x		x	
	B		x	x	
	G				
2					
	B	x		x	

Table 2 Subjects who used the mosaic technique in the two tasks

the task was not that of making a running vehicle on the ground, but a one-dimensional task, a mosaic poster, what we will call mosaic reasoning Those pupils took the material and super-imposed it to the drawing. The material that was the nearest to the shape and that could be moulded by the pupil is the one he/she chose. Two out of three gave some explanations.

There was a greater number of pupils, given Task 2, who were ready to fulfill the task in a three dimensional way. For indeed, 5 pupils out of 6 in Task 2, thought of it as a running object, while only 4 out 6 in Task 1 thought the same. We noted that the transport of people, and the transparency of windows appear more in Task 2. The time spent in choosing was longer than among pupils given Task 1.

Conclusions

The results of this study show that the multiplication of artefacts play an significant role in the choice of materials. Indeed, artefacts, design, functions and materials encourage the making of tri-dimensional objects. The role of artefacts was to be foreseen when taking into consideration cognitive ergonomics. Our experimentation indicates that some do better than others according as to whether the task is one-dimensional or not, and that some artefacts can be an obstacle.

Pupils who were asked to give verbally one or several functions, completed the task better than the other group, but they chose more slowly and gave less explanations.

The presence of the artefact drawn on paper appeared to be an obstacle for half the pupils. Several hypotheses are put forward. The first is to do with the stage in the child's development and comes from the 2-dimensional drawing. Maybe, it would have been necessary to have a reduced model at one's disposal for that type of tasks. There could be several possibilities:

- We can actually imagine that if the drawing has with it a reduced model, pupils will not be able to highlight the function of transport. For indeed, a reduced model runs but is not designed to transport people. This leads to the following question: is it more judicious to take a cart whose function of transport is visible to six year old children?
- Conversely, the drawing, with its reduced model allows them to look only at the function of movement. Is it more judicious to look only at this function of movement, before combining it with the function of transport?
- The choice of artefacts is an essential aspect for the task to be carried out. The one-dimensional drawing is an obstacle for some pupils and may come from school practices that favour that kind of work, such as posters, frescoes, decorations and wall collages, instead of the making of 3-dimensional objects.

The task must take into consideration school practice – Bourdieu, 1994 – the task, the class, and other considerations and practices unknown to the researcher, or else be put into its context very strictly, thanks to artefacts as work tools. In Task 1, the choice of material is faster and less pertinent than in Task 2. The identification of functions is a tool that enables the imagination to concentrate on the object itself and on its functions-that is to say in the context of its use. The connection between function-material-object during the choice of material puts the pupil in a situation that articulates various elements of conception, with the aim of producing and using that object.

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Developing design

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Introduction

Using a design based approach to teach technology has recently been implemented in the primary schools' curricula in New South Wales, Australia. To effectively utilise the design approach it is important to understand how students' learning occurs. Hope stated in 2000 that design has been identified as an association of drawing, problem solving and devising solutions (Hope, 2000).

McCormick and Davidson (1996) state that designing was seen as problem solving. An evident problem is recognised and a solution is designed to solve this problem. Design can also be a set of skills, where there is no evident problem. It is then defined as the ability to generate design ideas or evaluate ideas.

Design, defined by problem solving, applying skills and knowledge, decision making, being innovative and inventive, should be at the core of technology education. I will give insight into how a design based approach to technology can be used, to assist students' motivation and achievement. My findings are generated from research conducted in a NSW primary school during 2000

The main issues addressed are:
1 How do students go about designing?
2 How can design skills be enhanced?

Teaching students how to create suitable design sketches and drawings was an area of vital importance as identified through this research. I will address how students can develop their ideas further by developing basic drawing skills, how these communicative skills enhance not only their design process but also their design ideas.

Technology education in Australia

Technology plays a significant role on the future of Australian citizens, thus the need of technology education in Australian schools is crucial. Principals, teachers, parents and children have all noticed the importance of technology education, ranking this area fourth in eight identified learning areas, placed behind English, Mathematics and Science (ASTEC, 1997). Principals and parents also agreed that developing an inquiring mind and problem solving skills were the main goals of technology education. The skills include:
- Creativity and innovation
- Knowledge and understanding technological concepts
- Linking and applying what is being learnt to everyday life.

Principals and teachers also speak of how this learning area is a useful means to generate enthusiasm and motivate students. In their classroom, technology education assist the students in achieving literacy and numeracy, especially for students of non-English speaking backgrounds.

Most educationalists agree that technology education assists students in developing life skills in the form of inquiring minds, analytical skills, the ability to solve problems and the capacity to innovate (ASTEC, 1997). It is important that students have positive experiences of technology education in their early years of schooling so they will have a desire to learn more and be encouraged to enter into technology oriented careers. In most western countries children spend about seven years in primary school, that is about half of their time in formal education. Research shows that students are eager to learn in science and technology. They also appear to be capable to learn effectively in this area. Their abilities to think abstractly and to design creatively may have been underestimated in the past.

In the late 1980s the Education Reform Act brought technology into clear focus by providing greater emphasis on technology education as a subject, independent from science, home economics or industrial arts. Although the term 'technology' had not been previously used in the primary curriculum, it had been a part of the course through art, craft, applications of social science, social science and many other aspects of the curriculum. Through the document 'Excellence and Equity' technological literacy has been integrated into the new course Design and Technology in Secondary and Science and Technology for the primary curriculum. The connection between Science and Technology is broken in the secondary curriculum and becomes linked with Applied Studies which includes subjects such as Applied Design, Food Technology, Textiles Technology, and Computing Studies.

It is essential that a technology education programme is enriched by practical learning activities. They should be focussed on decision making and problem solving skills as well as further develop creativity and innovation.

The technology learning area provides opportunities for girls and boys for a fair chance at learning where neither gender is advantaged or disadvantaged. Rogers (1998) found there were no obvious differences in attitudes and participation between girls and boys when conducting design, make, appraise tasks for 307 students in junior primary school in South Australia. Boys and girls displayed a similar range of creativeness and complexity.

In reaction to the need for change within Australia's education system in Technology studies, there has been a progression away from skills orientated, materials based courses towards design-based courses (Kent, 1992). Design education is an important part of new curriculum trends as the focus shifts towards education for the future rather than job training (Fritz, 1994a).

In the early 1990s there was an emphasis on the abolition of gender-based subjects and a re-analysis of the relevance of content being taught within schools. In primary schools components of design and technology have always been a part of the curriculum but previously it was not recognised as a distinct area. Now design and technology has been given formal recognition.

In New South Wales technology education at primary school level is combined with science to form the curriculum area Science and Technology.

What is a Design Approach?

An important aspect of technology education is what has been called the 'design approach' which is a major interest of this study. The design approach to education has teachers setting a challenge for their class in the form of a design brief. Design briefs are used to outline the activity and inform students about the information they need to complete the activity. The concept of design is incorporated in primary technology education with a strong emphasis placed on the generation of a range of solutions, reflection and responsible decision making. Design is defined as *'the process of decision making and problem solving to determine the attributes of a product of the made environment. As there is more to design than just aesthetic and functional aspects.'* (Taylor, 1990).

Design

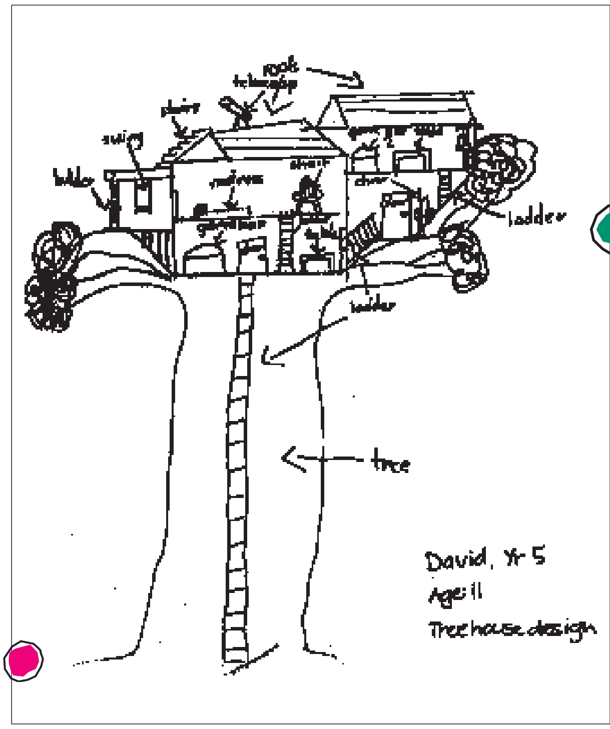
Design, as defined by problem solving, applying skills and knowledge, decision making, being innovative and inventive, should be at the core of technology. Teaching through problem solving encompasses the three key features of children's learning that will help in teaching from a design and technology approach. The features identified by Ritchie (1995) are:

- Children learn from experience
- Learning is an active process
- Learning takes place in a social context.

Fritz (1991) explains that design is a process that involves the consideration of available resources and technologies. Designers utilise these resources to provide a design solution that meets perceived needs. The design process also involves planning and evaluating. Garvey & Quinlan (1997) claim *'designing is not simply drawing and needs to be practised within the context of the designing and making process'* (p.40).

Drawing

The NSW Science & Technology K-6 syllabus considers: 'representing ideas by modelling and drawing' as a means of generating and selecting ideas which best meet the design task objectives. Thus, drawing in Science and Technology is used to enable students to analyse, formulate and convey their ideas. It allows students to explore their ideas and evaluate the materials, properties, structure and mechanism of a product (Bottrill, 1995). Thomson (1998) explains that drawing for designing is different to creative drawing, where the students draw freely and imaginatively. Drawing for designing would be of an item that can be made and that has a useful purpose. It is important to note that the drawing is not the final product, it represents the intent to make (Hope, 2000). Design has been identified as an association of drawing, problem solving and devising solutions.



Design Process

Design processes are used within the primary curriculum for technology education. There are many different versions of the design process reviewed in current literature (for example, Fritz, 1994b; Garrat, 1996; Haylar, B et al., 1995; Hutchinson & Karsnitz, 1994) however all incorporate the steps: design, make and appraise (DMA).

The Australian Education Council (AEC) (Curriculum Corporation, 1994a) developed 'A Statement on Technology for Australian Schools' which describes the nature and content for the Technology learning area. The four independent strands identified were:

- Designing, making and appraising (DMA)
- Materials
- Systems
- Information.

According to this statement, all learning in technology involves DMA where students explore, apply and develop materials, systems and information. Johnsey (1997) lists procedural skills that students use and develop as they design and make from as young as kindergarten aged children. These skills include investigating, identifying needs, clarifying, specifying, carrying out research, generating ideas, modelling ideas, planning and organising, making and evaluating. Design process skills involve creative aspects as well as critical or analytical aspects. Strategies of observing, problem solving, decision-making and team working are also involved (Newcomb, 2000). Complex thinking is required in the design process in the response to design briefs. This requires the use of both declarative and procedural knowledge. Declarative knowledge is static, quickly acquired, basic units are easily modified and declarative knowledge does not readily direct actions. An example of declarative knowledge is learning the names of woodworking tools. Procedural knowledge is dynamic and slowly acquired. Basic units are difficult to modify and procedural knowledge can impact on actions within various situations (Gagné, Yekovich & Yekovich, 1993). In relation to Design and Technology procedural knowledge would involve developing insights into the nature of the design process.

Complex thinking is necessary for Design and Technology students because it enables students to become competent in the tasks they are required to perform. According to Francis, Hill and Kay (p.6 – 7, 1994), if design and technology students are to become competent in complex thinking they need:

- Opportunities which will give them first-hand experience in tasks which require such mental activity
- To be made aware of, and able to describe, the declarative knowledge and procedures being used
- To be encouraged and supported in becoming reflective practitioners who can monitor and direct their own thinking and actions.

Teachers need to consider activities where students are developing skills of awareness and the ability to recognise problems and opportunities. They also need to help students to move from this level of awareness towards reflection.

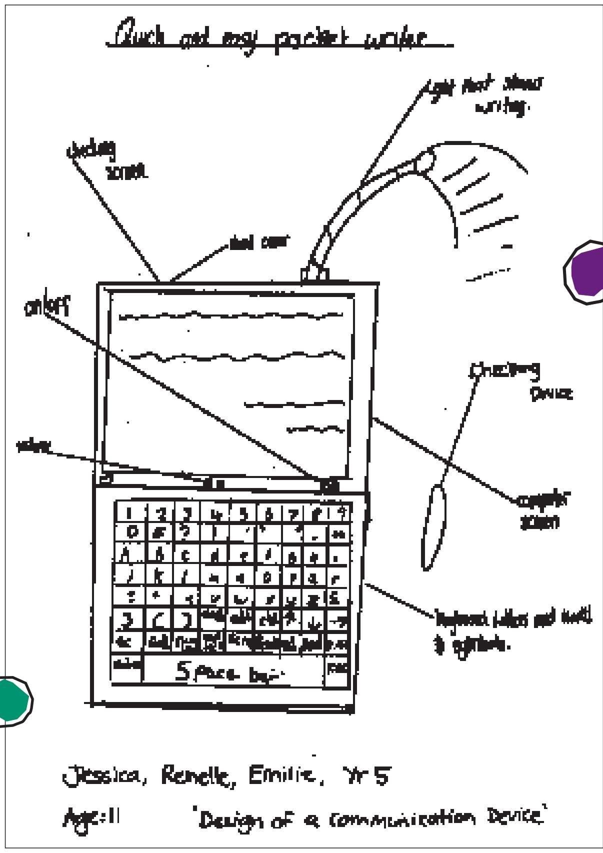
Evaluation

Evaluation is at the focus of the whole process of design. Students are encouraged to reflect on each action and each decision taken. According to Fritz (1991), this mental habit will become one of the most important outcomes of technology education. Evaluation is used to ensure that the standards of technical skills achieved during the course of studies are high. At all times the techniques must fit the material and the quality of the outcome must meet the needs of the application.

However a recurring problem with a design process is that teachers treat it like a way of working or a series of steps to follow like an algorithm, where the aim is to finish making a product (McCormick and Davidson, 1996). Students will not realise the value of a design process in helping them come up with an ideal solution to a design problem if the focus is on making a product. Learning which occurs through using a design process, would be ignored in favour of having a product to take home.

The curriculum does not have to be structured and systematic, in fact this hinders students' learning. The use of a design process works well in technology education. It can be achieved by primary students and caters for individual learners. Primary school students are given the basic skills and knowledge required for the task; they are not expected to solve a design problem without any background knowledge. This method is most suitable for students because it allows for all ranges of student abilities, interests and ideas.

More research needs to be done about students' methods of generating designs and how teachers of technology can assist these students to develop ideas.



So, how do students go about designing?
Research into methods of design carried out in NSW primary schools during 2000 found that students design through personal and social comparisons made in drawing designs, design problem solving and thinking of design solutions. Findings showed that students believed design drawings improved when needs were identified and ideas evaluated. Personal and social comparisons, task values and design process strategies affected the way

students designed. Most students preferred drawing and developing solutions based on their own needs. Some students compared their ideas with others in the class. Overall students felt better about designing when they had carried out the strategies in a formalised design process. Utilisation of a design process also determined how the outcome was achieved.

The methods students used for designing are multi-faceted. Personal and social experiences, utilisation of a design process and the context students work in, all impact on how students design.

Students felt they worked better in groups during the early conceptual stages, after ideas where developed, they preferred working on them individually.

Results

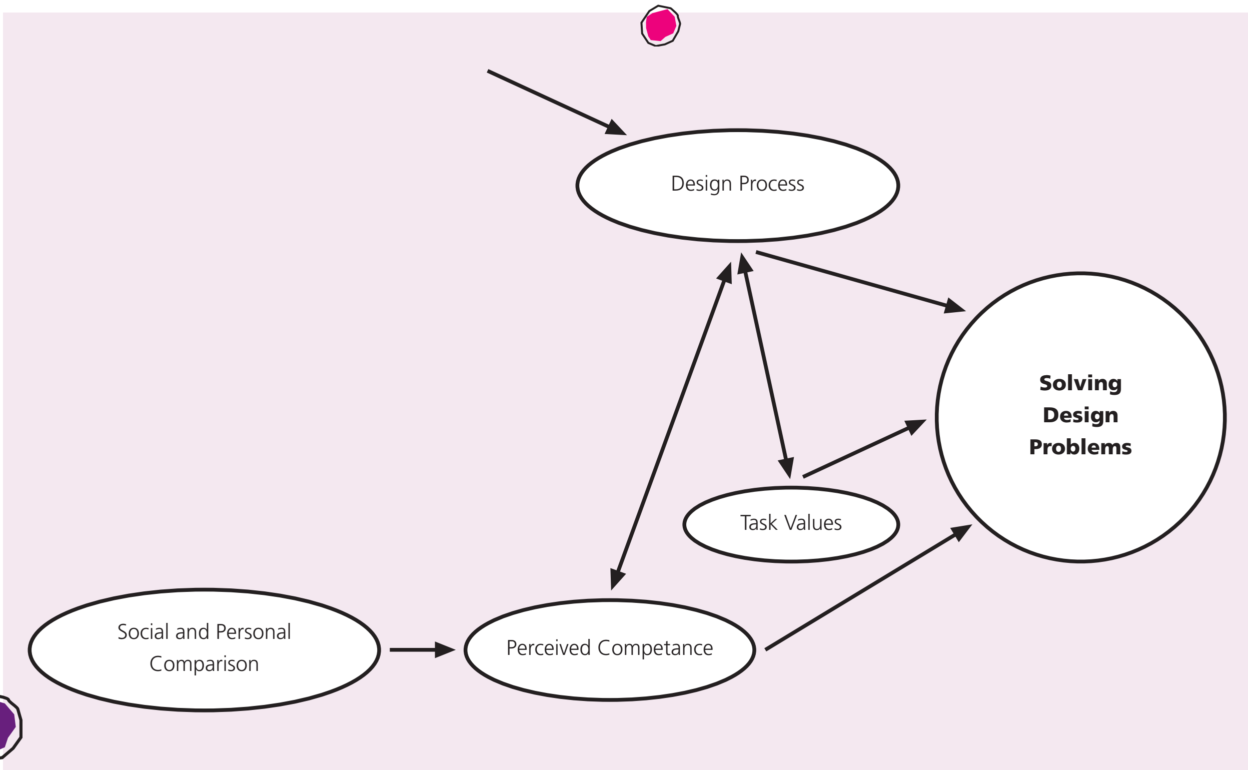
The children's responses to the Design Strategies Questionnaire are described in Table 1, Appendix 2. The results show that the survey items created internally consistent scales and that self-evaluations about design vary considerably across five-point scales, from inspection of the range and standard deviations (SD).

On average, it appears that children make some personal and social comparisons about drawing, design problem solving and design solutions, and that they prefer working on their designs as individuals to group contexts. Children tend to see themselves as competent at Science & Technology (where the mean scale score was above the mid-point of the scale). Although children think they need to be smart to do well in Science & Technology and other subjects, the perceived cross-over is low.

On average, self-ratings were moderately high for each group of design process strategies, children tend to value their designs and self-regulate learning processes, and feel quite good about their Science & Technology projects. In addition, children tend to feel embarrassed to show their designs and feel bad if they have few design ideas.

There were particular links among children's self-evaluations of design strategies suggesting that perceived competence at Science & Technology is related to children's personal and social comparisons about drawing, design problem solving and design solutions. In addition, children who see themselves as competent at Science & Technology also value their designs.

Particular self-evaluations were linked with some design strategies and not others. Perceived competence at Science & Technology relates to Design Strategy 2 and Strategy 6. Valuing designs was also linked with Design Strategy 6. Self-regulation was linked with Design Strategy 3 and Strategy 4. In addition, children who feel good about their Science & Technology projects were more likely to use Design Strategy 2, Strategy 3 and Strategy 6.



A model of children's motivations for Design and Technology

How can design skills be enhanced?

Results from the research showed that the personal focus given to the intervention enhanced design skills, particularly in design solutions. Social comparisons were made as students worked in a group context to solve the design problem. It was observed that students, who valued designs in terms of interest and usefulness showed an improvement in their final design solution. The personal focus given to the intervention showed improvements in students' scores for drawing, problem solving, design solutions, self-concepts and values.

Implications for Technology Education

Learning technology occurs through using the design process. Students should be given encouraging experiences in technology education at the primary level. Encouraging experiences would have enabled students to make personal comparisons that are positive. By understanding how students design and how design skills can be enhanced, we can motivate students to continue with technology education. Students should feel competent in their abilities in design to build positive attitudes about technology education. Positive attitudes reflect positive competence beliefs and builds values for technology education. Values predict performance and persistence. When students feel competent they will value technology education and would be more likely to continue with technology related areas in the future.

Technology education stemmed from societal changes and community concern that students were not provided with the necessary skills. It is important to ensure students continue with technology education. Societal changes have seen an increase in technological activity in all industries. These new areas require people who are equipped with skills such as being innovative, the ability to devise effective solutions to problems and are able to work in a team. Schools and the education system are depended upon to provide and train students with these skills.

This research project looked into students' design drawings, but there are many other ways to go about design projects such as building models, making prototypes, designing plans etc. These areas could be considered in the future to see if students' motivations and attitudes differ for the different methods of producing design projects.

Self concepts in Science and Technology, values and personal and social comparisons could be further tested after the design project has been completed to determine if there were any changes in the students' attitudes. The design skills researched in this project were mainly design drawing, design problem solving and thinking of design solutions.

Design drawings were analysed in the research project but students' actual drawing skills were not researched. Students' drawing skills and techniques could be further researched to determine if this has an affect on designing. Students could be taught basic drawing techniques so they can draw a clearer representation of their design ideas and this would be tested to determine if designs actually improved because their drawing skills had improved.

The design process could be further investigated and tested in a school that does not have a strong focus on design education to determine how much of an effect the design process has on students as a learning strategy and a method of further enhancing students' design skills.

Further research could be conducted to determine how students' design skills could be enhanced through working in groups and individual contexts.

How do students in secondary design and technology go about designing. What are the differences with primary students? This research could compare if secondary students also make personal comparisons, and if it enhances self concepts in Design and Technology. The study could also look into how the design process is utilised in the secondary curriculum because students have more refined skills and further knowledge within the technology area.

As can be seen from the above recommendations, a lot more research needs to be carried out in the area of designing, to be able to develop strategies to enhance problem solving skills. This project just has uncovered the tip of the iceberg and it is encouraging to note the research into Primary Design and Technology Education, which takes place worldwide.

Appendix 1

Research Methods

- Objectives: The main aims of this research project are to discover the procedure students use to go about solving design problems and how this information can be used to enhance design problem solving skills.

Method

- Design: The research project about children's design in primary Science and Technology was designed in two parts. Study 1 was a correlational study to examine proposed links in the conceptual model of children's motivations in relation to the design process and solving design problems. Study 2 was an intervention study with repeated measures on task values relating to solving design problems. The intervention used facilitated discussions of interest and usefulness of features of design and technology to raise children's awareness of these motivational components
- Participants: The participants were children aged between 10 and 12 years who were in Years 5 and 6 at a suburban primary

school. The school was selected under the recommendation of the Department of Education because of its strong focus on Design and Technology. Study 1 and Study 2 included girls and boys in Year 5 and Year 6 (N=31)

- Materials: The Design Strategies Questionnaire (see Appendix A) included sections on social and personal comparison, relation to design drawings, design problem solving and design solutions. Other sections included the design strategies used (design process), context in which designs are carried out, perceived competence, task values, self regulation and feelings.

Social and Personal Comparisons

Social comparisons were made by asking the students to compare their abilities in drawing, problem solving and creating solutions with other students in their class, students older than them and students younger than them.
Sample item: *'Compared to other students in your class how good are you at drawing designs in Science and Technology?'*

Personal comparisons were made by asking the students to compare the work they done with previous work they had done within Science and Technology and their abilities in other subjects.
Sample item: *'How good are you at problem solving in Science and Technology compared to problem solving in other school subjects?'*

- Context: These questions were asked to determine which situation the students preferred to work within. Contexts investigated included working in a group or individually, working at home or in the classroom
- Perceived Competence: Perceived competence was how smart the students thought they should be to do well in Science and Technology. This was investigated to determine if self-perception had an effect on students designing
- Design Process
  This is the process used to create a solution to a design problem. Students are taught the design process as part of the curriculum. The main features of the design process include identifying needs, collecting and researching ideas, selecting a solution, planning and making the solution and evaluating the final solution and reflection.

The items researched within the survey were based on the design process and observations from practice teaching experiences. These items were researched to determine how effective the design process is with assisting students in designing.
– Identifying needs sample item: *'How often do you think of improving designs for objects that exist around you?'*
– Collecting/researching ideas sample item: *'How often do you think about constraints on your design ideas?'*
– Selecting a solution sample item: *'How much do you check that the solution you have chosen is the best one?'*
– Planning/making a solution sample item: *'How much do you plan you time, resources, materials, space and tools before developing your final solution?'*
– Evaluating and reflecting sample item: *'How often do you think of better ideas or improvements to your design projects even though they are finished and handed in?'*

- Task Values: These items were used to measure how much the students valued their schoolwork, particularly within Science and Technology.
  – Sample item: *'How much does your school work mean to you?'*
- Self Regulation: This relates to how much the students evaluate and reflect on their past work. Constant evaluation is a major part of the design process and students would be constantly self regulating their abilities and motivations within Science and Technology.
  – *Sample item: 'How much do you evaluate your design solution ideas as you think of them?'*
- Feelings: According to the conceptual model, feelings have a part in all aspects of the procedures students use to solve design problems. Items researched here include how the students enjoy Science and Technology, problem solving, how embarrassed they are to show their work to others and how bad they feel if they cannot think of any ideas for design projects
- The design task: The design task included drawing a tree-house. This task was selected because it was age appropriate for the participants and was not gender biased because a tree house would be of interest to both male and female students. This task was also selected because it could be completed within ten to fifteen minutes without much guidance.
  Students were not given any cues as to what the tree house should include, nor guided as to the purpose for the design of the tree house. This was done so the motivational factors would not affect the design. This task was to purely assess the design skills of the students without any influence of the motivational factors
- Procedure: Children who participated in this research project were given permission from the school principal, classroom teachers and children had parental permission. The response rate was 43% for the Year 6 class and 67% for the Year 5 class
- Study 1) The Design Strategies Survey: The Design Strategies Survey was administered by giving a brief explanation to the students that this research project was being conducted to discover how students design and how design skills can be improved upon. These students were given a copy of the survey and each question was read out aloud. This was done because students may not have understood the full meaning of the questions being asked. Some questions were rephrased to assist the students, although most of them had already circled their answer. The scoring method was explained at the end of each question to reinforce the way the questions should be answered. (1=low, 5=high)
  During the completion of the survey, the class teacher assisted by reminding the students of past work they had done and assisting with explaining terms that the students may not understand.

The surveys were distributed to each student given permission to participate in the Year 5 class. The scoring method was explained to the students and the first few questions were done together. Students then proceeded to complete the surveys themselves and when they reached questions that used terms they were unfamiliar with, these terms were explained. The class teacher then went over the survey with the students, explaining the scoring method to them again and re-explaining the meanings of the questions. Students most likely do not prefer to work at home because the teacher does not allow them to work on their design projects at home because this means their learning cannot be assessed by the teacher

- The Design Task: Students were then given a piece of blank A4 size paper and were asked to design a tree-house. This was done to assess the design skills of the students. No directions were given, the exercise was purely to assess the level of the design skills of the students. The Year 5 students were given the design brief 'design a tree-house'. The class teacher informed that some of the students may not fully understand this task because there had been no lead up to the design brief. Students were then told to imagine a tree and to design the ideal tree-house for themselves. A minimal amount of guidance was given to avoid incorporating other factors into the design drawing. Factors will be tested in later intervention sessions. Students were given 10 minutes to complete their design drawing, which were then collected along with the surveys.

Study 2) The Intervention Study: The Intervention Study was conducted on both the Year 5 and Year 6 class to ascertain how students design skills can be improved upon.

Students were given the design brief: 'Design a communication device that allows you to communicate with someone over a short distance'.

Students were then asked to brainstorm different communication devices they have used or seen before. This reinforces personal experiences students would have had in relation to this design project. To reinforce task values relating to purpose students were then asked to brainstorm the different purposes of communication devices and the situations where communication devices are used. As a guide students were given the following questions to think about:

– Where have you seen communication devices used?

– What are the functions of communication devices? What do they do?

– What are important requirements of a communication device?

– How will your communication device work?

– Who will use your communication device?

To reinforce the social aspect of the design project, students were then asked to design a poster that explains how their communication device works so others can use it. Students were also required to draw their communication device on their poster as a labelled diagram for assessment of their design skills. To measure if there were any changes in the students motivations relevant sections of the Design Strategies Questionnaire were re-distributed for students to complete

- Analyses: The data was analysed using SPSS for Windows. Descriptive statistics describe the mean, range and standard deviation. Inferential statistics describe differences between means using t-tests (with a critical alpha value of $P < .05$, considering the size of the sample). Associations between variables are cross-tabulations of low, medium and high for each variable, with cut-off values at the 25th and 75th percentile. Chi squared statistics indicate the significance of associations (where $p < .05$).

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Table 1					
Personal & Social Comparisons	**alpha**	**Min**	**Max**	**Mean**	**SD**
Drawing	.89	1.2	4.5	3.3	.9
Design Problem Solving	.83	1.5	4.2	3.3	.7
Design Solutions	.83	1.6	4.4	3.4	.8
Preference for context					
Individual	.70	2.7	5.0	4.0	.8
Group	.78	1.0	4.0	2.2	1.2
Perceived competence					
Ask about D&T	–	2.0	5.0	3.8	.8
Need for talent at S&T	–	2.0	5.0	3.5	.8
Need for talent at others Ss	–	1.0	5.0	3.4	1.0
Talent at other Ss for S&T	–	1.0	4.0	2.2	1.2
Design Process Strategies					
Strategy 1	.77	2.4	4.6	3.5	.7
Strategy 2	.68	2.0	4.5	3.6	.8
Strategy 3	.69	2.3	4.7	3.5	.8
Strategy 4	.63	2.8	4.5	3.8	.5
Strategy 5	.70	2.0	4.5	3.4	.7
Strategy 6	.66	2.0	4.7	3.4	.8
Other cognitve self evaluations					
Designs are valued	.73	2.2	4.8	3.5	.8
Self regulation	.86	2.3	4.5	3.4	.8
Self evaluation of feelings					
Feel good about S&T projects	.75	2.6	4.9	3.8	.6
Embarrassed to show designs	–	1.0	5.0	3.4	1.6
Feel bad if no design ideas	–	2.0	5.0	3.8	1.0
Note. Satisfactory internal consistency of scales is indicated by Chronbach alpha coefficients of around 0.7 (see Kline, 1979).					

Table 1 Description of children's responses to the Design Strategies Questionnaire

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  4 (4), 6 – 7

Attitudes of Secondary Teachers of Technical Subjects and Home Economics Towards Curricular Continuity at the Transition between Primary 7 (11 years) and Senior 1 (12 years)

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Introduction

'Scottish education works very much on a compartmentalised basis. It's graphics. It's Craft and Design. We've structured our curriculum in S1 and S2 to make sure they know how it goes in S3 and S4. How that relates to 5 – 14 …that's probably a very thin link indeed …and I'm not sure that we actually want to link the two together' **(Secondary school teacher of Technical 2000)**

The pursuit of curricular continuity across the 'great divide' that exists between primary and secondary education is not by any means a new ideal. In 1931 the Hadow report on The Primary School clearly advocated the desirability of continuity in education *'It is true indeed that the process of education from the age of five to the end of the secondary stage should be envisaged as a coherent whole'* (HMSO 1931 p 70)

Rhetoric and reports are, however, frequently insufficient to effect changes in education. Evidence for this lies in the recurring emphasis on continuity in reports during the intervening years, such as the Plowden Report (HMSO 1967) and later the Bullock Report (HMSO 1975) which, although it had its main emphasis on language, also stressed the importance of liaison as a means of promoting continuity between the primary and secondary secondary sectors.

One factor identified as militating against continuity was the openness of courses to a wide and varied interpretation (SOED 1997). The introduction in England in 1988 of a National Curriculum document to be implemented in 1989, followed closely in Scotland by the 5 – 14 Curriculum Guidelines, which had echoes of the Hadow Report in the emphasis placed on 'progression coherence and continuity,' seemed at last set to address some of the problems of transition which had concerned educationalists for years.

The question now to be considered is whether the introduction of a National Curriculum – or guidelines which have had a very similar purpose – have indeed resulted in the progression, continuity and coherence envisaged and if not what some of the variables which prevent this may be.

Factors affecting curricular continuity

Several factors can affect the success of curricular continuity at the point of transfer from primary to secondary school. These include: the existence of effective liaison procedures between primary and secondary schools; a knowledge and understanding on the part of both sectors about the respective courses taught, programmes of work and teaching methods adopted; a willingness on the part of secondary teachers to value the work done in primary schools and to trust the primary teacher's judgment in terms of assessment along with a willingness to use information to provide an appropriate curriculum for all pupils. (Steed & Sudworth 1985) Secondary teachers must also have a commitment towards a secondary curriculum which builds upon the knowledge, understanding and skills already acquired in the subject in primary school.

While these factors are of clear importance to all areas of the curriculum, the focus of the present paper is on technological education that forms part of the environmental studies area of the 5 – 14 curriculum in Scotland.

In terms of continuity, coherence and progression, Achieving Success: A Report of the review of provision in S1/S2 by HM Inspectors of schools (SOED 1997) identified a particular problem in relation to environmental studies which was regarded as presenting a particular challenge in relation to course design. The ways in which the course had developed since its introduction in 1965 had resulted in difficulties in the establishment of continuity between primary and secondary schools. This was an area that clearly required to be addressed.

The third Standards and Quality in Scottish Schools Report (SOED 1997), moreover, found that the quality of attainment had some important weaknesses or was unsatisfactory in technology in over 65% of secondary schools.

The Nuffield Project

In an attempt to improve standards by means of greater continuity, Glasgow city council piloted a scheme using Nuffield Design and Technology materials covering the stages of P7 to S2 in two secondary schools and their associated primaries over a two year period between 1998 and 2000.

During this period, several opportunities for liaison between primary and secondary teachers were provided through joint training sessions, while curricular continuity was effected through the use of projects devised by the Nuffield foundation. These projects were specifically designed to provide curricular continuity across the P7 – S2 stages. Primary teachers were also encouraged to borrow equipment from the secondary schools where appropriate and to seek advice from secondary colleagues when necessary. By this means it was hoped that the collaboration necessary for effective continuity would be achieved.

As part of the evaluation of the pilot, the primary teachers involved along with the secondary teachers of both Technical Education and Home Economics were interviewed about their perceptions on the success of the project. (Although Home Economics is regarded as a separate subject in Scotland, the Nuffield materials used in the project were based on the English system which includes elements taught in both Home Economics

and Technical Education) Although many issues emerged, one important area identified was the attitude of secondary teachers to the teaching of technology subjects in primary schools and to the desirability of curricular continuity in this area.
'When I see thing in their (Nuffield's) list – hammer, nails, scissors, I think, well where's the craft in that? You're sort of knocking thing's together, a bit like primary school things where everything's knocked together – a touch of glue and it comes out looking like a dog's breakfast. I don't see that's our job to do things like that …They're not learning craft skills.' (Secondary school teacher of Technical 2000)

Since the sample of secondary teachers involved in the project was very small, (5) subsequent informal interviews held with principal teachers on the national executive of the Technology Teachers' Association suggested that the views held were not particular to those involved in the pilot A 'Fresh-Start' approach

Various aspects of attitudes held appeared to militate against a smooth transition from primary to secondary in this area. One important aspect was the desire of secondary teachers to maintain a fresh start approach to their subject.

The notion of secondary teachers preferring a 'Fresh-Start' approach has been well documented. (Nicholls and Gardner 1999)

Sutherland et al (1996) further suggest that the notion of the fresh start approach is a fairly complex one that may take several variations. The variations identified by Sutherland were: a concern with making the subject seem like new; a lack of interest or disregard of what has gone before; the predetermination of a fixed point at which all pupils should start at secondary and the clean slate approach.

Similarly in the present study, several reasons for preferring the fresh start approach emerged.

Predetermination of a fixed point at which all pupils should start was regarded as necessary because of the lack of information received by secondary schools about the levels of achievement reached by pupils in technology during P7. The result of this was that secondary teachers preferred to make the assumption that all pupils would start S1 working towards level A, which is the stage normally achieved by the end of P3.

An important factor in this is that the focus on assessment within the 5 – 14 Guidelines has to date centred on pupil attainment in language and numeracy. In these areas all primary schools supplied details of the levels attained by individual pupils in the various strands. None of the primary schools involved in the project, however, supplied information of any kind relating to pupil attainment in technology. In fact none of the primary schools had used any assessment of pupils' work produced during the project other than for ongoing diagnostic reasons or to gain an holistic view of work on completion. This was partly the result of primary teachers' unfamiliarity with the 5 – 14 Environmental Studies document. There was also a perception among primary teachers, however, that there was a lack of confidence on the part of secondary teachers relating to primary assessment in areas of literacy and numeracy currently assessed. This is a problem that has been identified as resulting from a lack of consistency in grading across schools (SOED 1997)

An emphasis on target setting emerged as another issue in secondary teachers' desire to adopt a fresh start approach. All secondary teachers interviewed expressed a need to focus on work that was of direct relevance to Standard Grade from the start of S1.
We gear our S1 and S2 towards Standard Grade. That is where I am judged. And until someone publishes league tables on environmental studies, that is where I will continue to put my focus.'
'It (Nuffield) gives a lot of what I call peripheral 5 – 14 stuff – the developing and forming attitudes about technology. There's no questions in Standard Grade about that.' (Secondary school teachers of Technical 2000)

Other factors

Time constraints in completing the necessary work were also a major issue in this respect. Another was the perceived lack of articulation between the course content and assessment procedures of 5 – 14, Standard Grade and the recently introduced Higher Still.
'The progression isn't naturally there because we have this (Nuffield) concentrating on some areas, the Standard Grade is skewed in different ways and then we come up to the Higher Still. It's different again.' (Secondary school teacher of Technical 2000)

Another factor that emerged was a concern on the part of secondary teachers that their status as the recognised experts in their subject area was protected. Related to this was the perception of primary teachers as generalists who were regarded as incapable of teaching all specialist subject areas effectively. Secondary teachers of both Technical Education and Home Economics expressed the view that primary teachers did not have the required knowledge and expertise to deal with either the theoretical or practical aspects of the subjects.
'We are asking people who are not trained to teach certain things. It doesn't work.' (Secondary school teacher of Technical 2000)

There was particular concern that subject matter might be taught in a way that would cause confusion to children. The Home Economics teachers, for example, expressed concern about the adoption of different classification systems.

'Nutrition's such a difficult concept and there are many different ways of delivering it – from pyramids to plates to food groups. It makes it difficult if they've learned food groups in a certain way.' (Secondary school teacher of Home Economics 2000)

Collaboration on this did not appear to be a consideration. The general consensus was that primary schools should concentrate on basic skills, such as how to thread a needle, as this would allow secondary schools to concentrate on the specialist aspects of the subject.
'We would prefer if they just stick to the very basic guidelines so they have a background knowledge rather than get the facts wrong.' (Secondary school teacher of Home Economics 2000)

Health and safety issues were also a serious consideration for secondary teachers. It was felt that primary teachers lacked the requisite training to carry out the practical aspects of the work in accordance with health and safety regulations. There was consensus, moreover that primary classrooms were totally unsuitable for carrying out the type of activities involved in both subjects.

Another factor affecting secondary teachers' attitudes to the kind of work carried out in primary school technology centred on the integrated nature of the work. The materials used in the project adopted the type of integrated approach advocated in 5 – 14 where the three areas of the secondary technical curriculum were combined along with areas covered in Home Economics into single schemes of work.

Secondary teachers of Technical Education were particularly reluctant to adopt this integrated way of working in S1 and S2. The reason given for this was the fact that the three areas of Craft and Design, Technological Studies and Graphic Communication form three separate Standard Grade subjects which pupils opt for in S3. There was therefore a concern that if the three subjects were taught in an integrated way, it would be difficult for pupils to distinguish between the areas at the stage where subject choices were being made.
'In the first year we always start off with the spatula. You know all your coping saws. You know your files. You know what your coping saw's for. You know the sandpaper. You know the trims. You know the finishing and all the reasons behind it. So out of that one job you get a lot of good outcomes and they learn a lot. But in the Nuffield I could never see that. They're not actually learning anything.' (Secondary school teacher of Technical 2000)

Conclusions

The SOED (1997) report particularly stresses the importance of a progressive experience for pupils at the point of transition.

'Secondary teachers who choose to ignore or take little account of pupils' prior attainment are failing their pupils.' (SOED 1997 p4)

Despite this, it was clear from the interviews with the secondary teachers both in the study and on the national executive of the Technology Teachers' Association that there was a clear reluctance to participate in a progressive and continuous approach in the area of technical education.

Although opportunities for liaison had been provided for participants in the Nuffield project, there was little evidence of secondary teachers sharing specialist knowledge and expertise. Primary teachers, for example, still displayed very little knowledge of the topics covered in the secondary technical curriculum. Although secondary teachers were willing to offer advice to primary colleagues, they showed little interest in building upon the skills and knowledge gained by primary pupils in this area.

Therefore it seems apparent that opportunities for liaison, although clearly important, are not in themselves sufficient to produce curricular coherence, continuity and progression. While curricular guidelines may stress the necessity of these, the attitudes of teachers must also be taken into account if they are going to be achieved.

How easy it is to affect attitude change is an area of research that is beyond the scope of the present paper. Yet it seems important to at least consider, how attitudes of secondary teachers may be altered to encourage them to value what the primary schools can offer in the area of technology and to enable greater curricular continuity to be achieved.

Opportunities for joint training at the stage of initial teacher education might provide a clearer view and better appreciation of the prospective knowledge, skills and methodologies involved at the different stages of the curriculum. Greater opportunities for primary teachers to specialise in areas such as technology would help raise the confidence of secondary teachers in primary teachers' capabilities.

The Scottish Executive has recognised the problem that pupils have in making the transition from one having one generalist teacher in primary to having to adapt to between 13 and 16 specialist teachers in S1 (SOED 1997). Opportunities for greater flexibility in the deployment of secondary subject specialists in primary along with opportunities for work shadowing in both sectors might provide an opportunity to address this problem.

The problems of articulation involved between 5 – 14, Standard Grade and Higher Still requires to be addressed. As long as secondary teachers feel under pressure to follow the requirements of the Standard Grade curriculum, they will be likely to adopt a fresh start approach in S1. Greater emphasis on the articulation that exists between 5 – 14 and Higher Still would help resolve this problem. Along with this, there may be a case for encouraging teachers to reflect on whole nature and purpose of technology in the curriculum.

'Technical education hasn't resolved yet whether it's going to be a practical subject or a design oriented subject.' (Secondary school teacher of Technical 2000)

It was clear from the interviews that the current emphasis placed by secondary teachers on the importance of developing craft skills along with the knowledge and understanding of tools and processes appears to be in opposition to the focus on the creative processes and development of understanding of the use of technology in society advocated by the Nuffield project.
'We're a traditional department so we look for craftsmanship, standards and so on. But this (Nuffield) is a totally different scenario.' (Secondary school teacher of Technical 2000)

Unless the attitudes of secondary teachers in this area are addressed, the chance of developing a coherent and progressive curriculum appear to be remote.

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Primary Teachers Confidence in Delivering Technology Education

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Introduction

This paper evaluates a recent pilot scheme carried out in two Glasgow secondary schools and their associate primary schools. The pilot ran for two years and involved the use of Nuffield materials in teaching the technology component of the 5 – 14 curriculum. The classes studied were P7 and S1 (The end of Key Stage 2 and the beginning of Key Stage 3)

Research has been carried out in the past in order to determine the confidence levels of primary teachers in the delivery of science. A fairly recent Scottish research exercise published in 1995, and carried out by Wynne Harlen and Colin Holroyd for the Scottish Council for Research in Education, concluded that, in general, primary teachers had a low confidence in the teaching of science and technology. (Harland et al, 1995).

Indeed, the situation is no different in England and Wales where similar research carried out by Kay Stables found results which corroborate the findings in Scotland (Stables 1997).

Work carried out by Wynne Harlen, used, amongst other methods, questionnaires which concentrated on aspects of the 5 – 14 Environmental Studies document (SOED 1993) relating to science. These questionnaires were used to indicate primary teachers' confidence in relation to the teaching of 5 – 14 science. The samples used were large by comparison to this study and ranged over P4 to P7. (Harlen, 1996)

Whilst this research is focused entirely upon the technology component of 5 – 14, it was felt that a comparison with the science research might prove useful.

Harlen found that 67 percent of primary teachers had no science background. (N=514). This survey found that whilst 94 percent had no science background, none at all had any technology background. (N=16) (Harlen, 1996)

Using a similar questionnaire to that used by Harlen, teachers were asked to respond to the following question in relation to each of a series of statements selected from the National Guidelines indicating the content and contexts through which primary 7 pupils should develop their understanding in technology.

Question 1

For the purposes of analysis the statements were sorted into the two key areas of the technology attainment outcomes' of 'Understanding and using technology in society', and 'Understanding and using the design process'. The statements were sub divided into the actual statements used in each of the two key areas for P7 to S2.

Table 1 gives the results for the sample of statements and the confidence index gives a summary for each statement. It is formed by multiplying the percentage of responses in category 1 by 4, in category 2 by 3, in category 3 by 2 and in category 4 by 1. The maximum confidence index for any item is thus 400, the minimum 100 and the mean is 250. This is the same format as that used by Harlen. (Harlen, 1996)

Table 1

Confidence Index	Cat1	Cat2	Cat3	Cat 4	
Technology and human needs	14	57	22	7	278
Technology and demand for resources	14	29	35	22	**235**
Technology as it affects lifestyles	14	43	29	14	257
Technology to control the environment	23	23	39	14	254
Technology responding to values and scientific progress	29	43	22	6	295
Understanding and using technology in society					264
Bolder figures show a confidence level below the median, indicating a low confidence rating					

Table 1 Teachers' confidence on aspects of 'Understanding and using Technology in Society' responding to each of the five categories (N=14)

The total confidence factor for this area is 264, which is above the median. Technology responding to values and scientific progress, which is described in the document as 'ways in which the development of materials and processes, customs, religious beliefs, advertising and the media influence ideas about fashion and design of products and built environments'. (SOED 1993), indicates the highest confidence factor, whereas technology and demand for resources, which is described as 'Ways in which technological developments interrelate and affect the development or decline of other technologies and employment opportunities'. (SOED 1993), indicates a low confidence factor.

The second key area in the technology component of 5 – 14 is 'Understanding and using the Design Process' Teachers were clearly less confident in this area as can be seen from table 2.

The total confidence factor for this area is 224 which is below the median. The lowest confidence rating for a single area of science, as found by Harlen, was for 'Understanding Energy and Forces', which gave a rating of 234. This single rating, although below the median, is significantly higher than the collective rating for 'Understanding the design process.'

Energy and forces form part of the technology curriculum as well as the science curriculum, and would normally be expected to be taught under the heading of 'Technology to control the environment' (Table 1). This area, paradoxically, had a higher confidence rating of 254 which suggests that energy and forces may not be recognised by teachers as part of the technology curriculum.

Table 2					
Confidence Index	Cat1	Cat2	Cat3	Cat 4	
Design and manufacturing processes	23	31	23	23	254
Selecting and using the design process	23	22	14	22	271
Properties of materials and tools in relation to their practical use	14	29	22	35	**222**
Devices and tools associated with control and their applications	0	29	29	44	**189**
Effectiveness of design in creations / systems and environments	14	29	35	22	295
Practical skills, techiques and safe procedures	6	35	14	45	**202**
Understanding and using the design process					224
Bolder figures show a confidence level below the median, indicating a low confidence rating					

Table 2 Teachers' confidence on aspects 'Understanding and using the Design Process' responding to each of the six categories (N=14)

An extremely low rating of 189, the lowest recorded, was indicated for 'Devices and tools associated with control and their application'. This demonstrates a very low confidence factor in the 'effective use of control technology in design tasks.' (SOED 1993)

Another very low rating was found under 'Practical skills, techniques and safe procedures', where teachers were not confident with the 'Safe and confident use of materials and tools and the organisation of a working environment where materials, equipment and space support the particular activity.' (SOED 1993)

These results give a clear indication that primary teachers have very low confidence in teaching the practical areas of the technology curriculum. This is very much in accordance with the findings of Harlen and Holroyd (1996), together with the findings of Kay Stables (1997).

Once again the present research used a similar construction to that of Harlen, where teacher estimates of difficulty were measured. For the purposes of the present exercise, the three areas of the curriculum for England and Wales were used, as outlined in the Nuffield materials. These three areas are Textiles, Food Technology and Resistant Materials. Each teacher was asked to fill out three separate questionnaires, each with an identical format, but appertaining to each of the three areas mentioned.

Question 2

The categories are as follows:

- Category 1 – Not at all difficult
- Category 2 – Sometimes a little difficult
- Category 3 – Usually quite difficult
- Category 4 – Very difficult.

Note the the 'Difficulty Index' is calculated in a similar way to the 'Confidence Index'. The higher the number the more difficulty.

Table 3					
Difficulty Index for Textiles	Cat1	Cat2	Cat3	Cat 4	
Introducing a new topic	43	29	21	7	192
Ensuring the equal interest of boys and girls	57	36	7	0	150
Ensuring the equal participation of boys and girls	86	14	0	0	114
Explaining ideas to pupils	57	14	29	0	172
Responding to pupils ideas about content	57	29	14	0	157
Using questioning skills to stimulate pupils thinking	71	29	0	0	129
Deciding concepts to be delivered in an activity	29	50	21	0	192
Deciding process skills to be delivered in an activity	28	50	21	0	191
Organising and supporting practical work	28	36	0	36	244
Record Keeping	23	31	31	15	238
Obtaining equipment	0	25	25	50	**325**
Maintaining equipment	0	18	27	55	**337**
Continuing assessment in relation to concept skills	14	43	43	0	229
Continuing assessment in relation to process skills	21	29	50	0	229

Table 3 Teachers' estimates of difficulty of certain skills in teaching the textiles componant of technology – items listed in order of increasing difficulty (N=14)

It is evident that although teachers have quite high levels of confidence in the pedagogic areas of teaching technology involving textiles, they are clearly not confident in obtaining or maintaining equipment. It is further evident that the practical work is a cause of concern.

Table 4					
Difficulty Index for Food Technology	Cat1	Cat2	Cat3	Cat 4	
Introducing a new topic	55	27	9	9	172
Ensuring the equal interest of boys and girls	55	36	9	0	154
Ensuring the equal participation of boys and girls	73	18	9	0	136
Explaining ideas to pupils	46	36	18	0	172
Responding to pupils ideas about content	55	27	18	0	163
Using questioning skills to stimulate pupils thinking	64	27	9	0	145
Deciding concepts to be delivered in an activity	18	55	27	0	209
Deciding process skills to be delivered in an activity	20	50	20	10	220
Organising and supporting practical work	18	18	18	46	**292**
Record Keeping	18	36	28	18	246
Obtaining equipment	9	27	9	35	**310**
Maintaining equipment	9	18	18	55	**319**
Continuing assessment in relation to concept skills	9	18	55	18	**282**
Continuing assessment in relation to process skills	18	18	46	18	**264**

Table 4 Teachers' estimates of difficulty of certain skills in teaching the food technology componant of technology – items listed in order of increasing difficulty (N=14)

Here again it is evident that teachers have quite high levels of confidence in the pedagogic areas of teaching technology involving food. Once again, however, they are clearly not confident in obtaining equipment or maintaining equipment. This was apparent in that none of the primary schools had adequate cooking facilities. Indeed, in one primary where the food technology component of the Nuffield materials was taught, the teacher had to revert to using the staff room cooker and had to bring in cooking utensils from her own home. It is now more evident here that the practical work is a cause of concern. This supports the concern that all the primary teachers interviewed had about resources for this area of the curriculum. It is clear that assessment for food technology presents an area of difficulty, both in concept development and process skills.

Table 5					
Difficulty Index for Resistant Materials	Cat1	Cat2	Cat3	Cat 4	
Introducing a new topic	15	24	46	15	**261**
Ensuring the equal interest of boys and girls	54	38	8	0	154
Ensuring the equal participation of boys and girls	75	25	0	0	125
Explaining ideas to pupils	8	23	46	23	284
Responding to pupils ideas about content	15	31	23	31	**270**
Using questioning skills to stimulate pupils thinking	31	46	23	0	192
Deciding concepts to be delivered in an activity	15	38	15	32	**264**
Deciding process skills to be delivered in an activity	23	31	15	31	**254**
Organising and supporting practical work	8	25	17	50	**309**
Record Keeping	8	25	42	25	**284**
Obtaining equipment	8	23	15	54	**315**
Maintaining equipment	0	23	15	62	**339**
Continuing assessment in relation to concept skills	0	38	38	24	**286**
Continuing assessment in relation to process skills	8	31	38	23	**276**

Table 5 Teachers' estimates of difficulty of certain skills in teaching the resistant materials componant of technology – items listed in order of increasing difficulty (N=14)

This area of the curriculum is without doubt the one which causes the greatest concern to primary teachers. A high level of concern was expressed in the structured interviews carried out in this research, which support the figures given, particularly in this area.

The work of Harlen et al (1995) clearly supports the findings from this research. When asked to rate their confidence in teaching various areas of the curriculum, 60% gave the lowest rating for technology, 41% for science and 1% for both mathematics and English. Only 6% were fully confident in teaching technology.

Table 6 shows a comparison between the three technology difficulty factors and the science difficulty factors as found by Wynne Harlen.

Table 6				
Difficulty Index Comparison	Science	Textiles	Food	Resistant
Introducing a new topic	145	192	172	261
Ensuring the equal interest of boys and girls	162	150	154	154
Ensuring the equal participation of boys and girls	162	114	136	125
Explaining ideas to pupils	168	172	172	**284**
Responding to pupils ideas about content	169	157	163	**270**
Using questioning skills to stimulate pupils thinking	173	129	145	192
Deciding concepts to be delivered in an activity	205	192	209	**264**
Deciding process skills to be delivered in an activity	211	191	220	**254**
Organising and supporting practical work	212	244	292	**309**
Record Keeping	237	238	246	**284**
Obtaining equipment	245	**325**	**310**	**315**
Maintaining equipment	245	**337**	**319**	**339**
Continuing assessment in relation to concept skills	**251**	229	**282**	**286**
Continuing assessment in relation to process skills	**251**	229	**264**	**276**

Table 6 Comparison of the three areas of difficulty in technology found in this survey and the areas of difficulty in science from the survey by Wynne Harlem in 1996

Resistant materials is seen here as the area in which primary teachers find the greatest degree of difficulty. This particular area most closely approximates the secondary technological areas of Craft and Design and Graphic Communication.

It can be further seen from the above table that areas involving assessment, obtaining and maintaining equipment, record keeping and organising and supporting practical work are seen as presenting the greatest difficulties for primary teachers. This correlates with the findings of Harlen et al (1995), where 'the most frequently cited source of problems was equipment / materials. Equipment was said to be unreliable, insufficient, difficult to obtain, store and access, with little or no guidance on what to do if things went wrong… finding time for preparation, safe management of pupils when some were doing practical work, lack of physical space and inadequate classroom facilities' (Harlen et al 1996. p6)

Similar results, involving other countries as well as England and Scotland, have been found from research conducted by Kay Stables. 'Very few primary teachers have received formal training in the teaching of technology education. Even those countries that have decided to introduce compulsory technology education into their primary curriculum, and who have set up training programmes to facilitate this, have a back log of unprepared technology educators teaching in primary schools' (Stables 1997. p60)

A precise identity for technology education appears to elude most primary school teachers. This was evident from the structured interviews which were carried out. Primary teachers had not read the Scottish Consultative Council on the Curriculum's Position Paper (SCCC, 1995), indeed, most did not know it existed. They were unclear as to the precise content of the secondary technology curriculum. They were unable to make a clear distinction between science and technology. Prior to the pilot most had no experience of technology whatsoever, either in their initial teacher education or subsequent professional development. This situation is echoed in the work by John Eggleston. ' Total or partial unfamiliarity with it (Technology Education) in their professional training or in their experience to date.'(Eggleston, 1994 p20). He goes on to suggest that this is not confined to teachers, but 'bewilderment over technological education is prevalent among parents, employers and the public at large'. (Eggleston, 1994 p20).

This is not altogether surprising. Technology education has changed considerably. Traditionally, technical education was predominantly craft based, non academic, for boys only and prescriptive in its delivery. It involved learning to operate industrial type machines, learning engineering based technical drawing and for the more able, mechanics. Girls on the other hand were taught domestic science. Boys were effectively being given training towards trades while girls were seen as homemakers.

The ghost of this perception, of what technological education actually involves, has faded but not entirely disappeared. It is axiomatic that, for a significant proportion of primary teachers, and indeed teachers of the subject, the old perception still applies. The idea that the design and creativity paradigm, incorporating technological capability at its centre, must now form the cornerstone of technological education, is not evident to them. This may go some way towards explaining the apparent fears, or at least anxieties, that many primary teachers express towards this area of the curriculum.

Technological capability is dealt with in the SCCC document (1995), but as mentioned already, primary teachers were not aware of this document. The design process is dealt with in the Nuffield materials, but again primary teachers did not appear to have a clear understanding of this.

Whilst all primary schools were issued with a copy of the 'Be safe' booklet, which deals with some aspects of health and safety relating to technology, none of the primary teachers were aware of its existence. Whilst this publication is clearly intended for Environmental Studies, 5 – 14, it is published by the 'Association for Science Education', and this is clearly indicated on the front cover. This may explain teachers' confusion.

If the 5 – 14 technology curriculum, incorporating the philosophy of 'Technology Education in Scottish Schools', is to be delivered effectively, which incidentally is regarded as a major aim of technical education by HMI (HMI, 1999), then primary teachers will be required to undergo development in the pedagogical issues relating to technological capability, before necessarily receiving training in the practical issues involved. An insight into the aims and objectives, or philosophy of technology education and its delivery, is suggested as a requirement, preceding technological subject knowledge and methodology.

It is recognised that, for Education Authorities to instigate a programme of primary teacher development, is a formidable task. However, this research clearly establishes that primary teachers require a broader pedagogical range and understanding in technology education before they can be expected to deliver the subject in a way which offers technological clarity, and a clearly defined continuity towards the secondary stages for the pupils involved.

Following this, education in practical issues is seen as vital, particularly in the safe use of tools and machinery, health and safety and a broader understanding of the various materials used across the wide range of the technology curriculum.

This is not likely to be achieved successfully without some coherent, central administration. The type of help that primary teachers seek includes, 'In service courses, print based resources, time to think and prepare, more and improved equipment, a school policy on what to teach and when, advice from specialists, and improvement in support and co-ordination within the school'. (Harland et al, 1996). The first item identified by Harland and Holroyd, that of in-service training, needs careful thought. The nature of the subject requires a hands on approach as well as a theoretical base. The training given to primary teachers for this pilot included a few days in secondary technology departments. Here they were able to use tools and equipment in dedicated workshops, graphics rooms and technology labs. This cannot ever emulate the actual requirements for the primary sector which must, in most cases, use the same classrooms for all activities, and certainly never involve dedicated technology rooms. This presents class management problems, health and safety issues and teacher skills which are totally different from the secondary sector, and which require dedicated in service courses, which have the necessary physical resources available.

Staff development relating to health and safety cannot be seen as desirable, but must be seen as essential. Information gathered from this research clearly indicates major concerns in this area.

Given that HMI have recognised that the extent of subject development recently has taken teachers to the limits of their own expertise, and given the wide range of courses offered by departments, teachers have not always been able to keep pace with the rate of curriculum development (HMI 1999 p6). This research suggests that if the 5 – 14 technological curriculum is to be delivered effectively, incorporating the philosophy of the SCCC position statement, then along with the provision of materials needed to support the delivery of the curriculum there must be 'Appropriate pre-service and in-service training for teachers.' (HMI, 1999. p5).

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From Unsatisfactory to Excellence – Partnership Approach to Teaching Design and Technology

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Introduction

I started my teaching career at Holyhead Primary School in 1997. Upon appointment I was given the responsibilities for design and technology as well as information technology. At this time the school needed to raise standards in all areas of the curriculum as it was about to reach the end of a second year in 'special measures'.

My first task was to establish where the school was at in terms of Design and Technology. After scrutinising the school's 1995 Report by the Office for Standards in Education (Ofsted), it was evident that the standards overall were not satisfactory at either Key Stage 1 or Key Stage 2.

- The report was generally critical on all aspect of the Design and Technology curriculum
- There was too much reliance on construction kits
- Too narrow a range of natural and manufactured materials for the pupils to use
- Sufficient time was allocated but not used to teach the subject
- Pupils were not able to solve problems as they encountered them and lost interest
- The main thrust of curriculum planning was aimed at children's planning and making
- Teachers had a tendency to take over from pupils when they had difficulties
- Lesson planning did not stretch the pupils ability or it was too closely prescribed to be of value.

The school had a technology policy, but there was no evidence of progression in the work planned throughout the school.

Resources were very limited, which was directly linked to poor attainment. Design and technology had no budget allocation at this time. Monitoring and evaluation of teaching was non-existent and staff had insufficient training, lacked in confidence and were not fully aware of the requirements of the National Curriculum for design and technology.

A brief history

From the original inspection in 1995 to 1997 the school had undergone a lot of changes. There had been two temporary head teachers, the appointment of a new permanent head teacher, staff restructuring and the appointment of three Newly Qualified Teachers, one of whom was me.

The school took a further blow in the Summer Term 1997, when a one day inspection recognised the improvements made, but felt that the school was not ready to be removed from special measures. There was an urgent need to further develop and write new policy documents and schemes of work, and teaching was only 60% satisfactory or better. After working throughout the six weeks holiday, I had put together a draft scheme of work and policy documents for staff discussion. Due to the limited time scale available, with another short inspection imminent, there was no time for the document to go to staff for their approval/input. Instead the document was checked by our school adviser who was the Local Authority Adviser for design and technology, and a training day planned with a skills development focus to provide the necessary skills to implement the new scheme of work.

After a lot of hard work and commitment, the school received the reward it truly deserved. On the 26th November 1997, the school was removed from special measures.

Figure 1 Holyhead staff participating in practical workshops to develop their skills in control

The First Steps in Raising Attainment

The implementation of the new scheme of work began to show a great deal of improvement throughout the school. Children were involved in investigating, disassembling and evaluating activities. Time was allocated in lessons for the teaching of specific skills through focused practical tasks (FPT's) and time was being given for pupils to experiment and participate in new learning experiences. The children respected this time, time for them to learn at their own pace, to develop individually and to move on as and when they were ready. As the children started to achieve, their confidence grew and grew, an ethos of mutual respect an understanding for the development of design and technology was beginning to emerge between teacher and pupils.

Discussions with children were integrated into the evaluation process. Due to the fact that children were now working more independently and following through their own ideas, failure was now occurring in the children's work. The problem was getting them to understand that it was acceptable to fail, and in terms of assessment, if the children could verbally indicate why his/her project hadn't worked then this was a clear indication of success. A real learning experience had taken place.

The scheme of work was divided into units that spread across the academic year. In Key Stage 1, each year group undertook three units of work, one for each term. The main focus for the units here were topics that could link well into Literacy, as this was one of the main thrusts of the school development plan. The units of work were written using DATA guidance materials and included stories such as, 'My Cat Likes to Hide in Boxes' – a structures project, 'New Clothes for Alex' – textiles, 'The Lighthouse Keepers Lunch' – pulleys and bags, 'Scraps' – puppets and so on. The development of a scheme for Key Stage 2 was not so easy, there was a need to boost skills so as to bridge the gap in the children's learning. In some respects for almost a year we had children in key stage one and two working at very similar levels, with progression being very difficult to identify. In fact, from an outsider's point of view, there appeared to be very little progression at all in the making and use of materials, but this was a necessary starting point for us all, teachers and pupils alike. Teachers' skills needed to be built upon as well as the pupils. Although design and technology was my main subject for my degree, I too was on a steep learning curve, developing my own skills as a teacher alongside developing my skills as a curriculum manager.

In 1998, as part of the Sandwell LEA's Ofsted Inspection, our school was chosen as one of the schools to be visited by a design and technology Inspector, Mike Ive. This visit was not to monitor us as a school, but to monitor the impact of a ten day training programme that the previous post holder for design and technology had attended. This member of staff had moved on, so as the new coordinator and as an NQT I was invited to have a chat with him. He looked through our scheme of work and examined samples of pupils' work from across the whole school. This provided valuable feedback for me as a coordinator. I knew in my own mind where the weaknesses were in school, but as an NQT, it was to some extent very difficult for me to advise and support teachers with 20 years teaching experience. The feed back from Mike was very positive overall, but he had identified weaknesses in upper Key Stage 2. There was no real challenge for the pupils and the work produced was well below expectations in years five and six. All other year groups were working towards expectations, but there was still a little too much overlap with the art curriculum. Although the scheme of work was appropriate for the children and potential outcomes for the units were well identified, the rage of resources and materials being used was still hindering progression and standards.

Moving Forward – the injection of capital & the development of Education Business partnerships

After discussions with the head teacher, who was as usual willing to listen to suggestions and open to new methodologies, it was agreed that an injection of capital was necessary, and design and technology was moved to take a higher profile on the school development calendar, it was now to be a high focus subject area. I was asked to draw up a list of the necessary resources to raise attainment. At this point we had no manufacturing materials, tools, glue guns, specialist textile equipment or equipment for food technology. A few days later I handed over an order list for £2000. The money was released and equipment and consumable resources were ordered. At our initial meeting I had also asked if I could investigate the Technology Tree Project, again without hesitation my request was agreed, our head teacher had already participated in a business partnership at a previous school so she was fully aware of the impact that it could have on the curriculum. Over the spring and summer term I was allowed to attend six business links days in a variety of companies and organisations; Tesco, Severn Trent Water, Salters Scales, Bierd Ware, and Robinson Chemical Works. It was at Robinson's that I was introduced to the Technology Tree Project. After arranging a visit to the school with Robert Hall and Dinah Jays, from Sandwell Education Business partnership (EBP) a partnership company was found, IKEA, Wednesbury. I made the initial visit and we agreed upon our first project. As I was to move to year six for the next academic year it was decided that they would be the ideal class to participate in the partnership.

IKEA Partnership

The project initially had a textile focus, the children were working on some ideas for a Millennium tapestry at the time, and although I had studied some elements of textiles whilst at University, I felt that I needed some expert input on textiles techniques and skills.

After a five-day teacher placement with IKEA, I returned to school with lots of new ideas that I wanted to develop. I also wanted to get a group of children into the company so that they could share some of the learning experiences that I had been exposed to. As this was a new concept for both the company and the school, it was a joint decision to take a party of just 12 children on the first visit.

The visit was set around the flooring department, where the children were given expert input on the development of designs, the use of colour, pattern, material and manufacturing processes. The children were also told about the different tribes who had been involved in the designing and making of the rugs from all over the world. The experience was so different from what they were used to. The added challenge was that their work was to be displayed in the store, so they knew they had to make a real effort.

The expertise and range of materials that were available was tremendous and the children's imaginations were fired. As a result, their questions were far more sophisticated and well informed. Their thirst for knowledge grew a great deal in that short period.

Figure 2 Year Six pupils examine a range of rugs and identified materials and manufacturing techniques used

The visit inspired the children so much that when they were back in school they researched a textile technique called 'couching' on the Internet, after following a couple of links the children were directed to the 'Young Embroiderers' web site, which gave a step-by-step approach to the technique. The site was so well illustrated and explained that even the children who had not visited the store were able to share the learning experience and develop their own work.

The school has now just completed a second project with IKEA, this time the project had a dual focus. Firstly, the children were taught to develop their designing skills using a storyboard approach following the same format as IKEA designers. Secondly, the children were involved in a wood joining and finishing project.

This was a very intensive and to some extent an ambitious project that ran over a three-month period. The children had to create a storyboard for a room that they would like to see on display in the IKEA store. This was a very difficult task in itself due to the number of considerations that the children had to undertake. They had to create the family who would use the room, consider the number of children, leisure time activities, types of occupation etc., as these were the major factors that influence people when setting up a home or buying furniture – the amount of disposable income they have left after paying household bills, food, planning holidays, considering the children's educations, clothing and so on. Other considerations included; types and styles of furnishing, flooring, curtains, lighting and accessories.

The children collected fabric swatches for curtains and furniture, pictures of furniture, samples of wall coverings and decorative rails to be used on their storyboards. Consideration was given to contrasting and complementary colours, thickness and durability of the materials being used and the suitability for the purpose.

Figure 3 Sample storyboards used for a stimulus

The second part of the project involved the children going into the store itself, this time to explore wood joining techniques and finishes. After some input from the IKEA staff on different wood joining techniques and possible applications, the children were allowed to explore the dining furniture department to find as many different joining techniques as they could, and sketch them. Staff were on hand to support and advise the children as and when needed. On the visit the children experienced a lot of expert tuition and they can now successfully identify a range of joints to include, dowel, tongue and groove, dovetail, mortice and tenon and laminating.

On returning to school the children undertook a task that involved putting one of the processes into practice. After some consideration the children were guided towards laminating, as this would give them the opportunity to explore a range of woods, both soft and hard which varied in both colour and malleability. The wood was prepared for the children so that it was of a uniformed thickness and lengths, jigs were also prepared for pressing the wood together after the children had glued their pieces of wood together. Once the wood was dried the children were shown how the wood was to be planed, and their samples went to a local carpenter to be prepared for the next step. The blocks of wood were back in school within a couple of days, the children sanded them using different grades of sand paper until the desired smoothness was obtained. They marked out their desired shapes, and the samples went back to the carpenter to be cut on an electric jig saw. Once the samples were back into school the children finished them off using natural bees wax. The shapes were mounted onto card and used for calendars.

Figure 4 Samples of year six laminating work

Technology Tree 3 – A three way partnership. Primary, secondary and industry

Due to our involvement in the Technology Tree Project we were asked to participate in new pilot project that was being undertaken by Sandwell EBP. The project involved a three-way partnership on this occasion, primary, secondary and industry. One of the project's aims was to get children from both year six and seven working with practising engineers and to undertake a joint project that would help to promote progression and continuity of the technology curriculum from key stage two to key stage three, which at the same time raised the profile of engineering as a future career.

To set the project up I had to complete a five-day teacher placement with the company along with the year seven teacher from our local high school. Our role was to find out as much as possible about the company, and to generate a scheme of work using the company as a stimulus that promoted progression from year six to year seven. The company involved in the project was 'Malcolm Electro-Painting and Powder Coating Company'.

Figure 5 Year 5 children preparing the cloakroom

After a lot of thought and investigation of the company's processes it was agreed that we undertook a control and monitoring project with Year 6, where the children would visit the company to explore the types of machines and mechanisms used on the shop floor to carry the component parts around from one process to another. At Year 7 the project would be based around 'What's in a Finish?' Here the proposed project was for the children to make an artefact from metal and take it into the company and put it through the powder coating or electro painting process. The object would then go through a series of tests in the company's labs to test for durability, rusting etc.

Before visiting the company a lot of preparation work had to be undertaken in terms of risk assessment by both the school and the company. The children would be walking around a factory floor where fork lift trucks were in constant operation, moving overhead conveyor belts which carried low loaded components of considerable weight in some areas, plus there was use of chemicals and a lot of very complicated machinery all around. As one of our pupils was deaf, with a cochlea implant, precautions had to be taken to ensure that she was not near any machinery that had a magnetic field.

Back in school the children had to be prepared for their visit, part of this preparation was done by Malcolm's, they went to a lot of trouble to digitally photograph parts of the factory floor and some of the process for us and E-mailed them to school.

The photographs were used to introduce the company to the children and what it would look like when they visited, they also provided valuable insight into safety issues and potential hazards. It was also an opportunity to see the types of machines and mechanisms used.

This was followed up with a work shop focusing on a range of mechanisms, with a particular emphasis on the use of pulleys and gears looking at the range and type and how they worked. The children explored spur gears, gear trains, idler gears, chain driven gears, ratchet and pawls, pulleys, the role of a drive pulley, how they worked and changing the speed of ration.

Figure 6 Finished cloakroom

The children spent half a day visiting the company and looked at the application of gears and pulleys within the factory, and how they were used to assist the work force in transporting heavy loads around the shop floor. The children also had the opportunity to see the use of limit switches in action and how the end of one process automatically triggered the start of the next. Yet again the children were being exposed to the expertise and resources that would not normally be available in the primary classroom. The range of questions asked by the children were very complex and illustrated an obvious desire to learn more.

Back in the classroom the children started work on designing a machine for a specific purpose, and elements of the Qualifications and Assessment Authority (QCA) scheme of work Unit 6C Fairgrounds was integrated into the planning, along with Unit 6E, balanced and unbalanced forces from science and unit 6C from ICT, Control and monitoring – What happens when…?

The design work was planned to take place over a two week period which was to be followed by four skills focus sessions over a two week period with the making stage of the project being a one week intensive workshop making their models. Unfortunately we didn't get as far as the making stage owing to an Ofsted visit, which coincided with Millennium week in school. This was to be a one off week in school when the children were going to be involved in a whole host of exciting projects and time table restrictions were to be lifted. Rearrangements were made so that the school could reflect a normal time table with the normal amount of time being set aside for all curriculum areas so that Ofsted could the see the full range of subjects being delivered reflecting the whole curriculum and not just design and technology. Almost immediately after our inspection Year 6 had to attended their three day induction at the high school and time ran out for completion. For us this was unfortunate in more than one way, not only had we not fully completed our objectives for the project, we found out that the Year 7 teacher was leaving to undertake a new job, and there was no one else within the technology department willing to take on the added responsibility. To some extent the partnership broke up at this stage, between primary and secondary.

Fortunately for Holyhead one of the company's managing directors joined our governing body which secured our links with the company for the foreseeable future. A year down the line the links with Key Stage 3 have been rekindled, but this time with the science department. The focus of the Key Stage 3 project is undergoing change, and will have a forces focus to build upon the knowledge gained at Key Stage 2.

The primary level of the project is scheduled to start again in May 2001. Even though the project remains incomplete from last year, the children gained a tremendous amount of knowledge and skills as a result of the partnership. The Ofsted inspector for design and technology recognised the contributions that were being made by our links with industry, and found that our children were working mainly at Level 5 by the end of Key Stage 2 for design and technology.

The Future

All staff in the school have now participated in a business links day for their own professional development, and years 2, 3, 4, and 6 have all participated in business partnerships to develop a range of curriculum areas.

It is hoped that with the continuation of existing projects and the integration of other year groups into other projects will enhance the curriculum even further, with projects starting lower down school giving us as a team more time and opportunities to develop our children further.

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Constructing ideas through drawing

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Introduction

The issue of how useful drawing can be as a designing strategy for inexperienced designers, continues to be a matter of debate between design educators. In this paper, I offer both a rationale for developing children's use of drawing, and a framework in which it can be used. I give an account of work with children in a primary school which illustrates this.

Design and Technology, both as a fundamental human capacity – that of being able to make changes in the material world to meet some human purpose – and as a school subject, is best characterised not in terms of a specific body of knowledge but in terms of purposeful activity. The active learning process which epitomises design and technology education is more closely aligned to constructivist epistemology than to any other (Dunn & Larson, 1990 pp. 4 – 5; Ritchie, 1995, p24;).

Constructivist epistemology is fundamentally based on the understanding that knowledge exists in the mind of a knower. In this, constructivism differs from positivist epistemologies, which posit knowledge as being grounded in some 'objective' reality. Constructivism sees the individual as constantly adjusting her/his knowing in response to new pieces of experience and/or information, and that the nature of such adjustment will depend not only on the nature of the experience, but on what the learner already knows, and how s/he knows it. The learner is an active agent of her/his own learning rather than passive recipient of transmitted knowledge. Ritchie (1995) identifies three 'key features of children's learning'.

- Children learn from experience, and practical activity has a vital part to play in providing that experience
- Learning is an active process which involves learners in constructing their unique understanding of the world and this understanding will be significantly influenced by what they already think
- Learning normally takes place in a social context and that context, similarly, influences learning. (Ritchie, 1995, p.24).

Constructivist theorists thus recommend teaching strategies which are based, firstly on trying to reach some assessment of what is already known or thought, and then on presenting the learner with the sorts of experiences that are calculated to develop their understandings in particular ways. Powerful learning experiences are recognised as being those in which learners, individually or collectively, act upon the world (for example by making something), examine the outcomes of their actions and reflect upon them. The necessity for doing and acting as ways into reflection-to-produce-understanding, and the development of knowledge derived from first-hand interaction with the material world, are central to design and technology education.

Mental Models and Expressed Models

Constructivist theory is based on the understanding that an important aspect of thinking, both about abstract ideas and about the physical world, is the construction of 'mental models' of phenomena:

Human beings understand the world by constructing working models of it in their minds. Since these models are incomplete, they are simpler than the entities they represent. (Johnson-Laird, 1985,p.83)

This understanding is widely accepted by psychologists. Eysenck (1993) argues that:

…successful thinking results from the use of appropriate mental models, and unsuccessful thinking occurs when we make use of inappropriate mental models. …A mental model is simply a representation of the state of affairs…, and it may be in the form of imagery. (Eysenck, 1993, p.150)

This development of cognitive models, that represent the perceived world in simplified ways, is crucial to our understanding of how people think and learn.

Gilbert & Boulter (1995) write: *'A model may be defined as the representation of an object, an event or an idea [which is] produced […] by the use of a metaphor'* (p2). They present a typology of models, including:

- A mental model (a personal, private, representation of a target)
  - An expressed model (that version of a mental model which is expressed by an individual through action, speech, or writing) (ibid., p2).

Baynes (1992) offers a way of categorising expressed models which refers to the function of the model:

- Iconic models look like that which they represent
- Symbolic models use an abstract code to stand for a selected aspect of existing or proposed reality
- Analogue models use representations such as diagrams that stand for but do not look like a selected aspect of existing or proposed reality
- (Baynes; 1992, p.13).

Because the process of design thinking involves successive iterations of expression of, and reflection upon, the mental model, it actively supports the development of skills of cognitive modelling, in particular in relation to imaging. Archer & Roberts (1992) suggest that:

The things or systems devised or commented upon by a child are indicators of the development of the cognitive modelling capacity which is the core of learning-through-designing. That is to say, the educational ends of design activity are, primarily, the development of the cognitive modelling capacity of the individual […] manifested and developed in intentional activity of which design is a sub-class. (Archer & Roberts, 1992, p.3) (my emphasis)

From this point of view, therefore, it becomes extremely important that we develop and support design modelling skills in all children. But can this be done without teaching them to use drawing/sketching as a modelling tool?

The National Curriculum Orders for design and technology, in their various manifestations, continue to emphasise the role of drawing as an aspect of design activity, and that children should be taught to use drawings in developing design ideas (DES 1990; DfE 1995; QCA 1999). The National Association of Advisers and Inspectors in Design & Technology also spell out aspects of modelling through drawing which should be taught (NAAIDT, 1996). Design educators, on the other hand, are not unanimous on this matter. Chambers (1989) points out the crucial role of discourses of design thinking in enabling student designers to clarify their intentions in the earliest stages of a design project (p.79). Kimbell, et al. (1996) recognise the variety of forms that modelling may take, and value highly the role of discussion in clarifying design thinking*, but also say:

Images are our prime instrument of technological expression. The things we can draw are in effect the things we can think. Models are the terms of our thinking as well as the terms in which we present our thoughts, because they present the objects of thought to the thinker himself. Before a drawing communicates ideas, it gives them form, makes them clear and in fact makes them what they are. (Kimbell et al., 1996, p.23)

A number of writers (Johnsey 1993; Constable, 1994; Bold,1997) comment on children's readiness to model in 3-D in comparison to their reluctance to use drawings to explore their design ideas. Bold (1997) offers the view that working in lightweight, disposable materials such as scrap paper enables them to modify their work and try a range of ideas without fear of 'wasting' materials, and to develop skills of 3-D visualisation. (p.39). She nonetheless identifies drawing as one of the main aspects of designing skills and personal communication (ibid., p76). Johnsey (1993, 1997,) on the other hand, observing that primary school children rarely choose sketching or drawing as a means of modelling their ideas, and that much designing and design modelling is undertaken through talk, gesture, and the manipulation of materials, questions whether any value can be attached to expecting children to use drawings. He suggests (1997) that teachers should empower children to employ what he calls a 'toolkit' of designing strategies or 'procedural knowledge'. The metaphor of the toolkit is a powerful one, since it implies that children are taught actively to select the designing strategy or concrete modelling device most suitable to the task in hand.

Barlex (1991) was concerned that in teaching design and technology, the product of externalisation, the visible model, may be over-valued:

It is all too easy to see the end result of the modelling activity, 'the models' as the most significant part of the activity. They are only significant to the extent that a) they help the pupil designer develop a clearer picture of that which he/she is designing and b) that they reveal to the teacher the mental processes of the pupil in coming to grips with the design task. (Barlex, 1991, p.148)

Although earlier versions of the National Curriculum emphasise the use of graphic techniques – drawing and sketching – for modelling, the Orders implemented from September 2000 give less emphasis to actual techniques used to model ideas. Drawing is mentioned alongside 'making models' as a method of communicating ideas, and the emphasis throughout the Order for Key Stages One and Two is on communication rather than on the process of examining an expressed model (QCA, 1999).

The Assessment of Performance Unit (APU) model of process in design thinking (Kimbell et al. 1991) offers a view both of progress through a specific process of design and realisation, and of the progress of an individual as a design thinker. The iterative relationship between the successive cognitive and the expressed models, whereby the struggle to express the 'hazy idea' develops the understanding of that idea, and the view of the expressed model clarifies the original idea and makes it accessible to modification, also provides a metaphor for the development of the designer. More experienced designers are likely to go through more of these process loops, from cognitive model to expressed model and back again. They are able to scrutinise their original expressed models, leaving them open to reconsideration and modification. Less experienced designers are more likely to be satisfied with their expressed ideas at an early stage in the process.

Bold (1997) believes that, although the APU model 'provides for progressive development of the designing process, it does not provide a model for teaching and learning that process' (p.25). According to Bold, the design ideas of young children are 'definite' rather than 'hazy', and thus not open to modification prior to making (p.25). It is possible, however, that this is not because children's ideas are not 'hazy', but because their limited experience makes it hard for them to recognise the haziness that inheres in their cognitive models. Several writers (Anning, 1993; Constable, 1994; NAAIDT, 1996; Bold, 1997) suggest that observational drawing of a product following the making may be a better approach for young children.

Drawing is clearly seen by experienced designers and design educators as a valuable method of modelling ideas. Yet opinion remains divided as to how useful drawing can be to a novice designer, and in particular to children in the primary phase. If it can be seen to be useful, then it is important to identify what those uses are, and how best to exploit them. If on the other hand there appears to be little purpose in children's engagement with sketch-modelling, we could ask how it could be made more purposeful, rather than simply discarding this approach. Is it possible to empower children to use sketching/drawing purposefully in developing their designs? What strategies will assist this, and in what situations, and what are the key features of such strategies and such situations? If engagement with sketching/drawing as a form of modelling has important outcomes for children's learning (for example in learning to deconstruct and to understand the visual expressions of others) how do we best enable children to achieve these outcomes?

Hightown primary: Children in Year 3, drawing before making

Hightown Primary is an inner urban school. It serves a mixed community, including children of Asian (mainly, but not exclusively, Punjabi) and Afro-caribbean as well as European origin. At the time that these observations were made, I had been invited to spend time working with children from the Year 3 classes. The teachers were keen to see how far children could extend their ideas in engagement with design & technology. They were interested in the ways in which they would be enabled to use a variety of components, and combine recycled and resistant materials to realise their ideas. Planning was undertaken on two pre-visits. It was decided that I should work with a small group from each class, to give the teachers the opportunity to see what was possible, and what the children's capabilities were.

I took on the role of support teacher, working with sixteen children in all, five or six at a time, for six sessions over a period of several weeks. I undertook all the detail of the planning and resourcing for the activity, and took charge of the children while they designed and made their products. I worked with the children in an area devoted to practical activities, outside the main classrooms, discussing their progress with the teachers at the end of each session. Evaluation of the finished products was undertaken by the teachers, and involved other children in their classes as well.

The design task was devised in collaboration with the class teachers. The year group was using a theme of 'clothing' as a focus for their work in science, history and geography. The children had already done quite a lot of work focused on textiles, and had had some experience already of weaving. Because the teachers wanted them to have some experience of working with resistant materials, it was decided that the focus of the design activity should be on washing clothes.

Rather than set a tight brief, we wanted to encourage the children, through discussion, to think about the various processes that clothes go through when being washed. I therefore started by asking the children to recap on some of the things that they had been finding out about clothes in their science work. I told them that what we would be doing together was thinking about how to get clothes clean, and all the things that we might need in order to do that. I suggested that, rather than all do the same thing, we might think of different ideas that the children could try out. The children then began to make suggestions about various aspects of washing and drying clothing. Among these ideas were the notion of a 'machine' to wash the clothes, something to get the water out of washed clothes, and ways to solve various problems associated with getting wet clothes dry, such as the problem of hanging out washing on a wet day. The children worked in self-selected groupings to decide on the focus for their work, mainly working in pairs or trios but one or two working alone.

As children came up with ideas, I suggested that they might be able to show me what they meant by making a drawing. I tried not to put pressure on them to draw, but to suggest that a drawing would help me to see what they were thinking about. Most of the children did respond to this suggestion by drawing something. These initial drawings, with a single exception, tended to be extremely tentative. [The exception was a pair of boys who chose to consider a completely different aspect of clothing. They drew in great detail a system whereby the production process was brought together, so that sheep are shorn, wool processed (cleaned, spun and woven or knitted) and garments constructed on a single site. They pointed out that this would save on transport between different sites of production – an extremely sophisticated view for children of 7 or 8 years!]

These tentative initial drawings then became the focus for further discussion. We looked at each drawing together, and considered how the intended product would work. Through this discussion, it was possible both to suggest improvements (for example, to consider how a vertical pole could be stabilised) and to find out in what areas the children lacked the necessary knowledge or skill to be able to carry out their ideas.

This enabled me to devise focused tasks for the various groups, based on what they intended to make. These focused tasks were carried out only by those children who needed them for their design task. Thus for three groups, who wished to power their devices with electric motors, the focused task involved making up simple circuits and incorporating home-made switches, whereas for other groups the emphasis was on cutting and joining spars and dowel.

As the children progressed through the focused tasks, we again looked at the original sketches, and discussed to what extent they now represented the children's ideas. The majority of the children at this point chose to re-work their sketches, because they now had clearer ideas about what they wanted to make.

Design activity in the primary school – Issues of 'realism'

A further question that merits some exploration, is consideration of the sorts of design tasks that children in the primary phase of schooling are asked to undertake, and the types of expressed model that are most appropriate in the course of such work. In the generality of writing on design processes, there often appears to be an embedded assumption about the 'reality' of the end product, which is not always borne out by observations of the tasks that children actually carry out in school. Much of children's design work culminates, not in prototypes made in materials that are appropriate for actual use, but in products that are themselves models constructed in easily-manipulated, inexpensive, or lightweight materials. Some are accorded the status of models, albeit working models – for example of historical buildings, of transport systems, of lighthouses and water-mills. In the worst case, these may be only representations of what they in fact purport to be – 'musical instruments' that cannot be played, 'kites' that will not fly, shoes that fit the feet but are insufficiently robust for continued wear. They thus come into the category of iconic models.

The outcomes of this design work thus have a physical reality, but may be perceived by the children themselves not as 'real' products, but as models. Even where a child has constructed, for example, a working 'torch' (a very popular project), the degree of 'reality' is confusing. The torch has a 'real' circuit, which works, but is constructed from components some of which are precisely those that would be found in a mass-produced torch, (the battery, the bulb) and others of which are not (such as foil reflectors, switches made from paper clips, casings from recycled materials). These then become representations of the components in the 'real' (i.e. industrially manufactured) torch. Quite aside from the questions of manipulability and expense of materials, there are excellent learning reasons why this should be so. A switch constructed from a paper clip, which manifestly opens and closes the circuit, serves as an analogue model (Baynes, 1992) of the press-to-make or slide switch in a factory-produced item. By constructing switches which are analogues of those used or produced industrially, children are enabled to assimilate and reinforce appropriate concepts about how electrical circuits 'work' and about the way in which electricity 'travels' or 'flows' in the circuit. Constructing their own switches enables children to understand how they work.

Children may be quite justly proud of their achievements in creating these artefacts, while at the same time not recognising them as 'real' in the sense that a bought product may be 'real' – even though they 'work' in essentially the same way. If the process of constructing such an artefact is in itself modelling, and is understood as such by the child, we need to ask whether – and when – graphic modelling serves a useful function. One might argue, that the process of constructing such an artefact is better served by the articulation of a specification, and by modelling through the three-dimensional construction, which is itself likely to go through a number of phases before the 'product' satisfies the expectations of the producer. To interpose the expectation that some part of the intention will be modelled graphically beforehand may become counter-productive. It becomes an act of 'modelling modelling' – outside the 'real' modelling which is inherent in the construction.

In the work at Hightown, the 'end products' of the activity were analogue models. Children were able to use and test them as scale-models, although knowing that full-sized versions would be constructed using other materials. Through the process, children were empowered through discussion to reconsider their initial drawings. They were able to think about how their ideas had changed in the course of the planning, and through the clarification of the ideas provided by carrying out the focused tasks. Some children, through this process, also chose to rework their drawings, or to make fresh drawings that more accurately represented their developed ideas. Although these fresh drawings did not fully embody the final products, they showed very clearly how their ideas had progressed. The representations produced by the children developed from rather vague, iconic models to those that were more closely analogues of the ways in which their products would work. It is also noticeable to what an extent this greater clarity of thought is reflected by greater assurance and skill shown in their drawings (figures 1,2,3).

I would suggest that there are several aspects of this work that offer a key to the successful use of drawing as a way of expressing and refining the initial mental models of children:

1. No expectation was placed on the children that they should come up with a 'finished' idea in the early stages. The initial ideas, and drawings, were used as a basis for discussion and further thought.
2. The emphasis in thinking about the intended products was on function and construction, rather than on appearance. We talked about how things would work, rather than what they would look like.
3. The suggestion of drawing, although it came from me, was specifically focused on its communicative purpose – it was to help me to understand their ideas.
4. By using the initial drawings as a focus for discussion, children were enabled to clarify their mental models for themselves as well as for me. They could then develop them further, in particular by identifying what they would need to know in order to have a clearer mental picture of the product they wished to make.
5. These discussions also helped me to devise focused tasks which were appropriate to each child's intentions, and supported their development of successful outcomes.

Much of this depended on working from children's ideas, rather than from some preconception about what they would learn. To that extent, it cannot be used as a model for planning and teaching in a crowded timetable with a full class, where more control needs to be exercised over the range of product ideas,and learning outcomes. However, it may offer some clues about the ways in which teachers can help children to build upon their initial ideas through focusing on their drawings as starting points for discussion.

* Kimbell and his associates in the APU project found that the opportunity for learner-designers to discuss ideas, with each other and with teachers, at specific points in the designing process was critical for the development of high-quality design thinking and design outcomes.

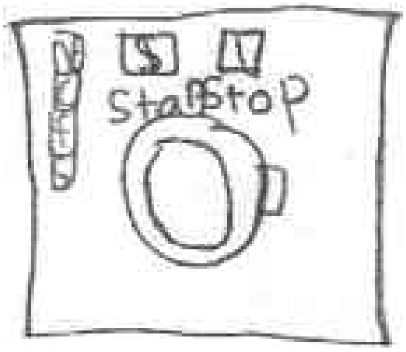

Figure 1

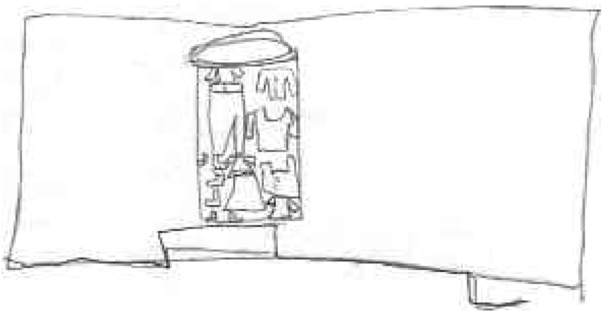

Figure 2

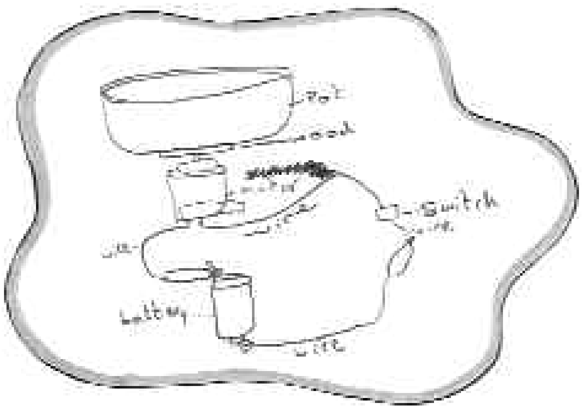

Figure 3

Figure 4

Figure 5

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Why we still don't have design and technology in our primary schools

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Introduction

During the development of our research work in our Production Engineering Post Graduate Programme, Doctorate in Production Engineering – Design field, at our University, and conscious of the importance and relevance of design activities to growing children, we wished to identify why the subject 'Design and Technology' is still not integrated into the Brazilian National Curriculum. We think there are two main reasons for this: the first one has a historical and cultural origin and it is about the type of educational system adopted in our country; and the second reason is essentially cultural, as it is about absence of advanced awareness, tradition and consolidated design culture in Brazil.

Brazil is the largest Latin American country. It has about 150 million inhabitants. It is a young and emergent nation. Its economic situation is that of straightforward development but it still has relevant social, economical and political problems. There are some poor areas, in the North-eastern part of country and around our big cities, a disproportion in personal income, demographic gaps in the North and crowded, high urbanised and high industrialised places in Middle-South, large cultural contrasts between North and South; and a search for a democratic reaffirmation etc. On the other hand, we have some unifying factors such as the use of the same language throughout our national territory from the Atlantic Ocean to the Andes Mountains and from 'Oiapoque' to 'Chuí' cities.

Our economy is the most diversified in South America. The industrial development, in despite of its traditional protectionist politics, has high potential and currently is facing the modernisation challenge, the international business competition and the globalisation of the marketplace. The vigorous growth tried from 1930's to 1970's in our economy created a model that increased our own social differences.

From 1500 to the present, we were under a strong physical and cultural influence from Europe, Africa and our Natives – our ethnic roots. Since then, we have obtained a rich and emphatic cultural diversity and a growing miscegenation of races, habits and social uses into our society. These seem to be a positive influence.

It is natural for a developing country to be worried about its basic social problems including health, food, shelter, transport, employment and education. As designers our concerns are the improvement of life quality through designing things to satisfy necessities, so building our material culture. As designer-educators, our worry is to provide adequate education in order to prepare our new generations to interact with rapid changes in science and technology. We are concerned to provide education to develop creativity in pupils to enable them to respond to the new demands of a post-industrial society. We think design is an important tool in this process and we believe in the high pedagogical potential in teaching and learning by it. In despite of all our social, economical and political problems, we must be part of technological advances and of world trends in education.

Education through design is already a reality in some countries. It is sad that the concerns already described, are still not shared with the managers of our national education.

Brazilian Education

Throughout its history, Brazilian Education has had some different 'owners' who have had different intentions. At the beginning, education was under the Catholic Church's desires of indoctrination and then under State's influence. In the struggle between State and Church, there was an increase of scientific knowledge into the school curriculum. The intention of this act was to replace the scholasticism and to improve a materialist view of the world – this was a strong influence of 'Illuminismo' (The Enlightenment). Later, we were under imposition and presence of a 'reproductive' and 'technician' model (North American model). Recently, the materialism, the absence of critical thought and the absence of making historical knowledge, were questioned. Today, we are searching for an holistic and interdisciplinary educational viewpoint.

Brazilian Education, for a long time, was characterised as a dual system of teaching: there was a school system for rich people and another for the poor. This dual system increased prejudice about technical and manual activities in primary and secondary schools, mainly in those schools that taught crafts to young people. To learn a craft was considered more appropriated for poor people. This is a Portuguese heritage (hand labour was done often by African Negro slaves) and then this kind of work was considered depreciative. For the rich, there was a classic and elitist school that prepared them for noble occupations, mainly those linked to magistracy. The majority of elitist schools were maintained by the Catholic Church or by private organisations. The public education, offer by the State was generally of low quality; our governors considered public education unimportant. The biggest demand for education was in urban places predominately in the fields of Arts and Sciences, under the strong influence of Europe, particularly the French School.

The panorama only changed after the second half of the nineteenth century when industrialisation started in Brazil. The need to read, write and calculate, turned out to be more evident then. Slowly, engineering and technical activities obtained a social status. To be a craftsman, who excelled in technological work in that society, was very important. This was a way to become recognised in the social hierarchy. The schools of arts and crafts, the Brazilian Navy and the Army Schools, taught and educated citizens to do specialised work. However these new professional occupations were considered most appropriate for the proletarians' sons, less appropriate to bourgeoisies' sons and rarely appropriate to the sons of the aristocracy. Then, the technical and manual activities were understood to be less important. We still must remember that the political end economical power was in the Brazilian aristocracy and ascendant middle class hands. The political decisions and the national orientations, including those about education, were caught under the values of dominant class. The ascendant bourgeoisie claimed for its sons the same education as the aristocracy. All kinds of manual work, craft or technical activity, in despite of its importance, were still considered depreciative. The dual system of education was still alive. Art had social status but not craft and industrial arts.

We must be fair. Some important personalities of that time were affirmative about teaching and learning manual and technological activities in our primary and secondary schools. One of them was Mr. Rui Barbosa, a famous Brazilian political person.

When the twentieth century began, Brazil was touched by 'modernity'. Some colleges, universities, technological schools, schools of art, schools of architecture and schools of engineering were founded. After the 1950's there was an expressive growth of our process of industrialisation. But, only in the 1960's, our first school of design was founded.

New pedagogy

With the new ideas in the pedagogical field, as 'Ativismo' (Activism in Education) and the 'Nova Escola' (New School Pedagogy), and later with the 'Constructivism' contributions, the manual and technical activities were being adopted in some Brazilian schools. Well, in an incipient way, industrial arts, manual works, crafts, games and drawing, were introduced into infant education in some advanced schools immediately. Our teachers received good influences from Maria Montessori, Georg Kerschensteiner, Célestin Freinet, John Dewey, and most recently from, Jean Piaget, Lev Vigotsky and Jerome Brune; and also from the Brazilian educators Anìsio Teixeira and Paulo Freire.

During the Brazilian military dictatorship, the 'Ativismo' and 'Nova Escola' ideas were completely suffocated. An Educational Reform was done in LDB – Lei de Diretrizes e Bases da Educaçâo (Brazilian Education Law). The process was despotic and through the Law no. 5.540 from 1968 and the Law no. 5.692 from 1971, the Brazilian Education got a pure 'technician' orientation.

In November of 1966 some 'secret' agreements established between MEC – Ministério da Educaçâo e da Cultura (Brazilian Ministry of Education and Culture) and USAID – United States Agency for International Development were made public. By these agreements the Military Brazilian Government received 'technical assistance' and some 'funds' to implement the Educational Reform. Our educational system represented a dependent model of economical development, imposed by USA economic policy for Latin American countries. Some others adjustments were made to the Brazilian educational system during these dark historical period.

After the 1980's, when the Democratic State returned to Brazil, it was possible to introduce a new Educational Reform. The new LDB was written in 1996, after some public discussions. In spite of its explicit and implicit references about technology, science, art education, training to work, the new Law did not consider the potential of manual or technical activities neither the possibility to teach and learn through design activities. Subjects, such as design and technology, do not have any legal prerogatives in the new LDB.

Design or... what?

In 2000 the 'PCN – Parâmetros Curriculares Nacionais' (National Curriculum Parameters) was published. These documents are the actual references to renovate and to elaborate educational projects for all primary (fundamental) Brazilian schools.

The knowledge areas defined in LDB and PCN nearest to design education were 'Educação em Arte' (Art Education) and 'Ciências Naturais' (Natural Science).

Art Education intends to develop the artistic thought. Through it, children can exercise his or her sensibility, perception, reflection and imagination (Brasil, 2000(b) p. 15). To learn art, involves making artistic works, to know, to appreciate and to think about individual or collective artistic productions in several cultures and several historical periods.

The role of Natural Science in the Brazilian Primary Curriculum is to enrich children's knowledge and understanding about the world and to promote his or her integration into the Universe. The concepts and procedures in this area join together to extend the children's knowledge about natural phenomena and how to use natural resources (Brasil, 2000 (c), p. 15). Technology integrates this knowledge area. The teaching of Natural Science should ease the meaningful learning of historical knowledge, establish scientific conceptions and set relations among science, technology and society.

PCN recognises technology as a way to transform and to apply raw materials and energy; as a way to choose, to interpret, to organise and to register technological information. Despite its recommendation to study equipment, appliances, tools, and to identify its functions to human activities, PCN ignores the designing process involved with technology (as a problem solver process, as a project activity or as a creative thinking applied to develop new things) and it does not include any reference relating to it.

In Art Education, although its reference about creation, construction, sensibility, expression, meaning, analysis, reading, valorisation, manifestation, production of visual forms and cultural wells, PCN doesn't recognise design things as coming from the same origin. The document only recommends promotion of the 'sensible touch', the recognition, the observation and the experimentation of visual forms in any media of image communication and then it includes industrial design in this group of things. This is the only reference about design (industrial design) in all pages of PCN.

Conclusion

We can conclude that there still is among Brazilian educators and legislators, ignorance and no awareness about the importance and potential of design activities when applied in children's education. We must remember that design and technology activities are recognised as a valuable way to teach and to learn and they are part of some official curricula in the world. Design and technology activities are encouraged and endorsed by, for example, museums, cultural institutions, professional organisations, non governmental organisations The low value of design and technology activities in our most important educational documents, should make those who are responsible for our national education, concerned.

However, if poor recognition of design pedagogical potential in our current curriculum generates worries, this is very good motivation for research, to discuss and to develop work in this field in Brazil. Moreover, as designer-educators, we are working to organise a multidisciplinary group to study and to research the education through design in this country. This group is linked to PUC PR – Pontif'cia Universidade Católica do Paraná – Curitiba, PR, Brazil, connected with UFSC. The first practical result of this initiative will be a complementary programme for primary education through design, applied in our context. We think from such an initiative, others will emerge in the future and then, we will have a dynamic and actual educational system, just as it should be.

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Technology education in French primary school: which direction for which goals?

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Introduction

Technology takes more and more place in our lives and we can observe the development of this influence: more presence, more incidences, but more misunderstanding. At the same time, technology education encounters many problems in trying to have a real place in education and specifically at primary school level.

The main idea developed in France about primary school is to organize education as progressive and built emergence of different subjects. French primary school is organized in three cycles for children from three to eleven years old. The first cycle, from three to five, is called a cycle of first learning. The second cycle, from five to eight, is called a cycle of basic learning. The third cycle, from eight to eleven, is called a cycle of fundamental learning. From start to end, progressively, pupils discovered how they could deal with the world and the way to observe, to understand, to interact with the world define different fields of knowledge. Subjects are not presented as an intangible fact but like a human elaboration.

Organisation of schools in France

In France, school is obligatory for all children between the ages of five and sixteen. However, on the one hand, infants schools have an obligation to provide nursery care for children rising three, i.e. from the age of two, and on the other, no child can leave school before the age of eighteen unless they enter vocational training. The legal obligation to be in education between five and sixteen has in fact become an obligation to be in education from three to eighteen. The French school system is organised at two levels, primary education and secondary education.

Primary education involves two schools, the infant school and the elementary school, which in turn are divided into three stages: the initial teaching stage for children aged two to three and up to five; the basic teaching stage for children from five to eight and the fundamental stage for eight to eleven year-olds.

Secondary education for all pupils starts with four years schooling, including all pupils in the same school year. The Lycée offers three options: the general option, with literary and scientific subjects, the technology option with industrial, service and biotechnology subjects and the vocational option, which covers all the vocational sectors. The Baccalaureat examination is taken at the end of secondary education and in 2000, approximately 80% of French students reached this level of education. In other words, all children born in the same year start their statutory education at six and all complete their secondary education at fifteen. At the moment, repeating a year, which was common practice about twenty years ago, and affected practically one pupil in three, now only affects one in twenty.

This massive broadening of the access to secondary education is accompanied by a re-definition of the aims and objectives of each of the education levels. Generally speaking, school up to the end of the secondary stage fits into the context of general education for all, whereas the objective of the lycée is to guide pupils towards a fast track vocational education via the various streams of the vocational lycées or towards university education via the general lycées. One of the major debates concerning education for all concerns equality: should the same thing be offered to all pupils or should all pupils be offered the same opportunities. The topic of equality is a recurrent theme in French education, which is inscribed in the republican values of secularity of schools and free education*. Naturally, we are very far from a caricatural debate, which only sees two alternatives: either we strictly offer exactly the same thing to each child, without any consideration for situations, conditions and environments, or we organise the school system as a form of tough social competition in which only the best succeed. These two terms have to be seen as the two poles between which the French school system vacillates in an attempt to reconcile the social demands for knowledge, the republican values of education and respect for the development of the individual.

Organisation of School and Curriculum

This debate affects the proposed curriculum organisation, particularly from the point of view of the organisation of knowledge. The first important comparison, as seen through the eyes of an informed observer, is the one made between education and the acquisition of knowledge. The two terms are often presented as being contradictory and the acquisition of knowledge is frequently also interpreted as the acquisition of academic knowledge with scholastic, dogmatic or stimulating connotations. Therefore, education was against instruction in the sense that the former allowed the personal development of the individual to be respected, whereas the latter was merely the simple transmission of knowledge, completely out of context and without any social use other than that of imposing a ratio of power between the one who knows and the one required to learn. For example, the term military instruction is used to describe the period during which the civilian is instructed in military things and, irrespective of the country or reference period, this instruction takes place with the tacit agreement of the authorities, expressed in the form of absolute obedience to the military hierarchy. To compare the acquisition of knowledge with instruction, we have to accept a shift in meaning which imposes both the form and the content and which therefore confuses the object to the transmitted and the method of its transmission. In this respect, it is possible to measure the effect of such a shift in meaning by the mass use, in educational debate, of such terms as "objective, strategy, plan, aim to be achieved, etc.", all terms borrowed from military language.

From a formal point of view, this organisation of education is seen as a gesture to behaviourist attitudes. Therefore, an objective to be achieved is determined in order to characterise the acquisition of skills, the mastering of which is checked via the performing of tasks and is based on the observable behaviour of the pupil assumed to signify the objective. This approach allows the author of the curricula and, by definition, the teachers responsible for implementing these curricula, to plan the activities very rigorously over a period of time. The proposed forms of organisation prefer the main axes to be the objectives to be achieved, the activities to be performed and the skills to be acquired. This is how the teaching programmes are constructed for the second subjects at primary and secondary school, in respect of which the subject aspects are undervalued and the specific knowledge is not really defined or organised for that matter.

Science and Technology – The Terms of Debate

At primary school, two main groups, French and mathematics, are the basis of the teaching programme. They constitute the essence of education and contribute to achieving the objectives expressed in terms of reading, writing and arithmetic. This fundamental teaching is the basis for educational teaching, like physical education and sports, cultural and artistic education or linguistic education. Therefore, you have one group concentrating on scientific and technical education, known first of all as "discover the world" during the first stage, then "discovery of the world" during the basic stage, followed by "scientific and technological initiation" in the fundamental stage, finally giving rise to subjects such as "technology", "physical sciences" or biosciences and geosciences". This organisation is based on a progressive construction of the education subjects built on the educational activities performed by the children. This organising principle progressively structures knowledge by organising it to give meaning to the educational subjects. Therefore, we can define the discipline matrices via these principles of a specific curricular organisation constituted to form a whole (Develay, 1992). However attractive this may be, this form of organisation has to be assessed in relation to one of the school organisations, in particular through teaching and learning issues (Charlot, 1997).

The progressive processing of the subject delimitations encourages a constructivist approach to knowledge, whereby the pupil learns new knowledge as the result of the discovery activities conducted in class. The pupil does not organise it in terms of pre-defined school subjects, but according to unifying criteria, such as the nature of the knowledge handled, the action it allows or the methodologies used in the activities. This is a form of construction that lends itself equally to the instrumentalisation of the new knowledge and its categorisation in epistemic references that, at the end of the day, will correspond to the epistemological organisation of the traditional school subjects (Ginestié, 1999). From this point of view, the school is the transition between a sensitive and intuitive perception of the world and a rational relationship via knowledge constituted as school subjects.

In fact, we are seeing a contradiction between this declared intention and the method of organisation of the knowledge chosen. The curricula are organised around a specific pair, the skills to be mastered and the activities to be performed. In this pair, we have seen that knowledge is consigned to references implicit in the subject areas. Therefore, key concepts can never be affirmed, because they would induce a subject breakdown that the authors of the programmes refuse to institutionalise. Contrary to the teaching of the native language or mathematics, which bases its progression on a progressivity of knowledge, the "discovery of the world" area does not display any organising principle; its progression is based on the complication of the tasks suggested to the pupils. The skills are the result of the processes necessary for performing the task. Actually, the only thing at stake is organising the pupil's activity so that he performs the task within the allotted time. The teaching as such is reduced to a collection of activities. In this closed area of the curriculum, the room for technological education is particularly limited.

In the first place, the association of technology and science reduces technology to a form of applied sciences or, more simply, the application of science. The pupils deal with a certain number of scientific concepts (electrical circuit, optics, mass and force, matter, etc.). This activity is based on an experimental organisation that pursues a double aim. On the one hand, the pupils follow a procedure that is close to the scientific procedure of reasoned observation. The pupils observe the effect of the change in certain conditions in an experiment that they set up. For example, they ascertain the visual effects produced by connecting two lamps in series or in parallel in a simple electrical circuit or forecast the position and size of the shadow produced by an object according to the position of the light source. On the other hand, the aim of this organisation is to develop the initial concepts of children concerning a scientific phenomenon and transform it into a representation that is nearer to the scientific concept. The development of concepts is an organisation very broadly developed in scientific teaching in France, whether it be in physics, chemistry or biosciences our geosciences (Robardet, Guillaud, 1997; Rumelhard, 1997). It can be broken down into two distinct stages: initially, the teacher ascertains the concepts that the children have of the phenomenon concerned (for example, what produces the shadow) and in a second stage, goes on to suggest experiments which question these initial concepts and induce the children to reformulate them so that they are closer to the scientific model. In fact, technology is only considered as a means of making an object suitable for the scientific principles being studied (for example, a cartesian diver in relation to shadow and light or a torch in relation to electrical circuits)

Secondly, the technological concepts are not dealt with. The strong link between the design, manufacture and use of a technical object is discussed in little detail and even if it is, a caricatural form of the project process is used where all the choices of solutions are made by the teacher beforehand. In the majority of cases, this organisation is reduced to the making of an object from recycled materials (paper, cardboard, wooden box, etc.) and always in connection with making a gift (mother's day and father's day are times of intense creative activity in classrooms). There is practically no researching of the functionality of the object produced, and the process fluctuates between a dimension of artistic expression and the mastering of motor activities associated with manual dexterity. These two dimensions are important, and we should not ignore their importance in primary education, but they should not be confused with a technological education that they would substitute.

Thirdly, this double confusion – application of science and creative manual work – is largely reinforced by the small amount of interest that teachers have in these areas. On the one hand, more than two teachers in three have a literary type training. Often this literary focus is chosen through lack of interest in the sciences. Also, through lack of time, but also through lack of distinction, the training provided does not allow teachers to measure the importance and rewards of a scientific and technological education and, even if they do appreciate their importance, they fail to understand the measure of the distinctions that exist between science and technology. From this point of view, the large majority of teachers use activities based on biosciences and geosciences (observation of the plant growth cycle, discovering the anatomy, notions of geology, ecology, etc.). In this way, they believe that they are fulfilling that part of the curricula that concerns the "discovery of the world". Few conduct scientific activities (the states of matter - transformation of ice into water in particular - electrical circuits and astronomy mainly spring to mind) and they all believe that they have discharged their technological duty as soon as their children have managed to make any kind of cardboard construction. In fact, in this area, few teachers observe the prescriptions of the curricula, or merely accommodate them by making a particularly restrictive interpretation of the requirements

The Development of Technological Education

The undervaluing of technological education in primary education in France is of an epistemological nature (absence of a clear distinction from the sciences and a definition of the concepts concerned), a curricular nature (absence of a precise definition of the place occupied by technological education and an organisation of the knowledge to be taught according to a progression) and of an institutional nature (lack of actual requirements with regard to the effective use of technological teaching in the classroom). The blackboard may appear quite black, and one would be rather tempted to say that at the end of the day, there is no technological education in the primary school in France. On the other hand, if we accept activities based on scientific applications or manual work as technological activities, it could be said that a technological education does exist. This debate is particularly heated in France between those who believe "that is not technological education" and those that think the opposite, "that is precisely technological education". In the first group, we find a strong representation of technology teachers who are involved in the training of primary school teachers, whereas the second group of debaters unites scientists and those who are behind the present curricula. Apart from these attitudes, the place of scientific and technological teaching in the primary school in France is sufficiently fragile for it to be the subject of particular attention that is often as spectacular as it is ephemeral.

In this stalemate situation, about three years ago, the minister launched an experimental programme called "Lend a hand". The aim is to encourage the development of educational experience in scientific and technological teaching and facilitate the exchange and dissemination of that experience. Widespread promotion and encouragement has resulted in the emergence of interesting projects and the Internet site responsible for gathering project information has soon accumulated a diversity of interesting suggestions. However, it is evident that since the confusion between science and technology has still not been remedied, the proposals put forward are all largely the result of a scientific initiative. Technology, where it existed, has remained linked with a scientific application or manual activities. The "lend a hand" plan has encouraged the emergence of projects, but this has not had the impact expected. Naturally, there has been an increase in the number of projects of interest that are evidence of the considerable degree of dynamism generated. But, it is not enough for a teacher to develop a project and for this to be distributed via the Internet and taken up and used by other teachers. The Internet server is essentially useful for those implementing the activities originating from the lend a hand project - they have been able to exchange ideas, projects, find new inspiration, etc. On the other hand, there has been no demultiplying effect and the projects proposed have not spread much beyond the circle of practising teachers.

In this context, which is not particularly favourable for the effective generalisation of technological education, numerous projects are developing here and there at various teacher training colleges or universities. This work can be divided into three categories. The first category reinforces the position of technological education firmly associated with a scientific initiative (for example, BÈrard, 1998). The second category tends to show the interest of a technological education from the point of view of child development and the contribution that this subject field represents (for example, BÈdart-Nadji, 2000).

Of the number of advantages, psychomotor development with motor control largely springs to mind, which in fact reduces technological education to a form of manual education. The third category is contained in a recent research area in France (approximately fifteen years), which is known as the didactics of scientific and technological education. This work concerns school organisation via the interaction in the classroom between the teacher, the pupil and the knowledge imparted (for example, Chatoney, 1999; Merle, 2000). The study of the influence of this organisation on the performance of the pupils from the learning point of view combines a very large number of projects aimed at devising more efficient and more relevant forms of organisation, didactic engineering in other words. This work is starting to have a real impact since its major development in the last five years, both on the initial and ongoing training of grade one teachers and on the teaching resources available to teachers or even taking into account technological education as a whole component of the general education of children. Apart from the grand declarations of principle, technological education in the primary school in France is being progressively organised around the link between the design, the making and use of objects, which underlines three points of view:

- The psychological point of view via the processes of anticipation, planning and regulation of the actions of the pupils. This has a structuring effect by inducing the children to organise their problem-solving strategy, allowing them to self-evaluate the effectiveness of that strategy and control its smallest details
- The epistemological point of view via functioning, functionality, structure concepts, technological choices or response to a demand. They can serve as a basis for a progression that is based on knowledge by encouraging the enhancement of the concepts through the diversification of the problems to be solved, the organisation of the action to be taken and the levels at which the interaction is taken into account
- From the educational point of view via the diversification of approach, which opposes a general approach and which distinguishes the technological approach from other forms of approach. It is the diversity of the references that allows children to modify their points of view, develop their critical faculties and increase their understanding of the world, in short to develop citizenship and ultimately conduct themselves as responsible and independent adults.

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*In France, 80% of the children attend state schools and 19%, private schools under contract (mainly catholic), i.e. schools that undertake to offer the same teaching programmes, observe the same school organisation (hours, objectives, examinations and evaluation, etc.) in return for which the government takes responsibility for their budget and personnel costs, which are calculated on the same basis as those in the public sector.

An approach to Primary Design and Technology Education at the University of Greenwich, London and some innovative techniques.

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Introduction

The aim of this work was to develop and trial a particular approach to design and technology (D&T) project work with trainee teachers and pupils. The approach was intended to allow maximum creativity while ensuring success, confidence, coverage of programmes of study and manageability for the teacher. Creativity is arguably at the heart of design and technology so it is important to develop ways to promote it. All too often projects such as 'design a desk tidy that will hold six pencils and a ruler using the material provided' type projects limit the scope for innovation in an arbitrary way. The approach set out in this paper is not proposed as the only one that should be adopted but if it promotes creativity it should perhaps be included alongside others. The importance of creativity in education and a rapidly changing world has been highlighted in the important National Advisory Committee on Creative and Cultural Education (NACCE) (1999) report:

…growing demand in business world-wide is for forms of education and training that develop 'human resources' and in particular the powers of communication, innovation and creativity. Creative abilities are needed in all forms of business and in all types of work including traditional manufacturing trades.

Research (still ongoing) seemed necessary to establish whether the approach set out in this paper had the effects that seemed likely. An action research approach suited what was intended and it was also familiar, being similar to the way design and technology practitioners usually work in their subject. Cohen and Manion (1980) describe action research as:

Small scale intervention in the functioning of the real world and a close examination of the effects of such intervention.

The approach described below was trialled with Key Stage 1/2, 2/3 trainees who were interviewed and observed. Two small-scale field trials were conducted later with children. Prior to their first D&T session student primary teachers were given a questionnaire asking them to list National Curriculum subjects in order of how confident they felt to teach them. Of eighty-seven respondents only one rated D&T as the subject in which they felt most confident, a large majority rating it towards the 'least confident' end of the scale. Only music inspired (slightly) less confidence than D&T. Encouragingly however the following comments were quite typical:

Slightly concerned because of inexperience in using materials but keen to learn and

I have a limited concept of technology and to a degree it's the unknown quantity that is case for concern. However I'm confident this will change.

Starting points

The approach being developed clearly needed to increase student confidence in D&T. Students were introduced to aspects of everyday technology that would form the basis for their D&T work. This included demonstrating examples of starting points that they would make later such as a coin operated switch (Good, 1999 p28), tilt switch (Good, 1999 p26) or variations on the pressure pad switch (Good 1999 p14 – 20). As their questionnaires showed, many new non-D&T specialist trainee primary teachers lack confidence as they approach D&T. Demonstrating the 'starting points' helped to reassure students (based on student interviews) that they would be able cope as well as introducing the starting point for their projects.

Establishing the importance of the technology involved early on was thought likely to help motivation. This included discussing and researching where the technology (e.g. pressure pad) is used in everyday life and included using information from a number of sources, including ICT-based ones. Another way of highlighting the importance of a piece of technology was to imagine the consequences if all examples of it were to suddenly vanish. This required students to establish where the technology was used before they could comment. Interviews with students supported the view that establishing a context and real uses for the technology was motivating. What we were doing was seen as part of the 'real world' beyond the classroom – it mattered.

Students were then shown how to make their own working examples of the starting point by following a clear recipe. At this point the emphasis was on following instructions, building confidence and gaining knowledge, skills and understanding in the process. The NACCE report seems to support the need for teaching specifics to support creativity and reinforces what many teachers D&T have discovered:

Creativity is not simply a matter of letting go. Serious creative achievement relies on knowledge, control of materials and command of ideas. Creative education involves a balance between teaching knowledge and skills, and encouraging innovation.

Teaching the 'starting point' with its associated focused practical tasks (FPTs) was intended to provide the knowledge and stimulus that were to form the basis for designing. One advantage of this approach was specific skills and knowledge were built in. Another benefit was that students with little experience were prevented embarking on designs that might not work at all.

Government initiatives in other areas of the curriculum have put considerable pressure on the time given to D&T at Key Stages 1 and 2 and this is very much reflected in primary teacher training. This approach allowed making to start quickly with a very good chance of some encouraging success.

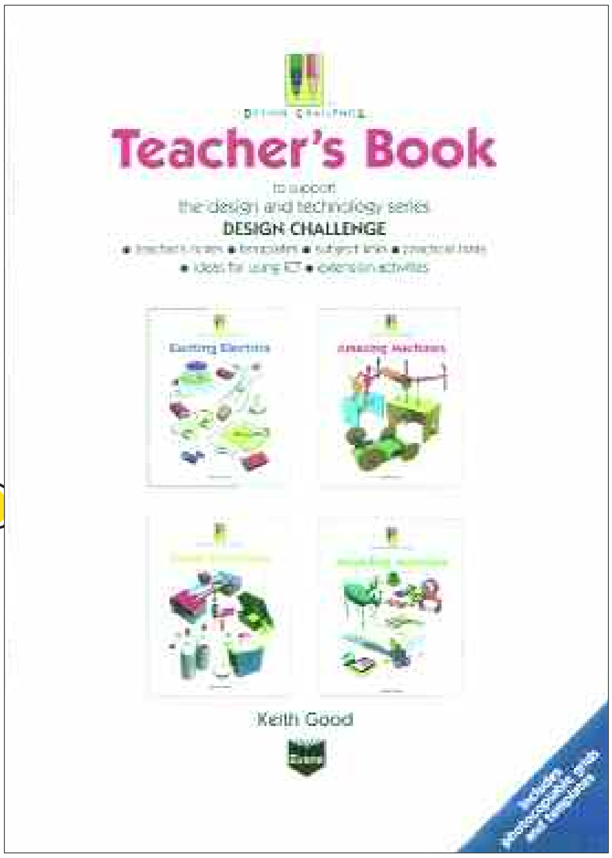

Figure 1 Teachers Book to support the design and technology series 'Design Challenge'

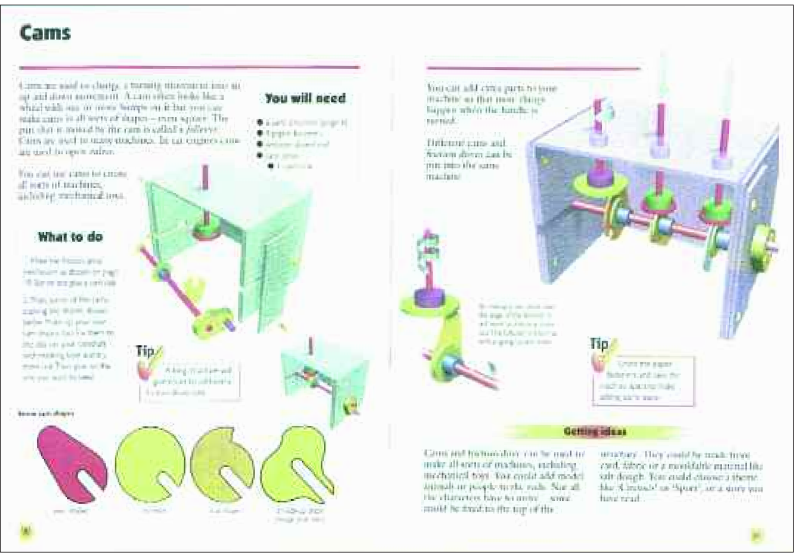

Figure 2 Typical spread from the 'Amazing Machines' edition

Crucial to this approach is that students could go on to develop a wide variety of different outcomes. Rather than confining students to variations on a theme e.g. perhaps not very different desk tidies, this approach seemed to allow scope for designing and making products with different purposes. The variety was made feasible with whole groups by the common tutor input and practical starting point. From observing and listening to students it was clear that design ideas often began to develop while the starting point was being made and that having this literally in their hands was a considerable help in stimulating ideas. The starting point also gave early success which helped confidence. Because students could design and make 'whatever they wanted' (within reason and as long as they began with the 'starting point') motivation was helped as designs could be linked with a perceived need, existing area of interest, other subjects or a problem that they had experienced. Less confident or creative students could be guided towards a narrower area to explore e.g. some kind of money box that included the coin-operated switch starting point. However many students initiated their own ideas e.g. using the switch to trigger a computer control program, make a timing device or sort materials into conductors and non-conductors. Developing the starting points also offered opportunities for using other aspects of ICT such as clip-art, computer generated text and graphics. Some students were able to negotiate modifications to the 'starting point', either at the outset or more commonly to fit their designs as they developed. The fact that the main input was common was what made diversity of outcome manageable.

The starting point approach can be used across a wide range of technology including mechanisms. The outcomes will all be machines but they can be very diverse in their functions and degrees of sophistication. Students and children need to work with and understand mechanisms because they play an important part in their lives as well as featuring in the National Curriculum. Creating the starting points for mechanisms based work gave an opportunity to critically examine existing practice.

Observations

Observing students indicated that there were drawbacks to the usual making methods. We had been using 'Jink's construction' (card triangles and wood frame) to make the supporting structure for any machines but as in school, time and space was a problem. Less D&T time for primary students meant the usual structure would take too long leaving little for the mechanisms or development. Students need to be shown how things can be done quickly and cheaply if they are to attempt similar work in school with literacy and numeracy so dominant. Our mechanism support (Good, 1999) is now made quickly from carton (cardboard with a corrugated centre). This material combines the virtues of being free, abundant and green, with easy working and a rigidity that helps hold working parts in place. Rectangles of card cut on a paper trimmer needed only to be cut part way down the middle from each end before they could be quickly folded into structure with a top, front and ends. The open back allowed mechanisms to be seen working. These structures were held together by two paper fasteners at each end and could be stored flat, saving space and making them easy to take home to work on further. Dowels to hold cams and other working parts, or garden wire crankshafts were held in slots by strips of card secured by the same paper fasteners already mentioned. 'Good' construction! This structure could be made in different sizes and proportions. Second year student teachers that had used the original frame method in their first year were interviewed and asked to compare the two methods. The much greater speed of construction was often identified and students realised that even when machines were almost finished, children would be able to store them flat in their work trays just by undoing the fasteners. Others commented on how easy they found it to measure, mark, cut and decorate the flattened structures. The general response to interviews was that this structure would be much better for school use. Pulleys, friction drives, handles and the fixing points for cams and other parts were all made using card rolling technique developed by the author (Good, 1999 p8) which is central to our mechanisms projects. The end of a strip of recycled card approximately two centimetres wide was glued to wooden rod.

When fixed, then the rest of the strip was glued and wound tightly round the rod to form a solid boss. The rolls bonded strongly and concentrically to the wooden rod and other parts e.g. card disks and cams could be glued securely to them. This method transformed easily worked thin card into strong, reliable working parts once the glue was thoroughly dry. The strips of card were produced quickly on a classroom paper trimmer. This new starting point allowed a range of mechanisms to be used in a class as only one basic method of making had to be taught. Students interviewed commented on how much easier this was than using mdf wheels, red plastic pulleys and other more resistant materials. Others appreciated that schools would need to buy less and that that reliable fixing would save teacher time. It was also noticed that much less equipment was needed.

Field research was necessary to make sure that pupils in the target age range (7 – 13) could make the starting points successfully. Field trials were carried out by the author with a cub pack who went from introduction to working products in one busy evening. A primary student teacher also trialled the method in a London school with considerable success in that most pupils managed with very little help leaving him able to discuss designs. Photographic evidence of the children's success work was gathered for use with trainee teachers. A technically sound starting point is important, as it is the foundation of the designing in this approach and all the varied projects that can result.

Conclusion

Starting with part of 'a solution' and then identifying a need or problem that it can meet (rather than starting with a 'design problem') is not such a strange way of working. Even when a new material or piece of technology is developed to meet a specific problem, designers and technologists often look at it as a source of inspiration for other new products. With this approach students never needed to be shown a finished project that the teacher 'made earlier' and which they might simply copy. Rather they were shown the starting point for many possible projects. In many subjects, the teacher does of course have the one right answer, which the student has to work out or if known, memorise and return. We need to establish that designing is special and that ideas will be considered on their merits against the need, design problem or project brief. Designing is a play-like activity where ideas and materials are manipulated to explore what might be, what could be and what should be.

One of the strengths of D&T at its best is that participants examine and judge their solutions against a task for themselves. In the case of the starting points the basic question was 'What can I do with this?' In this trial students were shown part of a solution but to a problem which they had to identify for themselves – no problem or 'right answer' was offered. Where inspiration was lacking specific context rather than a specific project could always be indicated. Students also needed to establish their own criteria for a successful project as each was designed to meet different needs. Organisations like the Technology Enhancement Project (TEP) are increasingly making new technology like thermocolour sheet and smart wire accessible to schools. Because the starting point approach focuses on the technology, it seems well suited to making the most imaginative use of any new materials as they appear.

In conclusion it seems that although the approach and methods described in this paper need larger scale and perhaps more formal research, they do seem to allow considerable scope for creativity and are worth pursuing. Readers interested in this approach and the books, CD or INSET based on it are welcome to contact the author. Overseas contacts are especially welcome: k.w.good@gre.ac.uk

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Comparing the English and South African Technology Education national curricula

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Introduction

Design and technology was introduced into primary schools in England as a statutory subject in 1990 following the Education Reform Act of 1988. In South Africa, 'Technology Education' will be phased into primary schools by 2005, although the curriculum is under review. It is still unusual to find Technology Education being implemented at primary level, so these two countries can be regarded as pioneers. In order to celebrate best practice and gain greater insight into teaching and learning, comparative research has been conducted in these two very different countries.

This paper highlights the similarities and differences between the two technology education curricula by focusing on a content analysis of year/grade 3 'mechanisms' teaching.

The results of this study may assist educationalists in the formulation of appropriate technology education curricula and good practice when the orders are being implemented in the classroom.

The Curricula and the Area of Focus

In 1990, design and technology, one of six foundation subjects, was phased into the statutory curriculum of English primary schools. The latest version of the English National Curriculum, C2000 currently in use is being used in this comparative report. In South Africa, 'technology education' in 'Curriculum 2005' (C2005) will be phased into primary schools over ten years by the year 2005. There are some differences in the learning areas of primary education, these are shown in Table I. In South Africa, technology education is one of eight learning areas usually taught within the 'life skills' programme.

There are some differences in the structures of primary education, these are shown in Table 1. Year/grade 3 children were chosen because most children have had three years of statutory education that includes technology education. Mechanisms was chosen as the focus as it is common to both curricula.

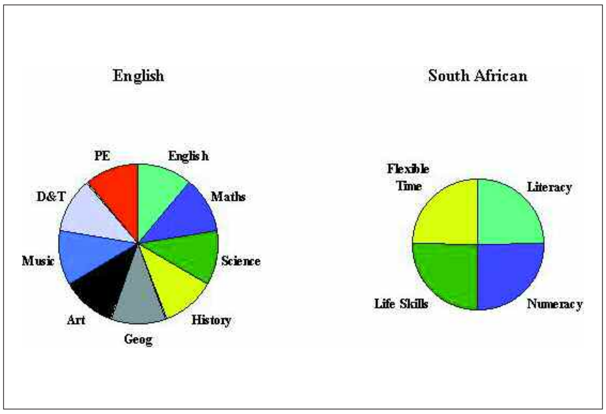

Figure 1 Pie charts showing the division of the primary curricula

Methodology of Implementation of Technology Education

Both countries follow a 'process' in order to implement Technology Education. In South Africa it is known as the Technological Process while in England it is called the Design Process. The methodology of implementation is similar. The teacher provides the children with a project 'brief', which describes a problem that they are required to solve following the given process.

The projects are introduced and researched, in England, these activities are known as 'investigative and evaluative activities' (IEAs), in South Africa they are known as case study tasks. Children are required to look at existing products that relate to the activity or they are required to find out about the project itself. The children are given tasks whereby they learn how to use tools or equipment and they learn relevant techniques for the materials they will work with-in England they are known as 'focused practical tasks' (FPTs) and in South Africa as 'resource tasks'. These tasks enable the children to design and make their own solutions, so in England they are presented with 'design and make assignments' (DMAs) and in South Africa 'capability tasks'. Further IEAs (investigative and evaluative activities) are carried out after the making takes place.

Table 1

	England			South Africa		
Year/ Grade	Age	Phase (Primary)	Year of Introduction	Age	Phase (Primary)	Year of Introduction
1	5/6	KS1	1990	6/7	Foundation	1998
2	6/7	KS1	1991	7/8	Foundation	1999
3	7/8	KS2	1990	8/9	Foundation	2000
4	8/9	KS2	1991	9/10	Intermediate	2001
5	9/10	KS2	1992	10/11	Intermediate	
6	10/11	KS2	1993	11/12	Intermediate	
7	11/12	KS3	1990	12/13	Senior	2000
		Secondary				

Table 1 Time frame for implementation of technology education

Technology Education in the Curricula

Having established that the models for implementing technology education are similar, a closer examination of the two curricula for similarities and differences was made. Both documents justify the inclusion of technology education and the rationales are similar – that it will help develop children's critical thinking and awareness of the relationship between technology, society, economy, environment, function, citizenship and industry both locally and globally (Table 2).

Table 2	
England	**South Africa**
• No single definition • None stipulated in the curriculum • Following statement appears at the start of each key stage 'Teaching should ensure that knowledge and understanding are applied when developing ideas, planning, making products and evaluating them'	• One single definition 'Technology is the use of knowledge, skills and resources to meeting human needs and wants, recognise and solve problems investigating, designing, developing and evaluating products, processes and systems'

Table 2 Definition of Technology

C2005 is arranged under seven specific learner outcomes. Under each of these is detail of the depth and breadth of content and assessment. C2000 covers similar outcomes as the foundation phase of C2005, but key stage 2 in C2000 is set out more concisely. It is split into two sections – 'knowledge, skills and understanding', under which the content is stipulated; and 'breadth of study', which shows the model through which the content is taught (i.e. IEAs, FPTs and DMAs). It does not include any assessment indicators.

Mechanisms in the Curricula

'Mechanisms' is selected, as an example of content that is common to both curricula. The second specific outcome in C2005 is 'apply a range of technological knowledge and skills ethically and responsibly'. It is in this outcome that the requirement of mechanisms is stated under the subheading of 'systems and control'. Elements of 'systems and control' being:

- Input, process, output
- Open and closed systems
- Types of systems
- Simple components and devices
- And the nature of basic interconnections in:
- Mechanical
  - Electrical and
  - Hydraulics/pneumatics systems.

(WCED, 1997:99)

The performance indicator for the mechanical systems is to,

- Demonstrate an understanding of simple ways in which the following mechanical components might be used to gain mechanical advantage and transfer movement (wheels and axles, levers and cranks, cams and gears).

(WCED, 1997:100)

In addition to the reference made in C2005, there are further references that learners a) 'gain knowledge and understanding of safety in systems and control' and b) learn to 'effectively evaluate mechanical products and systems'.

In the C2000 there are only two references to mechanisms at key stage 2. The first is under the fourth of four strands of 'knowledge skills and understanding' named 'knowledge and understanding of materials and components'. It reads that 'pupils should be taught: …c) how mechanisms can be used to make things move in different ways, using a range of equipment including an ICT control program' (DfEE, 1999). The second reference is as part of a list of materials and components stipulated in 'breadth of study'.

This close examination of the curricula reveals the major similarities and differences

- That the curricula actually closely resemble one another although they both have their individual characteristics appropriate to each country
- That one curriculum is more explicit than the other.

Looking at the example of mechanisms' shows the degree of this. C2005 lists specifically and clearly what aspects of mechanisms learners are required to study. The document also suggests how teachers might teach. Whereas C2000 merely states that pupils learn what a mechanism is for, the only specific requirement is that computer control is one of a range of equipment used to demonstrate this. The result of this has meant that some teachers in England have been uncertain or unsure of the degree and detail they should deliver. Teachers have also been concerned about the lack of information about how and what to assess. At the other extreme many teachers in South Africa have been overwhelmed by the breadth and depth of the orders and confused by the over complex demands. These have meant that technology education is taught to the assessment criteria rather than the knowledge, skills and understanding through the design process.

The difference in the physical size of the curriculum documents is significant. The English national curriculum needed a major review soon after introduction as it was so complicated and it's layout also implied it should be assessment led (Davies, 2000). The revisions that have been made in England have largely been made to reduce the over-complex and confusing terms and to ensure that teachers do not interpret the curriculum as assessment led. Since the original order we have seen six new versions, the latest one introduced in September 2000.

In the same way, the South African C2005 needed revision and has undergone a major review in 2000. Changes were recommended in order to simplify it. Initially it was suggested 'technology education' should be cut out as a single subject and instead be included in Applied Science or Art and Culture. However protests from teachers and educationalists have ensured that Technology Education is retained, as a learning area in it's own right.

One of the criticisms of C2005 is that the orders were over complicated. Throughout the curriculum, statements are thoroughly explained in simple language giving as much detail and direction as possible, this was deemed necessary as the subject was so new to teachers and many teachers were inadequately educated themselves – due to the education system that existed under the apartheid laws. At the time of writing of C2005 there were few South African resource materials available for teachers and the curriculum2005 policy makers tried to support the teachers by writing C2005 in great detail. But the explanatory and repetitive language and layout of C2005 caused confusion in reading and interpreting.

The original English and the current South African orders were written to educate teachers as well as state the requirements – this was a vital error. Publishing separate documents would have meant the orders and the information required to implement them were distinctly separate. Since the original introductions, education departments from both countries have published supplementary material to support implementation and management (WCED, 1999; QCA, 1998), these have been regarded by many teachers as genuinely useful tools that enable curriculum implementation and assessment. In England it has helped that over time teachers have become more familiar with design and technology so the statutory documents have needed less detail with less explanation of the language and terminology – there is hope that the same will be true in South Africa.

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The emergence of understanding of the relationship between planning and designing amongst young children

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Introduction

My research into designing began in 1996 with a 6-year old's question 'Why are we doing this twice?' Since then I have observed many children getting better at knowing why we need to plan what we want to make. What has become clear to me is that children will not use drawing for planning if they do not understand why they should do so.

I have observed and tracked the phases through which young children pass along this journey towards understanding the usefulness of drawing as a means of modelling ideas ahead of engaging with the materials of construction.

This paper describes and illustrates the characteristics of these phases of developing understanding of design drawing and its relationship to making a product.

'Why are we doing this twice?'

The children in Year 1 had heard the story of Flat Stanley by Jeff Brown. Now they were going to make a model of him to put inside an A5 envelope to post to California, just like in the story (only we weren't really going to post them). They were shown a table loaded with suitable materials to clothe the figure and given paper on which to draw their plans. Some were working with older children near a tape recorder because I was hoping to capture some examples of the older ones scaffolding the learning for the Year 1 children. I also had a tape recorder near some of my Year 1 pairs, hoping to capture articulations of unsupported design understanding as a comparison.

The question, which heads this introduction, came over clear and strong on my tape. A strident little voice demanding to know why they had to redraw the figure onto the card and decorate that rather than the one they had just drawn on the paper. I can't recall my reply but I do recall their solution: one child decorated the design sheet and one made a copy of it onto card.

When I started researching design drawing with young children in 1996 I was not sure myself what the reasons were for asking such young children to draw their ideas. Before the introduction of the National Curriculum, I had seen children of all ages quite successfully making all sorts of models without ever drawing it first. I justified it to the children in terms of wasting materials: we don't have many boxes/artstraws or whatever, so you need to plan what you will do with yours to avoid wastage.

I began to think in terms of the process from the child's point of view and to parallel it to how ordinary adults use drawings (as opposed to professional engineers, architects etc.). I collected examples from friends and family: my husband's cross-sectional sketch of the new patio to see if the levels of the drains were OK, my daughter's plans for a new wardrobe, my sketch for a model crocodile with moving limbs and a coat to show the Classroom Assistant what I wanted the children to make. I also went and looked at Turner's sketches and drawings, behind the scenes at the Tate, which was an amazing experience to handle the sheets with his notes and quick stripes of colour recorded onto his pencilled sketch of the scene before him.

The skill in common to all these tasks, which the application of pencil to paper was used to support, was planning.

Forward planning

Drawing for designing is teleological. It is used to support an intended activity, perhaps by crystallising ideas or by planning out the main stages of construction or the materials to be used. As I thought about it, I began to realise that how much one can plan ahead depends on how much knowledge one has of the materials as well as of the problem to be answered. Young children frequently lack both.

I recently recorded on video three Year 2 boys who spent nearly 15 minutes fitting a variety of round objects down a roll of newspaper and shaking them back out again. It would appear that their solution to how Frosty the Snowman could fetch his shopping from the shop on the next hill was to build a tube railway, like the London Underground in the sky. What they were doing was trying to find something that would pass down the tube made from the rolled up newspaper, into which the shopkeeper could put Frosty's food.

Planning ahead also depends on the child current position on the reality / fantasy continuum. Children are much more adept at swapping from one to the other than adults. Stables (1997) stresses the parallels between playing and designing and the utilisation of play and fantasy as design strategies (citing Jones 1981) She quotes a previous article in which she had described children designing litter collectors for a park. The creations were "only boxes" yet the child had embued them with a whole range of useful litter collecting functions. This is directly parallel to the activity of the designers discussed by Jones.

My video also captured two boys discussing their design drawing. They are prodding the paper with their pencils and saying things like 'What you could do is…' but the suggestions relate to the logistics of getting food from 'there' to 'here'. It is not about the logistics of making a model of this with the materials to hand. They are happy to enter into the world of Frosty and his shopping problem and conjecture solutions and allow the lines on the paper to stand for those conjectures.

How it will be made is far less important that what it will be in their imagination.Both groups of children were faced with a double-edged problem: they to have enter into the fantasy of the problem, but then have to swing back into the reality of how to make a model of it with the materials to hand, using drawing to develop these ideas and then make a model which we are all going to pretend is the real thing. They are playing with ideas, concepts, materials, and at being designers.

Development of understanding of design drawing

The way that children use drawing in a design context hinges on their perception of the purpose of the drawing. Most Primary children use the drawing to develop initial ideas and do not really refer to it once they begin making (Egan, 1999). However, their understanding of how the drawing relates to developing these design ideas changes considerably across the primary years.

Duckworth (1987) comments that

Making new connections depends on knowing enough about something in the first place to provide a basis for thinking of other things to do…. The more ideas people already have at their disposal, the more new ideas occur and the more they can co-ordinate to hold up still more complicated structures. p.14

Understanding that drawing can place-hold ideas and free the mind to consider new possibilities and improvise on those already recorded is one way in which even more wonderful ideas can be generated and developed.

As a result of several years analysing young children's design drawings I have come to identify certain phases in the development of understanding the use of drawing for designing. There are no age norms attached to these. Many Reception children can begin to record their intentions if the task is simple – a puppet of a well-known story character, a collage of a meal on a plate, whereas some Year 2s may not have yet made the connection between drawing and making. Conversely, I have observed Year 2 children treating their drawings in an interactive way in discussion with a friend, yet have had Year 4s show me a single picture with the announcement 'I want to make this'.

I have come to label these phases as: Picture, Single-draw, Multi-draw, Multi-design, Progressive and Interactive. The examples used in the following descriptions of these phases all come from the same design task, conducted between November 2000 & March 2001, making a model of "Flat Stanley" to fit inside an A5 envelope. No special design sheets were given to the children. All drawings were done on blank paper. Pink card was provided as a base for the models.

The Picture

The child sees the drawing as an end in itself, rather than future-planning. The child may include features of narrative or representational drawing which are inappropriate to the genre of design drawing. The child is not addressing design problems and client needs, they are drawing a picture that relates to the subject or problem. The drawing is perceived a product, a completed activity, which does not cascade into the making process. Therefore, the drawing may either be abandoned completely and something entirely different is made, or the picture is decorated to make a collage of the subject instead of making a separate product at all. The child has seen the two activities, drawing and making, as unrelated except for subject matter.

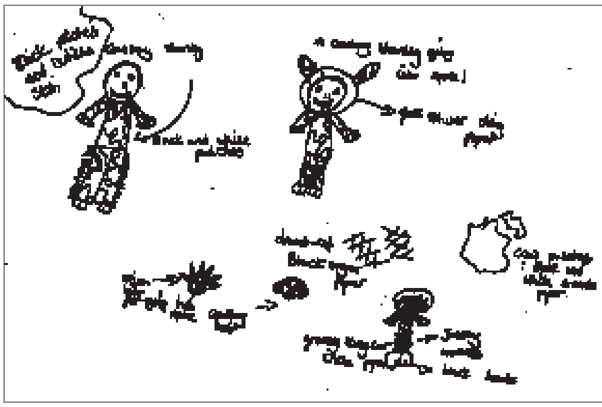

Figure 1 This 6 year-old has drawn a picture of something she likes drawing (princess) and then made a collage of the task set to the class (model of Flat Stanley to go in A5 envelope). She was oblivious to the planning and designing and model-making around her

Single-draw

The drawing is seen as a record of an idea that might be made, to show the teacher before going and making it or something like it. The genre of design drawing, an object disembedded from its background or context, has been grasped but the drawing is not used to develop design ideas. It is a picture of what they have been asked to make. Once allowed to handle the materials, the drawing is frequently forgotten, although copying it exactly without any subsequent development or modification is equally common. There is no record of constructional issues having been considered. These are not recorded on the drawing. Progress in understanding of the purpose of drawing for design then seems to take one of two alternative paths, which I call Multi-draw and Multi-design.

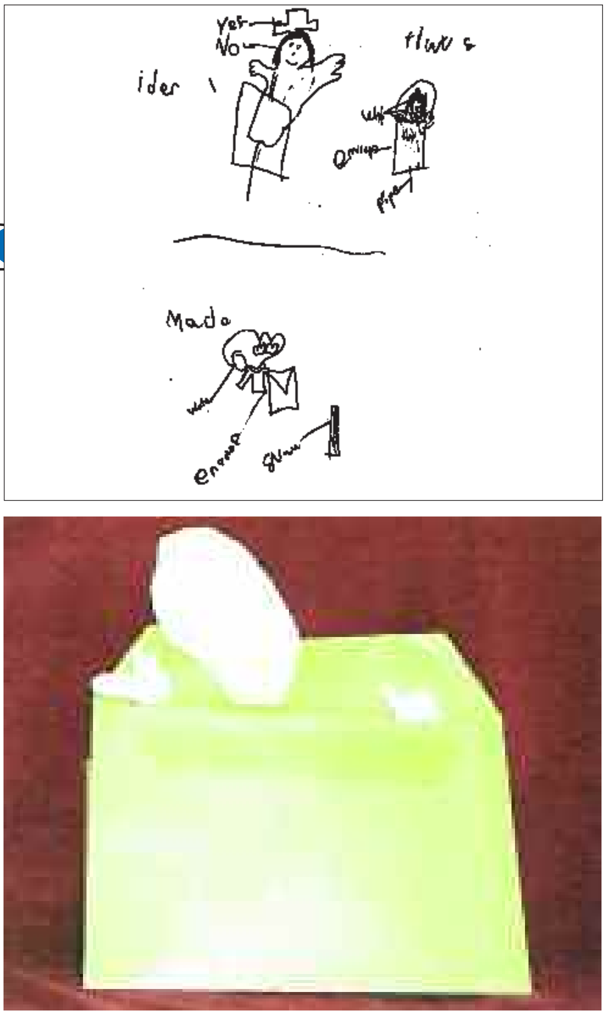

Figure 2 Single-draw-This year 3 child's current characterisation of the human figure has remained undeveloped into a problem solution. He has drawn another similar, but not identical, figure on card

Multi-draw

The child seeks to perfect their drawing of a single idea by redrawing several times rather than using drawing to develop and explore design ideas. There is evidence of understanding of the needs of the client, but only one real solution to the problem is recorded. Drawing is not used to explore and envelop a range of design ideas. Evaluation relates to the appearance of the drawing rather than to the practicalities of construction or alternative design solutions. Surprisingly, after spending time perfecting the drawing, it does not necessarily inform the making since the child has not really seen the role of the drawing as a way of modelling real outcomes.

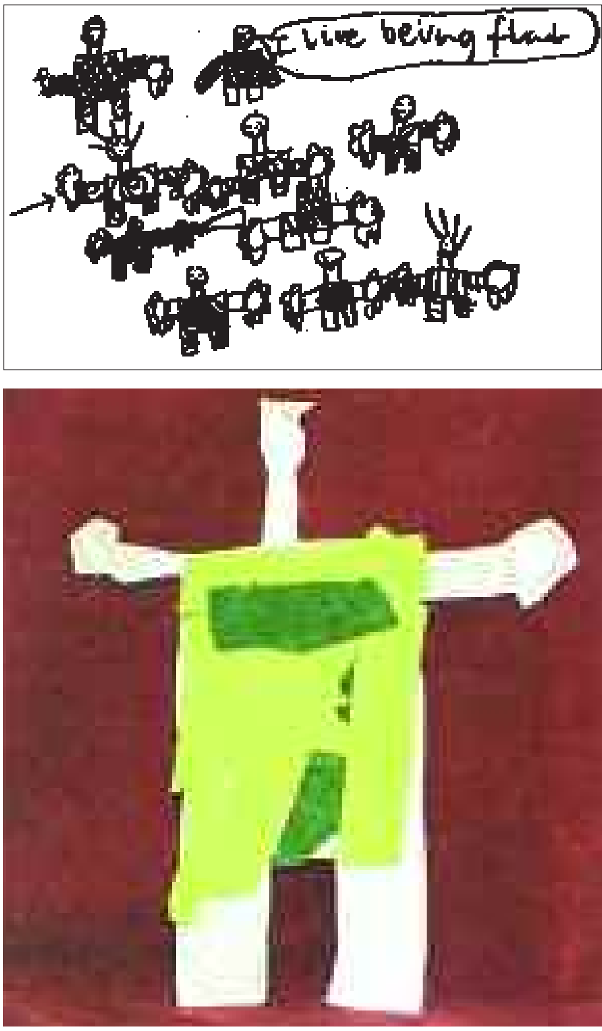

Figure 3 This Year 2 girl has had 4 attempts at drawing the figure to her satisfaction. Apart from the addition of the hat and bag to the drawing with which she was finally satisfied, the ideas have not moved on from the first sketch

Multi-design

The child sees the role of the drawing in designing as a means of brainstorming ideas. The design sheet will be filled with different ideas, some related more closely than others. The object made may even be yet another different idea. The child has grasped the idea that the paper can be used to try out lots of ideas related to client needs and to working out solutions to the design problem, but without thinking too much about constructional issues or evaluating how any of the ideas would work out in practice. The product to be made may well be selected on the basis of 'best drawing', even though it may not represent the most fruitful or practical idea.

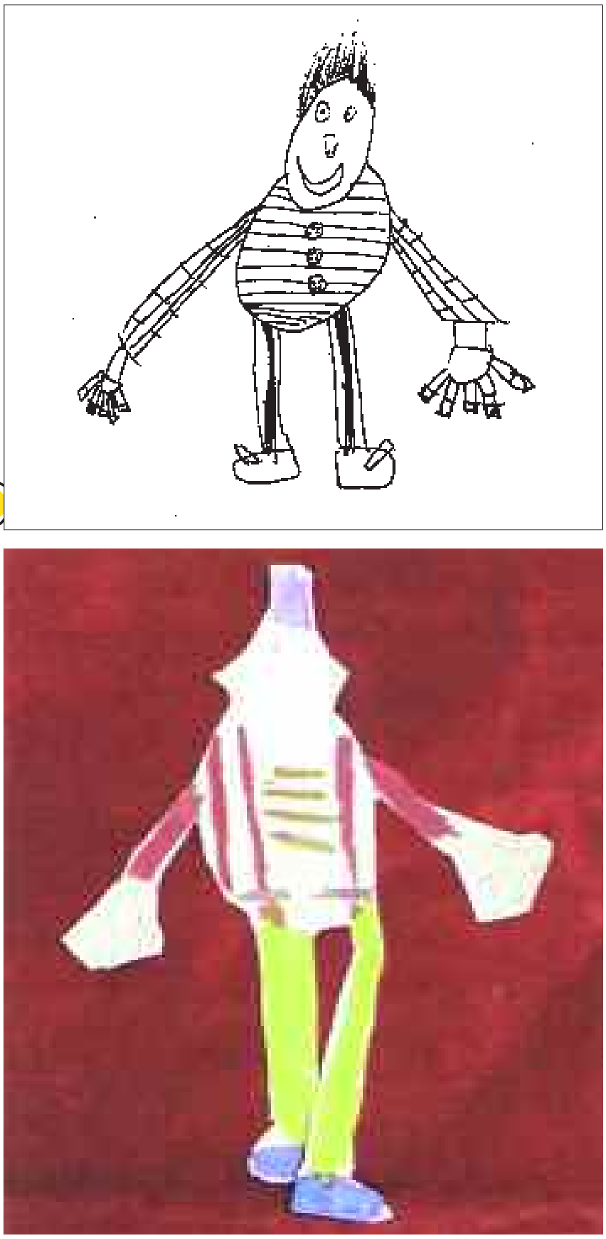

Figure 4 The arrow indicates the idea which this Year 2 child told me he had made. The swirly pattern was drawn on his model but then covered over by the green felt

Progressive

Although they may arrive by differing routes, all children need to reach this phase in their understanding of design drawing. This is the point at which they realise that they can use drawing to progress their ideas about the design solution and work out how the object will be made or fit together.

Constable (1994) concluded that children need to understand the purpose of the drawing as a working drawing, conveying sufficient information to guide the making of the product, with different views of the object and enlarged drawings of small details. These features begin to emerge at the Progressive phase of understanding. Labels, verbal descriptions, expanded drawings to show small or separate details, diagrams which attempt to show different viewpoints or results of movement. The product is a realisation of the final drawing. It should be appreciated that this phase does not necessarily 'follow on' from Multi-design. Children more frequently opt for one good idea and develop it into an action plan.

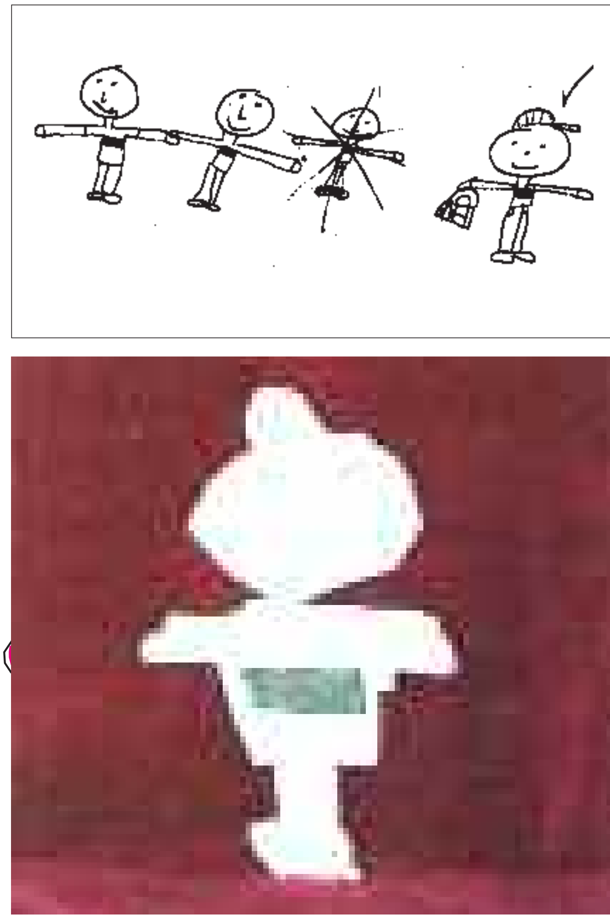

Figure 5 This Year 2 child has had the idea of making Flat Stan into a pop-up inside the envelope. His 3 drawings of his ideas show a cut-away drawing as well as an outside view of his idea and a "parts needed" diagram

The first indication that the child is beginning to use the drawing to plan a product is the recording of the colours in writing. A child who simply colours the design sheet is not necessarily planning the colours to be used in the product, whereas a child who labels the drawing with colour words more frequently is. Once children begin to annotate their drawings, they are seriously considering them as plans for making.

Interactive

At this point the child begins to have a conversation with the drawing. The child sees the drawing as a means to work out what will be made and how to make it. This phase can almost be seen as a combination of Multi-design and Progressive. More than one design idea is recorded, which are then thoughtfully evaluated and discarded or developed through more drawings, combining and discarding elements of several drawings. Several related ideas, styles or construction methods are considered and combined to develop a product based on this process. Evaluation occurs as part of the total process. Further ideas about previously drawn solutions may be recorded after other solutions have been developed as the child begins to combine ideas (in the example below, the comment at the top left was added last).

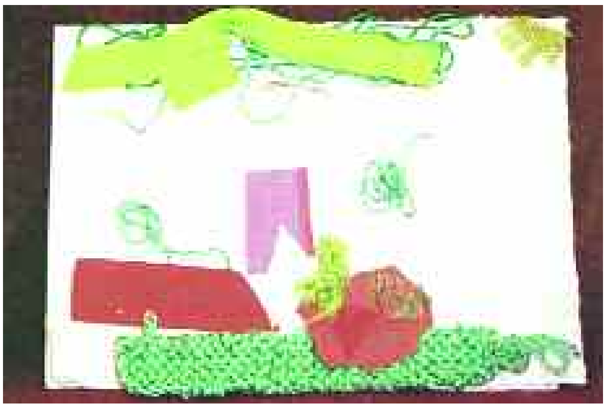

Figure 6 This Year 4 girl began with the idea of Stan in a cowboy suit, then a space suit, which sparked off the idea of alien hair. All 3 ideas were combined into a cowboy in the process of changing into an alien, for which she subsequently made an alien space helmet

Relationship of drawing to making

Comparing the finished product with the drawing can be salutary. Children often have grandiose ideas which cannot be realised with the materials provided. Changes to what they drew do not always come from misunderstanding the relationship between drawing and making. Frequently I can see the same events occurring as would for adults in the same circumstances, for example, the students on Cooper's WISE project were unable to anticipate the complexities involved in realising their designs (Cooper 2000).

For the three Year 2 boys described earlier, collaborating on one child's idea meant that the other two abandoned their designs to make their own version of the tube train because they had invested so much time in experimenting with it.

Another boy in the same class, C, produced a range of ideas on paper, including a jet plane with swept-back wings. He began to make this with a cardboard roll fuselage and lolly stick wings, but abandoned it when construction became too difficult. Instead, he adopted the rope-bridge solution developed by other children because it was far easier to make, even though he had not drawn one on his paper.

As teachers, we must not be rigidly unrealistic about children's reasons for changing or abandoning their original ideas. A drawing of 'What I made and why' could be a useful finishing activity. Children can be quickly taught the kinds of answers to give: 'Because Nick's idea was better', 'Because there was no more green felt left' or 'Because the first one fell apart' rather than simply 'I liked it.'

What is the purpose of the drawing?

Finally, if we are making judgements on children's use of drawing for designing and identifying their perception of its purpose as the key to understanding the way they use it, then what is our perception of the purpose of the drawing?

Egan (1999) observed the use of drawing only at the beginning of the activity, for Year 6 as well as for Year 1. Most of the drawings I have analysed have been of this sort. For young children certainly, I agree with her conclusion:

Drawing the idea 'in the mind's eye' supports the development of visualisation skills. If, however, the drawing is regarded rather as a working drawing than as a first expression and exploration of the idea, which will inevitably be modified in the exploration, there may be little scope for children's understanding of the drawing to develop. A working drawing, after all, freezes the idea rather than freeing it. (p.116)

As teachers, we need to have a clear idea of how children might usefully employ drawings to develop design ideas and be aware of the competencies which they might realistically acquire. To this end, I hope that my observations of children's design drawings might prove useful.

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A comparative study on the implementation of technology education by ORT-STEP in the Cape Metropolitan area

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Introduction

Technology education is a new learning area in South Africa and will be phased in over a number of years. Some difficulties have been experienced by educators with regard to the implementation of technology education. This paper looks at the progress and problems within five different disadvantaged areas and one affluent area the Cape Metropolitan area.

History of ORT-STEP

World ORT

The Organisation for Educational Resources and Technological Training (ORT) is one of the largest non-governmental education and training organisation in the world, with its operations in more than 60 countries.

The ORT South Africa initiative, ORT-STEP (Science and Technology Education Project), offers in-service training for educators of technology education, science and mathematics. Technology education 'puts education into practice' and prepares the school leaver for the world of work.

ORT-STEP's philosophy is: Education for life.

The ORT-STEP Institute

ORT-STEP was established to help South Africa take a giant leap into technology education and initially promoted technology education in addition to its primary function of training educators in technology education.

Courses introduce educators to the principles of outcomes-based education (OBE) and to enable them to meet the requirements of the technology education curriculum prescribed by Curriculum 2005.

The institute considers the training of in-service educator to be the most important factor in any education system. Motivated, self-confident, professional and well-qualified educators should be able to provide effective education.

ORT-STEP Western Cape

Advanced Certificate in Education (Technology Education) – ACE

The Western Cape offers an advanced certificate in technology education in collaboration with Rhodes University, a qualification recognised by the National Education Department.

This course consists of technology education 1 and 2, science 1, mathematics 1 and education 1. The technology education component is also offered in a modular form (foundation course; mechanisms; textile technology; food technology; materials and structures; information technology; graphics and man, society and the environment) to educators who wish to do only technology 1 and 2.

Tech-Know-Alley

The Tech-Know-Alley centre provides workshops in technology education for educators and learners.

Information Technology

The training caters for the ever-increasing needs of educators, learners, corporate and private individuals who wish to study information technology and delivers:

- Introduction to computers
- Microsoft Office 2000 package
- Pastel Version 5.2
- Visual Basic 6.

History of Curriculum 2005 and Technology Education in South Africa

The Minister of Education announced in March 1997 the phasing in of the National Qualification Framework (NQF) and Curriculum 2005. The process of implementation began in 1998:

Table 1	
Grades phased in	**Year**
Grade 1	1998
Grade 2	1999
Grade 3 and 7	2000
Grade 4 and 8	2001
Grades to be phased in	**Year**
Grade 5 and 9	2002
Grade 6 and 10	2003
Grade 11	2004
Grade 12	2005

Table 1 The time span for the implementation of Curriculum 2005

Technology education is being phased in as one of eight learning areas in Curriculum 2005 (see table 1). To support the introduction of technology education, the Technology 2005 Project was launched by the HEDCOM (Heads of Education Committee). This project was driven by the national task team and supported by nine provincial task teams who worked with practitioners in selected pilot schools.

Table 2	
Phase	Learning areas
Foundation phase	3 learning areas – technology education and five other learning areas form life skills
Intermediate phase	6 learning areas – natural science and technology education form one learning area
Senior phase	8 learning areas – technology education separate learning area

Table 2 Implementation of technology education in the three phases of the GET band

Some successes were recorded, but as a whole very few of the provinces had success. On 8 February 2000 the Minister of Education announced a committee to review the implementation of Curriculum 2005. The report was published on 31 May 2000. The committee recommended that technology education and economic and management science should be dropped as separate learning areas (technology education should be included in natural sciences and art and culture). An outcry from provincial, national and international educators followed. In July 2000, the cabinet approved the recommendations of the review committee, with the exception of reducing the number of the learning areas to six, thus technology education has been retained as a learning area in its own right.

A working group tasked with the responsibility of implementing the review committee's recommendations by streamlining and strengthening the technology education part of Curriculum 2005 was established. The streamlining process will restore the balance between the learning of discrete content and skills and their integration and application to real life problems. They will specify core concepts, skills and values to be attained or developed in each grade. This working group put together a 'Technology Contact Team' against which ideas can be bounced. ORT-STEP serves on the proposed contact team and will comment on the technology education curriculum documents drawn up by the working group.

The Mitchell's Plain Technology Education Project

In 1999 a donor indicated that money would be made available for a technology education project in disadvantaged areas in the Cape Metropolitan area. In conjunction with the Western Cape Education Department, the following areas were targeted – Mitchell's Plain (a coloured area), Gugulethu, Crossroads, Philippi and Nyanga (predominantly black areas). Forty-six educators from five different areas enrolled.

The areas of Gugulethu and Nyanga are well established with some infrastructure, with the result that the learners are younger when starting school. Philippi and Crossroads are fairly new areas with most of the residents coming from the Transkei, a very poor rural area in the Eastern Cape. Therefore these learners start school later than the usual six years of age and they have been exposed to education in their mother tongue in Transkei and taught in the second language at these peri-urban schools.

The Mitchell's Plain project kicked off in May 2000. After the June 2000 announcement that technology education might be dropped as a learning area one high school, from the Philippi area, decided to drop out. Wynberg Girls High School was then selected to join the project to achieve a balance between the number of primary and high schools. During the course of 2000, the students completed the foundation course, textile technology, materials and structures and mechanisms modules. As the result of the partnership with Rhodes University, most of the educators have opted to enrol for the ACE and will be completing the electricity and electronics, information technology, graphics and man, society and the environment modules towards technology 2.

Table 3	Mitchell's Plain	Gugulethu	Philippi	Crossroads	Nyanga	Wynberg
Language	Eng / Afr	Xho / Eng	Xho / Eng	Xho / Eng	Xho / Eng	Eng
No Schools	10	2	2	2	3	1
Primary	6	1	1	1	2	0
Secondary	4	1	1	1	1	1
Pupil profile	Single cultural	Single culture	Single culture	Single culture	Single culture	Multi-cultural
Pupil age	6 – 18	6 – 18	6 – 23	6 – 23	6 – 20	13 – 18
Pupils / class	35 – 45	35 – 40	45 – 65	45 – 65	35 – 40	25 – 35
Trainees	23	4	6	4	7	2
Area	Urban	Peri-urban	Peri-urban	Peri-urban	Peri-urban	Urban
Unemployment	30 – 40%	30 – 40%	50 – 60%	50 – 60%	30 – 40%	20 – 30 %
Literacy	Average	Average	Poor	Poor	Average	Good
Electricity and water	Most	Most	Most	Most	Most	All

Table 3 Comparison of the different areas included in the Mitchell's Plain project

Table 4	Phases implemented	Grades implemented	Number of projects for the first term	Resources and material available	Dedicated technology centre	Curriculum development	Extra donor support	Workshops offered by ORT-STEP students
Mitchell's Plain	Foundation Intermediate Senior	R-3 4-6 7, 8	1/2/4	2 Yes 8 No	1 No 9 Yes	2 No 8 Yes	No	1 No 3 Yes
Gugulethu	Intermediate Senior	4 7, 8	1/2	No	No	1 Yes	No 1 No	No
Philippi	Intermediate Senior	4-6 7-8	1/2	1 No 1 Yes	No	Yes	No	No
Crossroads	Foundation Intermediate Senior	1-3 4-6 4-6	1	No	Yes	Yes	No	No
Nyanga	Foundation Intermediate Senior	1-3 4-6 7, 8	1/2	2 No 1 Yes	2 No 1 Yes	1 No 2 Yes	3 No	2 No 1 Yes
Wynberg	Senior	8	2	Yes	Yes	Yes	No	No

Table 4 Comparison of the findings in the Mitchell's Plain project

Summative and cumulative assessment is used to evaluate the work and progress of the students. Schools are routinely visited and the principals are required to submit a quarterly report on the progress of the educators, the implementation of technology education as well as the progress of the learners of the school.

Findings

During the visits to the schools and the reports from the principals the following was evident (see table above):

From these findings it was clear that the schools from the Gugulethu, Philippi, Crossroads and Nyanga areas were in desperate need of even more guidance and assistance. These schools were not only having difficulty implementing the learning area but financial constraints hindered successful implementation. These schools are entirely dependant on the Western Cape Education Department, as they charge minimal school fees due to the high unemployment rate and therefore have limited funds. The educator and learner ratio was a problem for practical work, e.g. grade one pupil educator ratio 65:1. Most of the primary schools in these areas were adopting a policy of class teaching rather that specialist teaching, due to financial constraints. Some trained educators successfully implemented technology education, while untrained staff found it difficult and sometimes almost impossible to do so.

During the visits to the schools in the Gugulethu, Philippi, Crossroads and Nyanga areas, it was observed that many of the schools received equipment through the Western Cape Education Department. Money was donated by the Netherlands Embassy and was used to uplift 100 of the most disadvantaged schools (according to the norms and standards of the Western Cape Education Department) in the Cape Metropolitan area. The learning material and resources delivered to each school included technology education equipment for food and textile technology, electricity components and some general tools for working with different materials. Technology education received the biggest allocation. Basic equipment for other learning areas such as life orientation, economic and management sciences, music and arts and culture was included. These schools received the equipment but were not given any support in the form of training in the use of these resources. A Netherlands Embassy and Western Cape Education Department representative visited some of the schools to establish whether the equipment was received at the school. However, after a while some of the equipment disappeared or was stolen due to the equipment not being utilized.

Conclusion

ORT-STEP soon realised that training was not enough and so with the help of donors, started equipping disadvantaged schools and training a minimum of two educators per school. It has now become evident that equipping the schools and training the educators are in fact not enough. Most of these severely disadvantaged schools are not in the position to implement technology education effectively, even after training and being supplied with the basic tools and equipment. They also need on-going support to help them with the planning and implementation of technology education.

ORT-STEP will continue to train and support educators in disadvantaged areas as technology education is vital to the upliftment of both the educators and the learners.

Tables, chairs, and filing cabinets – Teachers as designers of the classroom environment

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Introduction

Intuitively, we know that the physical environment of the classroom has an impact on the behaviour of both teachers and pupils. The difficulty is to understand how this impact occurs. The environment plays a significant role in the lives of people (Rivlin and Wolfe, 1985) and we can both select and modify our own surroundings.

The environment can be seen as a series of relationships between things, things and people, and people and people. These relationships are orderly, that is, they have a pattern and a structure... (Rapoport,1982: p.178)

Environmental awareness is the ability we have to analyse our spaces critically and to function intelligently within these spaces. Developing our environmental awareness prepares us to become more autonomous and effective, but also to be able to evaluate the places we live in. Such knowledge or awareness can be used to seek out more satisfactory spatial arrangements or to design structures that better meet users' needs (David, 1975).

Carefully and knowingly arranged, the environment adds a significant dimension to a student's educational experience by engaging interest, offering information, stimulating the use of skills, communicating limits and expectations, facilitating learning activities, promoting self-direction, and through these effects supporting and strengthening the desire to learn. (Loughlin and Suina, 1982: p.xv)

There is a complex relationship between the physical structure and arrangement of the room, the teacher, the students and the distribution of space (Gump, 1987, Rivlin and Rothenberg, 1976). The physical characteristics of a setting can influence both behaviour and educational programme (Rivlin and Weinstein, 1984) being a direct expression of the educational philosophy (Proshansky and Wolfe, 1975). It also has a preconceived cultural image (David, 1975) and this image is embedded in our society.

This paper is focused on how teachers in primary schools use their spaces. It demonstrates what is happening in the classroom, and what the teachers' perceptions of this setting are. It is an illustration of the relationships between the designed space of the classroom and the practice of teachers.

Methodology

The methodology consisted of a combination of physical measurements, observation, and interviews based on a behavioural mapping framework. Behavioural mapping is a spatial approach to observation. We track the movement of people through existing physical settings and observe the kinds of behaviour that occur in relation to these settings. Mapping seeks to identify the uses of space as a factor in behaviour (Ittelson et al. 1974). It is a naturalistic time-sample technique for describing patterns of activities and the use of the physical space (Rivlin and Rothenberg, 1976).

Behaviour will be enacted in accordance with the opportunities or limitations of the setting in which it occurs. Behavioural maps look for patterns of relationships between the observed and described properties of physical settings and the similarly observed and described reactions of people in these settings (Proshansky, 1976). Since the influences are mutual, it is these patterns of relationships that are critical and not the isolation of how one variable causes effect in another.

The analysis developed for this research generated a series of constructs that produced tools for a deeper examination of the data. These constructs are bonded with the research instruments and the findings, and become a unique way of visually 'seeing' a lesson. They are an important component of this research, as the technique becomes a tool for a visually descriptive instrument both of how teachers structure their lessons and of the areas of the room that they use with that specific structure. The interviews provide support and enrich the results of the constructs. The sample size is of 18 lessons observed in 4 different primary schools with a total of 22 hours observation and 13 interviews.

Analysis constructs and trend relationships

All lessons observed were classified in clusters of activities that characterise a lesson independently of the subject. These clusters are: introduction, teacher teaching, pupils on task, transition and conclusion. These may be present or not and the order in which they occur varies generating two of the constructs developed: Lesson profiles and Cluster columns (figure 1). The lesson profiles provide an instant picture of the shape of the lesson informing how the lesson was structured.

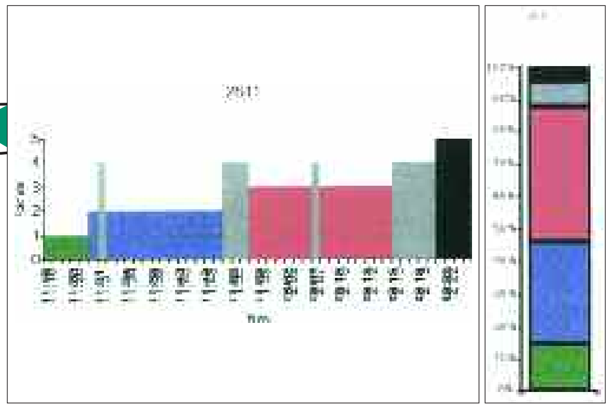

Figure 1 Lesson profile and Cluster column (Introduction, Teacher teaching, Pupils on task, Transition and Conclusion)

Dominantly the pattern encountered when analysing the cluster columns is that primary teachers tend to spend not more than 50% of the lesson time on any of the clusters (figure 2).

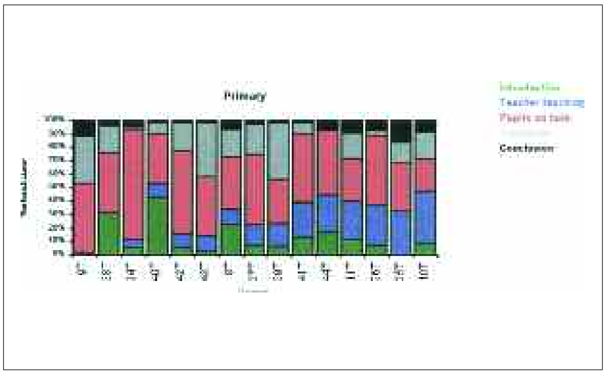

Figure 2 Primary teachers have a tendency to balance the structure of their lessons

Hierarchy of designability, flexibility, mobility, density and centredness

The hierarchy of designability is a construct that measures the degree of control of change that teachers have over the physical elements of the classroom setting. In examining teachers' use of the classroom space, architectural elements have been classified in terms of hard (fixed features) and soft architecture (semi-fixed, semi-flexible and flexible features). With these data it was possible to measure the flexibility factor of each classroom. The primary classrooms observed have an average flexibility factor of 93% (93% of the elements in the classroom are flexible/movable). This might appear a very high figure and indeed it is and rooms have a much higher possibility of change than that which is perceived by teachers.

The floor plan of the classroom provided a starting point for the development of the behavioural maps. The teacher was the focus of the observation and the data show the route taken by the teacher within the room (figure 3). The mobility factor illustrates patterns of the teacher's movement within the space available.

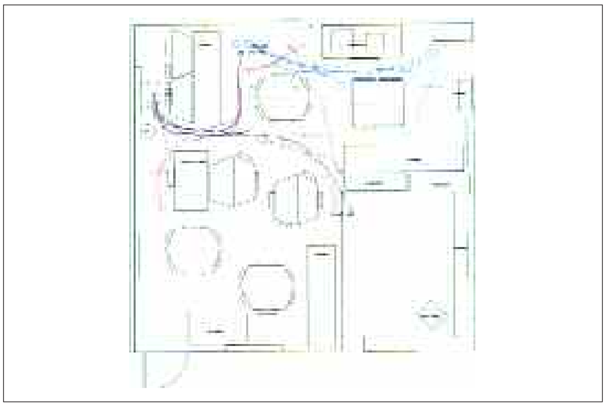

Figure 3 Classroom map with teacher's mobility

It was found that in the primary school classrooms observed, as flexibility increases, there is a tendency for teacher's mobility to increase as well (figure 4).

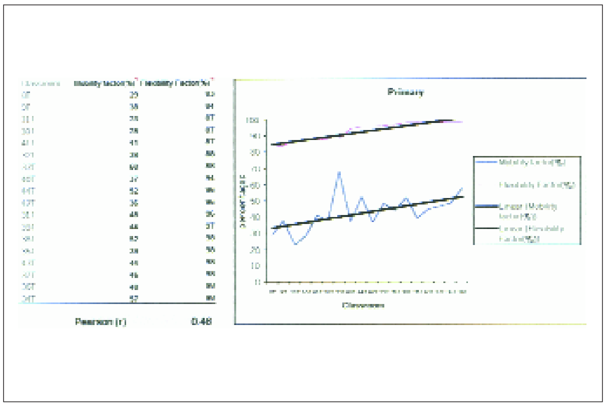

Figure 4 As flexibility increases, so does mobility in primary schools

The main mobility trend relationship found was that the more the teacher moves in the room, the denser the class is (density is the amount of space per pupil in the classroom). In other words, the more packed the rooms, the more difficult it is for pupils to move, hence, the teacher tends to move more in order to make more contact with the pupils.

Teachers have a tendency to spend extended periods of time at specific locations in the rooms. Certain areas were identified as being more used than others. These areas were called the teacher centres and a degree of centredness was developed. Mobility and centredness have consequences for the pedagogies employed by the teacher. These two constructs demonstrated the enormous impact of their movement patterns and location on what teachers actually do in the classroom.

How about the layout?

Room layouts were classified using two factors: (i) in terms of the way children are seated (rows, groups, combination and horseshoe or circle); and (ii) in terms of the special resources and functions of the room required for teaching (multiple activities room, single specialist rooms and general rooms). Each room is a combination of these two factors. Primary classrooms tend to be organised in groups and have multiple activities centres where different tasks are performed in different areas of the room.

Figure 5 illustrates how these constructs can inform how the space is being used. In classroom 2S10T I observed a lesson where the amount of time the teacher spent on each cluster was: teacher teaching – 40%; pupils on task – 23%; transition – 21%. The teacher's location followed a very specific pattern of movement with a definite pathway across the room, a mobility factor of 28% and a degree of centredness of 35%. The seating layout is in-groups and the classroom is organised in multiple activities centres with a flexibility factor of 87%.

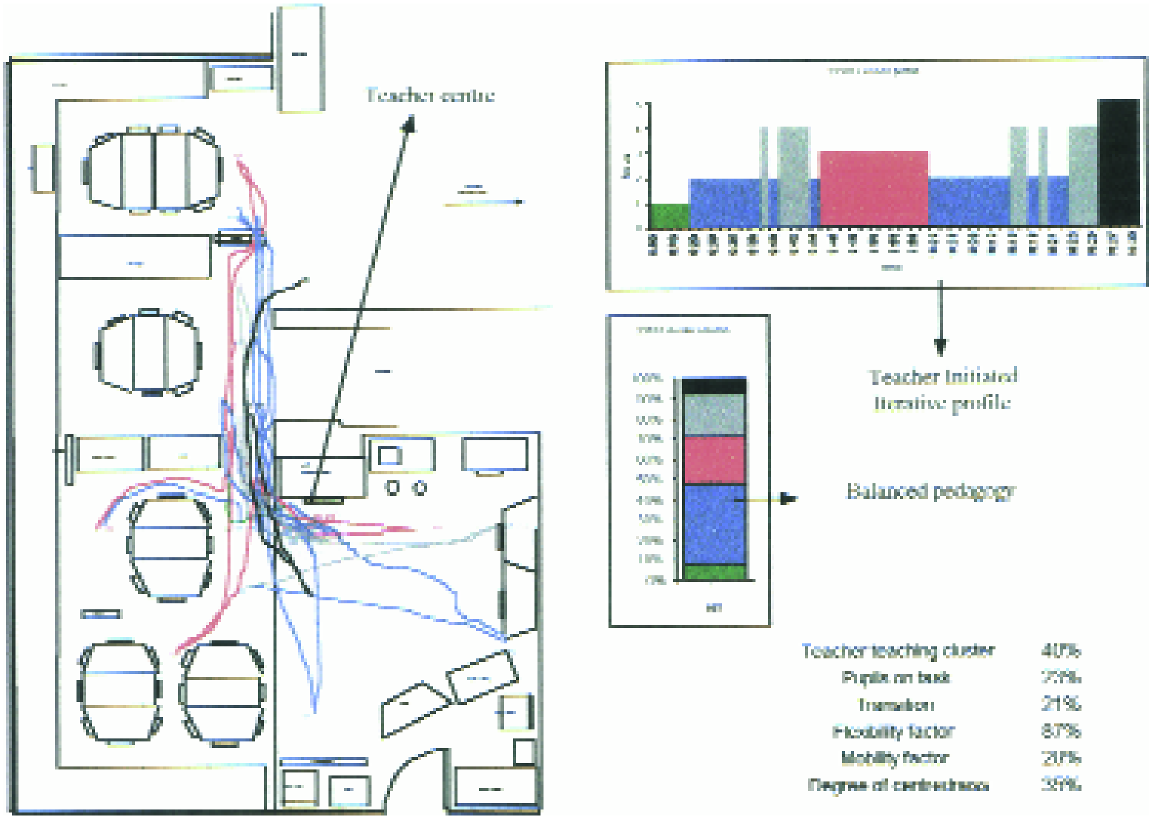

Figure 5 Classroom 2S10T visual data including maps, profiles and cluster columns (1-Introduction, 2-Teacher teaching, 3-Pupils on task, 4-Transition and 5-Conclusion)

The instrument, as seen above, can be very powerful for both researchers and teachers. A teacher could self assess herself/himself in the use of the classroom setting and reflect on her/his lesson, her/his pedagogy related to the setting, her/his mobility, the layout, her/his chosen routes and pathways and a combination of all these. The few images above have an enormous array of information for the teacher, the school, the researcher and whoever wants to be informed on how classrooms are used.

The interviews

Following the analysis of the constructs and trend relationships, the interviews were used to enable a closer examination of the meaning behind these constructs. The hierarchy of designability was used here in relation to the teachers' degree of control of change over the features of the environment. The interview data is used to support the observations and to identify issues that are not easily observable (e.g. personal feeling of control of change of the features within the classroom environment).

Teachers were asked if they took into consideration the space in which they would teach before planning their lessons. Most of the teachers (80%) expressed that the classroom environment has an impact on the planning of their lessons and 20% believed there was no impact or no relation between the classrooms and their planning. 73% of these teachers also find that there is a relationship between their teaching style and the layout of the room.

Teachers' sense of control over the physical features of the classroom have been examined. Teachers' responses in relation to the elements of control (semi-fixed, semi-flexible and flexible features) illustrate perceptions of how much control they have over individual features of the room. As one might expect, the interviews confirmed that the degree of control of change that teachers feel they have over the features of the classroom environment increases, as flexibility of the features increases (figure 6).

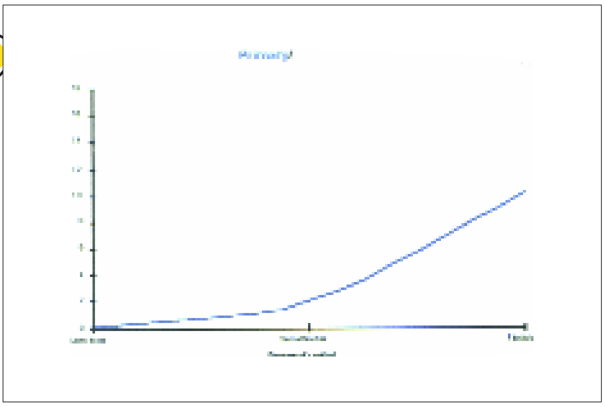

Figure 6 Primary teachers' hierarchy of designability

When we examine teachers' perception of semi-flexible features (bookshelves, filing cabinets, heavier furniture), we find they have mixed understandings of how to deal with these features. Although these features are movable and changeable, the teachers that answered to these issues demonstrated different perceptions of change. Some teachers feel they have control over semi- flexible features while others feel no control of change over these same features.

Flexible features (tables, chairs) are in general, perceived by almost all teachers as movable and changeable. Teachers demonstrate that these elements do not challenge them in terms of being able to make diverse arrangements. That does not mean that the arrangements made are the best suited for the purpose of a specific lesson but there is a high degree of sense of control over these features.

Teachers have also been individually scored in their degree of control of change according to statements given on the interviews. Teachers that scored "0" have no control over any feature of the architecture. Teachers that scored "1" have control over one feature of the soft architecture (always the flexible features). Teachers that scored "2" have control over two features of the soft architecture (semi-flexible and flexible features). Teachers that scored "3" have control over all features of the soft architecture (semi-fixed, semi-flexible and flexible features). None of the primary teachers observed scored ì3î. Figure 7 illustrates that most of the teachers follow the expected behaviour of feeling in control over the flexible features of soft architecture but not the other features within the hierarchy of designability.

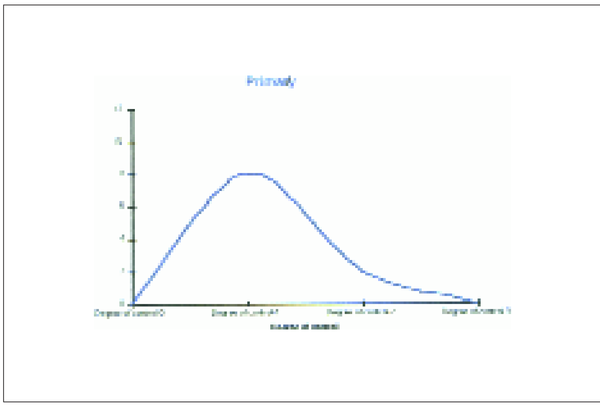

Figure 7 Primary teachers' degree of control of change

The shape of the curve between teachers that are satisfied with their classroom settings and the ones that have mixed perceptions or are unsatisfied with their rooms is quite different (figure 8). The tip of the curve when teachers are satisfied scores a degree of control "1" while when they are not scored a degree of control "2". This demonstrates that satisfied teachers tend to have a more limited degree of control of change than the ones that find more problems with their settings. Perhaps, dissatisfaction with the classroom physical environment is the first step towards taking control over it.

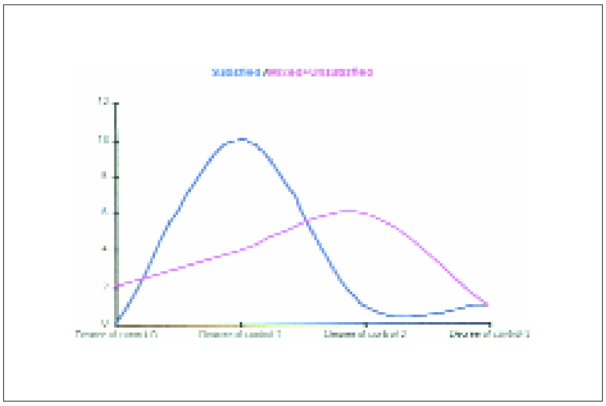

Figure 8 Difference on the degree of control of change between teachers that are satisfied with their settings and teachers that are not

Conclusions and reflections

What can we say about teachers' perceptions of the use of their classroom settings? How do teachers react towards their physical space? Do teachers feel empowered or defeated by their environments? How do different perceptions demonstrate different attitudes towards the space?

The interviews revealed that hard architecture (walls, windows, doors) seems to be taken as immutable as teachers would not even comment on it. It is seen as just a shelter and what is inside is more reachable for teachers in terms of possible change. This fortifies the argument of concentrating the study on the soft architecture where teachers would feel more in control of different features. Teachers seem to be aware that the setting affects their teaching styles and a large proportion of teachers take into account their classroom spaces when planning their lessons. What seems to be controversial among teachers is their perception of control over different features of the soft architecture, mixed and confused perceptions especially when semi-flexible features are concerned.

Reflecting over the data and findings, it is clear that teachers who question more about their own settings have a tendency to be less satisfied with their classrooms. When a teacher does not recognise the role of the environment, it is unlikely that change will occur. On the other hand, dissatisfaction with the environment seems to be a first step towards change. The data suggests that some teachers question and tend to recognise problems with their setting, but that they may stop once that recognition is made, not taking any further step towards being more proactive in changing the space.

There seems to be a need for teachers to learn how to question their settings in a constructive way, looking for solutions and being proactive in feeling in control of change over the changeable features. Taking a proactive attitude would permit the teacher to experiment, and with experimenting find out what works and what does not work, since each teacher and each group of students will be different. The classroom cannot be allowed to exist as a static feature. It needs to be questioned, challenged and transformed. According to Trancik and Evans, the ability to control the environment leads to feelings of accomplishment and independence whereas a lack of control may result in helplessness (Trancik and Evans, 1995). When teachers realise that they have control, they can feel empowered by this same environment that once would have defeated them.

Developing environmental awareness would lead to a new understanding of how the environment relates to human activity. But awareness, by itself is not enough. A teacher might be able to identify problems occurring in a setting but be unable to use this knowledge to carry on a meaningful dialogue with the environment to transform it to fit their requirements. Awareness is the first step, but may not prompt any movement away from passivity. It may not be enough to provoke teachers to take action and rearrange a setting. I agree with David who stated that ìthe development of environmental literacy involves the transformation of awareness into a critical, probing, problem-seeking attitude toward one's surroundings.î (David, 1975: p.166) Developing from awareness in to competence requires that we overcome passivity, making active choices and experimenting with a variety of spatial alternatives. This enables the teacher to challenge and develop the environment.

There seems, therefore, to be two jobs to be done. First, developing environmental awareness involves understanding the effects that the classroom environment has on the teacher. Second, being environmentally capable of responding to the knowledge, requires that teachers act as designers of their environments, taking deliberate control of the settings. It is necessary to find ways to give teachers greater authority in designing and redesigning the spaces in which they teach. The implications of this should be recognised directly in teacher training and in teacher's professional development in terms of enhancing their environmental awareness.

This study illuminates the relationship that exists between teachers' practice and the environment in which they operate. I have argued that teachers should be self aware of these relationships and that this awareness should not be left to chance but rather should be deliberately developed in them. The training of teachers in understanding the effects that the classroom has on them is therefore clearly a matter of importance. However, it appears that it is not an official requirement. The Teacher Training Agency (TTA) has produced a set of 'standards' by which teachers' competence will be judged. These exist at several levels and my concern here is with the standards for the award of QTS (Qualified Teacher Status for new teachers) and for the award of 'subject leader'. In neither standard is there any significant mention of the impact of the classroom environment on teaching. The only mentions are either highly generalised or relate to health and safety (TTA, National Standards for Headteachers, 1998a; National Standards for Qualified Teacher Status, 1998b; National Standards for Subject Leaders, 1998c). None of these references relate to understanding the setting and learning about the relationships that exist between the setting and the practice of teachers. Since so little understanding is required, it is reasonable to suppose that there is equally little training for teachers in this area. And yet, at the very least, teachers need to have this understanding.

The classroom environment influences behaviours in many different ways. Environmental messages stimulate movement, call attention to some things but not others, encourage involvement, invite children to hurry or move calmly. The environment sends messages and both teacher and pupils will respond. The influence of the environment is continuous, and how well the environment communicates with the users will depend on how well the environment is planned. Architectural facilities are designed in terms of a generalised prediction of behaviours, activities, functions, and teaching styles. However, a variety of teachers with different groups of pupils will subsequently inhabit and inherit these spaces. Each teacher and each group of pupils is different, and teachers must develop the environment for specific purposes and groups. The classroom can only be a finished beginning in which adaptations will occur.

When looking at this study it seems reasonable to suggest that the arranged environment can be used as a deliberate part of the teaching strategy, complementing and reinforcing other strategies the teacher uses to support children's learning.

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Is there a place for futures education in design and technology?

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Introduction

Remember the prehistoric 1980s? No CDs, no internet, no ringing mobile phones during your trip to the cinema or theatre. How far has the world come since then? Is this rate of change going to continue? Will it accelerate, propelled by our remarkable ability to innovate and invent?

The ideas that take hold in our minds today will shape the world of tomorrow. Which ideas shape our future, and what kind of future do we want? Do we want to create of our future, or do you want the future to create us?

To most people, thinking about the future meant thinking and planning your next big event such as a holiday, wedding or the arrival of your child. It took the threat of the Y2K bug for the world to wake up and notice and seriously consider the future, and the future effect we have created.

Of course many environmentalists, futurists and visionaries have for many years tried to convince the rest of us to 'think globally and act locally, become resourceful and adapt to continuous change'.

If we consider a desirable future, we should consider the preparation of young people who will occupy that future.

As Hooker (1988) states:
'A central function of education is to prepare students for the future, including both their societal and their personal futures. An education system can only be successful in this aim if it correctly identifies the sources of change in its society and adapts its curriculum accordingly.' (p.2)

Toffler (1974) indicates that:
'All education springs from some image of the future. If the image of the future held by society is grossly inaccurate, its education system will betray its youth.' (p. 3)

In the Australian Education system there have been many small – scale innovations, with the last major development the educational reform in 1988. One of the major changes in education was the recognition and emergence of technology education, defined as a key area of learning. It was recognized that many aspects of learning take place outside a school environment. A move from learning at schools and colleges until one participated in society to 'life long learning', shifted the axis of education and the learning process. Rather than learning from the past to deal with tomorrow, education moved from learning from the past and today, to define and shape the future.

Thus central to the stated purposes of school education in Australia is the notion of preparing young people for the future. In April 1999, State, Territory and Commonwealth Ministers of Education met as the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) in Adelaide. At that meeting, Ministers endorsed a new set of National Goals for Schooling in the 21st Century. The new goals were released in April 1999 as The Adelaide Declaration (1999) on National Goals for Schooling in the 21st Century.

However, while the notion of 'future' has been clearly articulated in relation to purposes of education, there is little evidence to suggest that policy makers and curriculum developers have considered the significance of futures in any depth. The Adelaide Declaration does not address the issue of preparing young people for life with ongoing change. The notion of 'futures' is clearly lacking in the subject matter of school education, as the measure is again a passive, non-active response to the future. Education becomes a learning of strategies to accept the future and how to deal with it, unfortunately it fails to address the skill development and strategies needed for considering, conceptualizing, shaping and coping with the future.

Much of our school curriculum is based upon an assumption that the transmission of an existing body of knowledge is the most appropriate way to prepare young people for their futures. Futures education therefore engages students in examining and scrutinizing the past, to be able to elicit the future.

At the enlightened end, teachers may address recent changes and trends, but they rarely challenge young people to operate in the context of the future. They rarely challenge young people to think about the actions needed to shape the future in desirable and responsible ways.

As a community, we accept an approach to education that is based upon the transmission of knowledge and skills that are relevant to the world, as it exists at present. To some extent, we seek to turn our children into likenesses of ourselves.

It is most likely that this approach is not one that will best prepare young people to live in a future that will be characterized by ongoing social, environmental and technological change. Futures education should empower students with skills to seek and select alternatives for preferable futures at personal and societal level.

Technology and Change

There appears to be broad agreement among social commentators that technological change is closely related to social, environmental and economic change. Many events in history can be linked to technological innovation and development. Conversely, changes in social and economic relationships give rise to different human needs and motivations, and consequently spawn new forms of technology.

A diversity of new and complex scientific and technological ideas is accelerating the pace of technological change. Slaughter (1999), in Futures for the Third Millennium lists new factors with future impact as:

- The human genome project and synthetic organ replacement
- Research on the control of aging
- The forging of new person/machine links
- The development and application of nanotechnology
- Universal digital communications systems
- High-tech terrorism using miniaturized weapons.

As reported in a review of his book, The Sun, The Genome and the Internet on the Radio National Science Show (30/10/99), Freeman Dyson, Emeritus Professor at the Institute of Advanced Studies Princeton University provides the following scenario for the development of technology in the next 50 to 100 years:

"Try to imagine a world where people get energy from fields of trees that have been genetically engineered to secrete liquid fuel from their roots into underground pipes. In an adjacent field, other trees might grow silicon chips in the same way they grow flowers. Surgeons no longer use knives but inject their patients with purpose-built viruses that seek out and eat damaged cells and organs. Roads are constructed out of engineered organisms in the same way that coral polyps make reefs. Cities are smaller, as the majority of people choose to live in small communities, yet wherever they live everyone is connected by a mature Internet that is truly global.'

The pace and scope of technological change will challenge the capacity of individuals and communities to make wise decisions about their broad application. Many developments will raise profound issues of ethics, global equity and social justice.

The February, 2000 edition of Wired, reported on the work of Kevin Warwick, Professor of Cybernetics, University of Reading, UK. Warwick has implanted silicon chips in his own body in order to communicate with a computer via radio waves. His research program will explore further applications of cybernetics including the communications of emotions via the Internet. He argues that 'thought to thought' communication is a feature of cybernetics that may be important 'as we face the distinct possibility of being superceded by highly intelligent machines'. In conclusion, Warwick states'

'Since childhood I've been captivated by the study of robots and cyborgs. Now I am in the position where I can actually become one. Each morning I wake chomping at the bit, eager to set alight the 21st century – to change society in ways that have never been attempted, to change how we communicate, how we treat ourselves medically, how we convey emotion to one another, to change what it means to be human and to buy a little more time for ourselves in the inevitable evolutionary process that technology has accelerated' (p.151)

While there is a clear relationship between technology and change, issues of control, power and economic advantage are much less clear. Many thinkers about technology advise caution. Slaughter (1999) states:

'The machine at the heart of the world has not always been there. It was inserted during the scientific revolution and became steadily universalized over subsequent centuries. The machine metaphor derives from a particular world view, which brought with it a number of assumptions and prescriptions: assumptions about people and their relation to nature; about knowledge and how to obtain it; about progress, growth and most of all about the pre-eminence of instrumental rationality'. (p 108)

A large proportion of students entering our school today will live through an unprecedented period of change. Governments and educators who are far sighted will equip young people to participate in change processes and prepare them to shape change in responsible ways.

Technology Education – an Australian Experience

In the context of rapid change, NSW schools have focussed their curriculum to pursue the basic aim of preparing students for their future. It is necessary for all educators to acknowledge the future as a dynamic force in their own lives, professional development, curriculum planning, the students' lives, and classroom practice. How can the study of futures become an integral part of the educational disciplines and provide a framework for interdisciplinary learning in schools? Key issues for educators are:

- Which of the numerous competing futures will influence curriculum work?
- Which approaches and strategies are appropriate for futures study?
- How can education move from a 'consequence' perspective to a truly 'futures' perspective?
- How can a futures directed education be implemented at classroom level?
- How can futures directed design and technology education encompass human issues without subversion of prevailing values?

Design in Technology Education

Traditional approaches to technical education involve students in rehearsing and practicing an established set of industry skills and practices.

The more recent approaches to technology education require that students learn through design processes and learn to use design processes to create products, systems and environments. Design is concerned with the formulation of ideas or concepts in advance of production. Implicit in the word 'design' is the creation of something that will exist in the future and with which people will interact in the future. We shape the products, systems and environments that will be used in the future, but equally those products, systems and environments influence how we behave, what we believe and what we are.

De Bono argues that:
'Our excellence in working with 'what is' has meant that insufficient attention has been paid to the 'what can be' side of thinking… The 'what can be' aspect of thinking is concerned with design rather than analysis, with value rather than truth.
You can analyze the past but you have to design the future'. p 277

However, our experience in Australia suggests that students can engage in design processes without consciously thinking about the future, or the type of future they might think is desirable. To address this problem the Commonwealth Government funded a National Professional Development Project to incorporate the notion of Appropriate Technology in technology education.

Appropriate Technology: Designing the Future

The Appropriate Technology Project sought to extend the definition of technology. It argues that appropriate technology may be generally defined as:
"technology which in its creation and use, meets human needs while considering the short-term and long-term consequences for society and the environment.". p 9

The Appropriate Technology Project also advocates a discipline for the design process whereby those who design give ongoing consideration to issues of culture, energy, environment, ethics and gender.

While we consider that we have much of the structure right, the Appropriate Technology Project does not present futures in an adequate way. The project is strong on consequences but does not go far enough in attempting to change the mindset of students to a futures orientation. Considering consequences may not be the most appropriate or efficient way to progress toward a desirable future.

Futures education must move beyond its present level and have a responsive, decisive, action-oriented focus, as the following example illustrates.

Towards a Futures Approach to Learning

Recently a young teacher in a senior Design and Technology class set a design brief which was concerned with re-using old things for new purposes. Mistakenly, he assumed that 16 year-olds would already appreciate the importance of conserving resources and re-using materials, and that they would get a 'buzz' out of this type of project. Nothing could be further from the truth. Initially students saw the project as awful and worthless. Only politeness prevented them from questioning why they had to work with 'old junk'. The teacher had mouthed all of the appropriate rhetoric about appropriate technology but it did not make connections with the students.

When the teacher realized this, he immediately stopped the project and spent the following two weeks exploring issues of resource usage, pollution, technological change and, costs and benefits of development. Students looked for balanced points of view and avoided negativity whenever possible. They used facts and figures from reliable sources, drew on industry projections and government reports and, most importantly, discussed the types of changes that will be necessary to create a sustainable future. They looked at buildings and environments that were created using sustainable technology and considered the type of world we would like for the future.

On returning to the project, the teacher found the students transformed into environmental zealots – totally committed to their Design and Technology projects. They haunted second-hand shops, recycling centers and council clean-ups. They created innovative and worthwhile new products that they continue to value. They developed a wide range of design and technological skills and capacities. The teacher had learnt the need of spending time to change students' mind-set from a 'present, responsive, reactive' orientation to a 'futures, directive ' orientation. He also realized that to do this, students require particular 'content' about the issues they need to consider during the development of a design project – facts, figures, trends and projections.

The above example highlights the fact that the concept of futures research and futures studies is well placed in Design and Technology Education. However it also highlights the need for:

- The development of quality strategies for implementation
- The design of suitable and exciting activities and teaching resources
- The development, planning and implementation of evaluation and assessment.

Fitch and Svengalis (1979) offer the following 'goals' of futures education. Futures education should:

- Attempt to help students understand the concept of alternative futures
- Aid the student to understand the concept of change
- Promote an understanding of the possible modifications in human behavior necessary for the future
- Promote a holistic view of the natural and social worlds
- Promote an understanding of important societal trends and their implications

- Promote an understanding of the relationships between values and the future
- Promote an understanding of the ideas of major futurists and the methods of futurism
- Promote an understanding of the relationships between past, present and future present and
- Promote a variety of additional perspectives and inquiry strategies
- Promote the general improvement of basic research and communication skills
- To expand the range of possible and plausible futures to extend areas of choice
- To define and clarify the content of preferable and probable futures

The 'Quality Teaching Project' (QTP)

In 2000 the Commonwealth Government of Australia initiated a project to improve the quality of teaching and learning across a number of subjects, i.e. The Quality Teaching Project. As part of the project work has commenced on the professional development package to improve the delivery of Science & Technology in NSW Primary Schools, (Science & Technology uses processes of investigating, and designing and making).

Futures in the QTP

As a part of the Quality Teaching Project it was decided to explore the further development of a futures orientation in Design and Technology, using processes of Practitioner Research. Project work has been set up in three Primary schools with teachers who operate through a design process. In selecting teachers priority was given to those who have had experience, working on the Appropriate Technology Project.

Processes of 'practitioner research' are being used to explore the idea of orientating student thinking toward the future during the development and implementation of design projects.

The following research questions are being used:

- What preparation must be done to orient student thinking toward the future?
- What materials and support must be used throughout a design process to maintain students' futures orientation?
- How does a futures orientation change the design process for students?
- Which issues need to be considered?
- How will ideas be conceptualized?
- How will ideas be communicated?
- Which technologies will be used?
- Which evaluation measures and processes will be employed?
- How do student understandings of futures change from Kindergarten to Year 6?

Participating teachers will document their own practice in planning and implementing a unit of work based upon a design process and collect student work samples that support their responses to the questions detailed above.

Findings will be presented at the conference and published at a later date.

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Children Designing & Engineering

The College of New Jersey, USA

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Introduction

Children Designing & Engineering (CDE) is a collaborative project of the College of New Jersey's Center for Inquiry and Design – Based Learning and the New Jersey Chamber of Commerce. Its goal is to develop instructional materials for elementary teachers to use in their classrooms with children in Kindergarten to grade 5 (ages 5 to 10 years). These materials take the form of 4 to 6 week units (15 to 24 hours of class time) in which children work to meet a major design challenge. Each challenge is presented within a scenario based on the activities of a New Jersey business. Meeting the challenge requires applying knowledge of math, science and technology, among other subjects. Units are also intended to provide glimpses of the work world that will be meaningful to children and to provide an early orientation to the skills and attitudes sought by employers.

Creating convincing contexts for learning which capture students' imagination while addressing standards from a number of subjects is a difficult challenge in today's educational climate. Add to this a clientele of elementary teachers unfamiliar with design and technology and a general population confused about the nature and value of technology education. And yet, to many of us, contextual, design-based learning is such a compelling idea that we choose to struggle with the issues in the hope of creating some new models, alternatives to traditional classroom practice.

The Educational Climate for D&T in 2001

Two years ago, Clare Benson described several factors necessary to the successful development of primary design and technology in her paper "Quality in the Making" (1999). Citing these factors, she was able to report on both the support structures and the stumbling blocks that have affected the progress of primary design and technology in England. The same questions of "infrastructure" can be applied to the American scene, where rather different circumstances exist.

A National Framework

Unlike its UK counterpart, US education is a responsibility of state rather than federal government. No national curriculum exists to coordinate education nationwide. Important national policy-making organizations, however, underwrite studies and projects whose influences are felt all over the country.

During the past ten or twelve years, a strong standards movement has swept the US, involving professional education organizations and often supported by foundations that receive both governmental and private funding. The groups responsible for national standards for mathematics, science and technology, for example, have all received funding from the National Science Foundation, along with other funders. The standards for art were underwritten largely by the Getty Center for Education in the Arts, and those for geography were funded by the National Geographic Society and the National Endowment for the Humanities.

Figure 1

State	Exam	Grade	Subjects
NJ	ESPA	Grade 4	Language Arts, Math, Science
	GEPA	Grade 8	Language Arts, Math, Science
VA	SOL	Grade 3	English, History, Math, Science, Social Studies
	SAT 9	Grade 4	LA, Math, Reading, Science, Social Studies
	SOL	Grade 5	Computer/Technology, Reading/ Literature / Research/Writing, History, Social Studies, Math, Science
	SAT 9	Grade 6	LA, Math, Reading, Science, Social Studies
	SOL	Grade 8	English, History, Math, Science, Social Studies
	SAT 9	Grade 9	LA, Math, Reading, Science, Social Studies
PA	SAT 9	Grade 3	Language Arts, Math, Science
	PSSA	Grade 5	Math, Reading

ESPA = Elementary School Proficiency Assessment
GEPA = Grade Eight Proficiency Assessment
SOL = Standards of Learning Assessment*
SAT 9 = Stanford Achievement Test
PSSA = Pennsylvania System of School Assessment*
*reflects state standards

Source: SmarterKids.com State Test Prep Center at http://www.smarterkids.com/state/STP_FAQ.asp

Figure 1 Standardized testing varies greatly from state to state

All of these national standards are offered to the states as voluntary guidelines. But even at the state level, responsibility is largely decentralized. While forty-nine states have produced state standards, state-wide assessments based on those standards are rare. Virginia is one of the few states with a coordinated plan for implementing and assessing learning based on state-developed "standards of learning" (SOLs). Other states use commercially available standardized tests at various grade levels (typically 4th, 8th and 12th or ages 9, 13 and 17), but these are often only math and language arts exams, and may not be coordinated with state or district standards. Figure 1 illustrates when and on what subjects testing takes place in New Jersey, as well as in Virginia and Pennsylvania, two states with which we have worked closely on a number of design and technology initiatives over the past decade:

Technology Standards

National Standards for Technological Literacy were published in 2000 by the International Technology Education Association, recommending the study of technology from kindergarten through graduation. In reality, however, little understanding exists of technology as a school subject. From the boardroom to the classroom, the word "technology" is more often assumed to mean "computers" than anything else. At the same time, modern triumphs of technological design highlighted in the media are invariably attributed to science assumed to be the field of study that produces both researchers and engineers. Efforts to explain that technology education is rather about "practical problem-solving" still conjure up visions of industrial workshops, the only experience from their own schooling to which many parents can relate the term "practical." Unfortunately, this is also the vision of many of the teachers (especially at secondary level) whose shops have been renamed "technology labs."

The National Standards for Technological Literacy were the result of five years of work by a very large and diverse population of stakeholders. The main components of the study of technology which emerged from that effort include:

- The nature of technology
- Technology and society
- Design
- Abilities for a technological world
- The designed world.

The very visible presence of design within those standards is extremely gratifying. Much of the impetus for the inclusion of design came from abroad, and it may be some time before the importance of this component is fully recognized in the US.

Currently, state standards exert more influence on the daily life of schools than national standards. Since most of the state standards predate the national standards for technology, many (including our own state, New Jersey) do not encompass the national vision. The Standards for Technological Literacy should help in pointing out the critical need to recognize this largely invisible force in our lives and to establish its place in our educational system. But beyond their public relations value, the standards have provided a starting point for the development of new visions of teacher training, classroom practice, and student outcomes. Efforts to create exemplar technology programs are in the early stages, and the standards are helping to direct and validate the effort.

Practice in Schools

What technology education should look like in schools is still an open question. Both cognitive and process statements are described in the standards, along with possible classroom scenarios that feature designing and making, use of computers and other tools, integration of science and math, cooperative learning, documentation and many other features. The scope and sequence of these components has not been worked out.

Adding a new subject to the curriculum will be a hard sell to teachers, unless they are helped to see technology as a way to facilitate learning. The pressures on elementary teachers have increased dramatically in recent years. A back-to-basics movement similar to that in the UK is exacerbated by a cry for more testing and penalties for poor performance. Creativity and risk-taking have been put on hold in many classrooms where teachers struggle to meet requirements for more reading and more math, or to make sense of state or district standards. At the same time, the move away from special education to inclusiveness; the growing diversity of student populations; and even the litigious attitudes of some parents makes teaching an ever harder job.

Taking on a new subject is understandably daunting to many elementary teachers, few of whom studied technology in their pre-service education. Several D&T oriented projects underwritten by the National Science Foundation provide in-service and support materials for elementary teachers, but schools are not always supportive, requiring that workshops for professional improvement be held on the teacher's time after school, on weekends or in the summer. These initiatives include Project UPDATE at the College of New Jersey; the MSTe Project at Hoftsra University; and the DTEACh program from the Southwest Educational Development Laboratory.

Other Support

While the standards are new, the vision of K-12 design and technology has been under development for some years. The earliest proponent of Design and Technology education in the US, TIES Magazine, now in its thirteenth year of publication, reaches about 45,000 teachers. Originally targeted at secondary schools, TIES now includes an increasing number of articles of interest to elementary teachers. ITEA's quarterly magazine, Technology and Children, has also recently begun to include design-oriented articles. Other resources are available from science and technology museums, as well as professional design and engineering societies. A range of notable initiatives and resources in art, design and technology were cited in 'Design as a Catalyst for Learning' (1997) from the Association for Supervision and Curriculum Development (ASCD).

Another issue for implementation of the Standards is initial teacher preparation. Secondary technology programs are at all time low enrollments. Currently few elementary education programs include anything like design and technology, but the College of New Jersey has recently instituted an integrated math/science/technology specialization for elementary education majors in the hope that the design aspect will entice more female students into contact with math and science, unpopular options among elementary majors.

The Children Designing & Engineering Project

Within this climate of exciting possibilities but fragile infrastructure, the CD&E project was undertaken in 1998 as a three-year effort to help elementary teachers incorporate design and technology into their teaching. Project collaborators from the College of New Jersey and the New Jersey Chamber of Commerce set the following goals:

- To design real-world, developmentally – appropriate instructional units
- To pilot, field-test and improve model instructional units
- To assess the usefulness and impact of the learning activities on student performance and attitudes, and
- To share sample units, models and protocols with elementary educators, and individuals from business and industry, in preparation for national distribution of the products and procedures of the project.

Over the past three years, project teams have designed twelve contextual learning units (CLUs), six for grades K-2 and six for grades 3-5. Contextual learning units are distinguished from standard thematic units in that all of the content within each unit is intended to help students meet a major design and make challenge. Contexts for CD&E units are drawn from the world of business, specifically seven New Jersey companies representing the states major industrial sectors. Participating companies include:

- Six Flags Wild Safari (entertainment)
- Lucent Technologies (communications / research and development)
- Marcal Paper (manufacturing)
- Johnson & Johnson (pharmaceuticals)
- Ocean Spray Cranberry Products (food production)
- Public Service Electric and Gas Company (power utility)
- Elizabethtown Water Company (water utility).

The design and technology approach central to each unit employs hands-on, practical problem-solving as a vehicle to integrate and apply knowledge of mathematics, science and technology (Kolodner, et al., 1998), based on national standards for each of these subjects. In addition, the units are designed to introduce students to a number of New Jersey Cross-Content Workplace Readiness Skills (New Jersey State Department of Education, 1996), including career planning; use of information and other tools; critical thinking, decision-making and problem-solving; self-management; and application of safety principles.

Each unit has been designed to represent an aspect of the business from which it was drawn. To explore the work of these companies, teams comprised of elementary teachers, curriculum writers, subject specialists in math, science and technology, and a Chamber of Commerce liaison person toured each of the businesses. Industry hosts explained the activities of the company, discussed issues related to operations, economics, personnel, work environment and other factors. Each fact-finding outing ended with a brainstorming session in which team members discussed what they had seen, offered tentative ideas for instructional units or activities, and identified questions for further research. Curriculum writing workshops were carried out during the summers of 1999 and 2000, with project staff developing and refining the materials during the intervening months.

Setting Contexts

The basis of contextual learning is the belief that relating schoolwork to the real-world makes learning more interesting, relevant, and ultimately effective (Kimbell, et al., 1991). The literature on contextual learning suggests that contexts appropriate for early elementary students exclude the workplace, since most young children have little experience of real work environments (Resnick, 1987). Yet many children are fascinated by "playing work" – being storekeepers, doctors and nurses, teachers, mail carriers and firefighters, and CD&E staff sought to build upon this inclination. The challenge was to create scenarios based on the work of partner industries that seemed likely to capture the imagination of students while addressing the requirements of the curriculum for each grade. A scene-setting video is planned for each unit, although only two of these have been produced to date. The following scenarios were eventually proposed for the first six units:

- Opening Day at the Safari Park (Six Flags Unit, K-2)
  Students design and make a classroom safari park as they learn about African animals, natural and built environments, structures, and systems for communication and transportation. They plan an opening day celebration, and sell tickets to cover the costs of food and souvenirs
- Bright Ideas Playhouse (Lucent Unit, K-2)
  Students explore properties of light, then apply what they've learned to design and make shadow puppet plays based on familiar nursery rhymes, to which they invite guests and charge admission

- Earth-Friendly Greetings (Marcal Unit, K-2)
  Students study the waste stream and recycle paper products into new paper, from which they design and make original greeting cards to sell at a class boutique
- Say It with Light, Inc. (Lucent Unit, 3-5)
  As employees of a communication company, students learn about the roles of scientists, designers, engineers and marketing professionals in developing products. They investigate light and communication, then work as interdisciplinary teams to propose new products that use light for communication and present their ideas to the company's directors
- Camp Koala (Six Flags Unit, 3-5)
  Students design and make a visitors center for Camp Koala, a new home for an endangered species that is being planned for a local safari park. Topics include endangerment of animals and impacts of technology as well as technical methods for creating moving displays. They stage a "Koala Gala" to publicize and raise funds for wildlife preservation
- Paper Products: You Be the Judge (Marcal Unit, 3-5)
  After investigating the claims made by companies about their paper products, students design and carry out scientific tests, then present their findings in a classroom version of Consumer Reports.

Addressing standards

In choosing industry partners, the project directors strove to include companies that would allow the units to explore a range of sciences: life sciences, earth science, physics and chemistry, but no attempt was made to address all of the standards. Nor was it possible to tackle questions of progression. Benchmarks for the Principles and Standards for School Mathematics (National Council of Teachers of Mathematics, 2000), the National Science Education Standards (National Research Council, 1996) and the Standards for Technological Literacy are provided for grade 2 and grade 5. Little guidance is provided in the standards for the specific content and skills at each grade level. Grade-specific guidelines for writers were synthesized from textbooks and sample curricula, but units were typically developed to be used within any grade of the three-grade span and include suggestions for extending and simplifying many activities. Because the challenges were designed from a technology perspective, addressing technology standards, especially those relating to the design process, was fairly straightforward. Some mathematics standards were addressed in all units, such as measurement, estimation and graphic representation. Others appeared in only some units, while some never proved suitable for practical application. Standards matrices were developed for each unit, indicating which standards were addressed by the various activities included in the units. A sample page of the technology matrix for the Safari Park K-2 is provided in Figure 2, below.

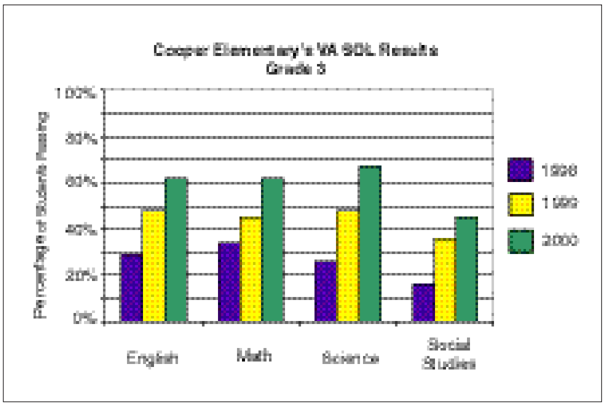

Figure 2 Coordination of activities with national standards is displayed on a standards matrices like the one above

Unit Content and Format

Each unit consists of four to six weeks of work, with a week envisioned as five or six forty-five minute periods. Attempts have been made to focus weekly lessons on a specific topic for exploration, making each week something of a self-contained unit. For example, in the five-week Safari Park unit for K-2, weekly topics include:

- Introduction to the challenge with a video visit to the Safari Park
- Investigating, designing and making structures for animals
- Investigating, designing and making things for workers and visitors clothing, tools, rules
- Investigating, designing and making safari park vehicles (See Figure 3.)
- Planning and carrying out an opening day celebration.

Figure 3 First graders in animal costumes get ready for a bus tour of their safari park. The children made small model vehicles to test wheel shapes and different propulsion methods.

In the Safari Park, learning content and meeting the big design challenge are interwoven activities. The challenge is met cumulatively as the classroom environment grows over the entire five weeks.

More advanced units tend to require considerable information gathering before design work begins. For example, in Say It with Light, Inc., a six-week unit for grades 3-5, students analyze their problem and list things they need to know; spend three weeks learning about light and communication through a range of analysis, experimentation and assembly activities (which also introduce making skills; see Figure 4); then devote three weeks to designing, modeling and presenting ideas for a new light-based communication device. In all cases, mathematics and science are presented as practical tools for solving problems, and teachers can extend or emphasize coverage of those topics, as needed.

Figure 4 Fourth graders assemble light houses, using gears and an eclipser to solve a communication problem

Addition of a graphic designer to the product development team has helped establish a user-friendly format. Each unit contains a teacher's guide, a guided student portfolio, a scene-setting video and a kit of resources. The teacher's guide contains background on the project, unit overview, weekly summaries, daily lesson plans, instruction sheets for various activities, transparency masters and templates, evaluation rubrics and advice for adapting lessons for special needs. Guidance is also provided for customizing units in order to partner with local industries and to address state standards. Many teachers will have had no technical experience, and project staff have strived to provide directions for practical activities, such as building with square section wood, making cardboard mechanisms and wiring a circuit. Reviewer/pilot teachers have also requested examples of possible solutions to challenges, since many of them are unsure what results are realistic.

Unit evaluation

Perhaps the most daunting aspect of the project has been the question of evaluation. Interim evaluation through pilot testing is providing good formative data that has allowed us to modify and improve the units. The National Science Foundation has granted an extension to the project in recognition of the ambitious nature of the undertaking, but the question of summative evaluation is more difficult. The National Science Foundation sees contextualized, design-based activity as a way to make mathematics and science more meaningful to students. Demonstrating success in these areas would be easier if there were examinations based on the national standards, at least at the grades 2 and 5 levels, but no such tests exist.

Our "parent" project, Project UPDATE, has provided interesting insights into the effects of design and technology in a number of classrooms in Philadelphia, Delaware and Virginia. In these settings, success of students in classrooms where teachers had received training in design and technology was monitored over a three year period. Different standardized tests were used in each setting, but in all three instances, students of UPDATE – trained teachers who applied contextual D&T approaches showed greater improvement in math, science, reading and other subjects than students in classrooms where teachers had no D&T training. Some results of this research are illustrated in Figure 5, below:

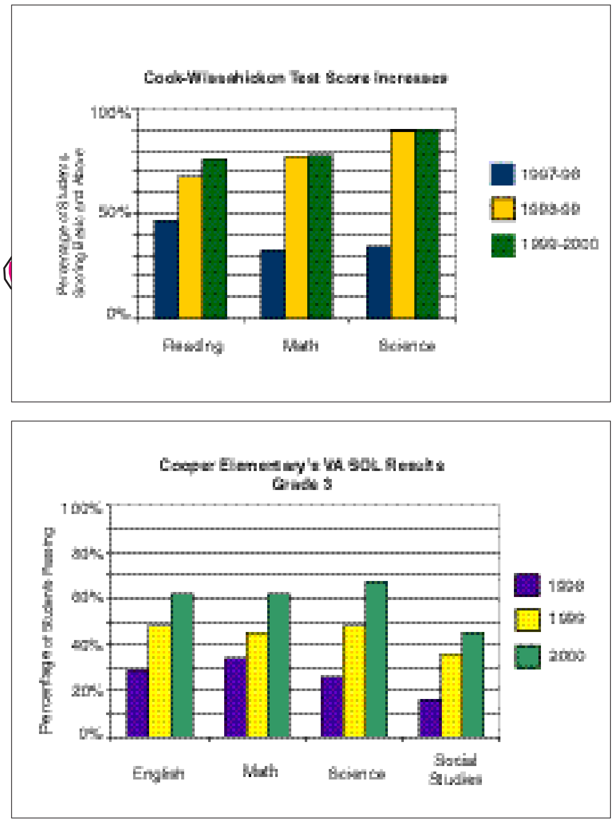

Figure 5 Cook-Wissahickon School (Pennsylvania) and Cooper Elementary (Virginia) both showed improvement in test scores over a three year period among students whose teachers had been trained in design and technology approaches

Judging the effectiveness of specific units will require a more focused kind of assessment. Funding for project evaluation is insufficient to allow us to develop and validate our own tests, but some specific questions will be posed for individual math, science and technology activities in each unit. These questions should demonstrate that the approach effectively delivers targeted learning as well as more pedantic means. To enrich these findings, however, it will be necessary to gather more qualitative data about student engagement with the activities, collaboration and communication skills, self-confidence and transfer of learning. Many of these benefits have been reported from work with Project UPDATE, and are among the outcomes sought by our business partners (The College of New Jersey, 2000).

A final component of assessment is usability by teachers. While contextual work pays off in terms of student engagement, we are aware that establishing a context takes time often not directly tied to recognized curriculum goals. Many teachers are reluctant to spend time on preparing the classroom, setting up a resource center, and adapting content to a theme when a textbook curriculum is so much more familiar and less demanding (Davis, et al., 1997). To this end, we have tried to include guidelines for time and resource management wherever possible.

Toward the future

Development of the second six CD&E units will continue through the next fifteen months while the first six units finish piloting, revision and field testing. Several interesting issues and questions have emerged from the design phase of the project, including:

- Are there generic kinds of industy-oriented activities that can be adapted to educational settings?
- How can the different relationships between science and technology in the real world help to inform worthwhile activities for students?
- What support is needed to justify the time necessary for contextual work in an already crowded school day?

Evaluation findings will certainly pose more questions, and provide more fuel for future research projects.

The development of design and technology in the US faces an uphill battle for many reasons, including competition with more established disciplines, confusion over the nature of the school subject and ignorance of the role of technology in modern life. Yet collaborations with enlightened businesses, support from agencies like the National Science Foundation, and the success of international colleagues in the development of the discipline justify the effort.

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A Comparative Study on Technological Aspects of 'Science' and 'Art & Crafts' in Elementary Schools between Japan and Singapore

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Introduction

This study was undertaken to compare technological aspects of 'Science' and 'Fine Arts' in primary schools in Japan and Singapore. The reference books, or textbooks, of those subjects were used in this study. In addition, we studied the Course of Studies of 'Science (Rika)' or 'Fine Arts (Zuga-kousaku)' in Japan and compared them with those of Singapore.

As a result, it could be concluded that there were many technological aspects in those subjects in Singapore. They contained very useful content for a student's life. For example, technological aspects of 'Science' were work oriented and so on. And those of 'Fine Arts' were included the subject matters titled 'The Traditional Houses in Southeast Asia or Miniature Gardening' and so on. On the other hand, the Japanese school 'Science (Rika)' and 'Arts (Zuga-kousaku)' tended to be dependent upon views of 'Shizen' very much. 'Shizen' is the traditional word in Japanese that translated, means the word 'nature' in English. Many Japanese science or arts educators have emphasized views of 'Shizen' and refused to accept technological aspects.

Problem

In Japan, competition of the examination for entrancing some famous universities, secondary and elementary schools or kindergartens has been very severe. It is said that the social status of exam subjects has been higher than the status of no exam subjects (Benesse, 1999). On the other hand, pupils who dislike 'Math' or 'Science (Japanese subject name: Rika)' have increased more and more from year to year and the phenomenon has already happened in elementary and lower secondary schools (National Institute for Educational Research in Japan, 1997; Third International Mathematics and Science Study (TIMSS) International Study Center, 2000).

From the viewpoint of international comparison, many countries have been coherently introduced technology education as a general subject from elementary schools to upper secondary schools since 1990 (Yamazaki, 2000a,b,c). In Japan, in contrast, technology education has only been taken effect a 'Technology (Gijutsu) and Home Making (Katei)' subject in lower secondary schools. On the other hand, the Scottish Office Education Department (1992) pointed out that there were technological aspects in 'Science (Rika)' in elementary schools in Japan: *For example, the energy source could be either a battery or a solar cell. Assembling the chassis and body of the car involved an understanding of drive mechanisms, including the use of pulleys and simple gears to achieve forward and reverse movement, and aspects of traction and friction.* (The Scottish Office Education Department, 1992: p.12).

Additionally, the Scottish Office Education Department (1992) indicated that the work gave little scope for teaching the processes of design as in the English or Scottish technology curriculum. On the contrary, many Japanese people have not been aware of technological contents and designing in 'Science (Rika)' or 'Fine Arts (Zuga-kousaku)' in elementary schools, Japan. Particularly, it is clear that 'Fine Arts (Zuga-kousaku)' has stressed on fine art rather than handicraft very much.

In Singapore, one of neighboring countries of Japan, technology as a subject has not established in elementary schools as well as Japan. The data of Table 1 showed that most Singaporean 8th grade pupils liked studying 'Science' subject though many Japanese pupils dislike 'Science (Rika).' The Singaporean were not only good ranking but also many pupils thought that the science subject was very useful for their life. Additionally, it was clear that they were interested in studying very much and in recognizing the relation between their study and daily life, too. However, it was difficult for Japanese pupils to understand the significance of study or the relation between the subject and their own selves.

Table 1

Content for Investigation	Japan	Singapore
Ranking of TIMSS	Third	First
I like Science subject	56%	92%
Science is an interesting subject	53%	90%
Science is not an interesting subject	33%	15%
Science is an important subject for our daily life	48%	93%
Science is an easy subject	15%	42%
I want to do works in related to science	20%	61%

Table 1 International comparative results of 8th grade pupils in the Third International Mathematics and Science Study (TIMSS)

Purpose

The first purpose of this study was to examine whether science and fine art subjects were comprised technological educational contents and activities in comparing Singapore with Japan. The second purpose was to inquire causes that why the results of TIMSS in Singapore were much higher than the ones of Japan in most of items.

Results and Consideration

The Previous and New Course of Study for Elementary Schools in Japan

The Japanese Course of Study for elementary schools was revised in 1998. Referring to technology education, this study was examined whether there were comprised technological objectives or contents in the Japanese Course of Study for elementary schools in 'Science (Rika)' in comparison with 1989' and 1998' revision (Table 2). Taken in the light of the object of learning, both the previous and the new Course of Study dealt with both 'Japanese nature (Shizen) and western science views. There were two different points between the previous and the new revision. The first point was that there were many descriptions of 'to use the contents of learning in your daily life' in new revision. This point suggested that the purpose of revision was to make the contents of 'Science (Rika)' related with daily life. The second point was that the technological terms, that is, 'Monozukuri (it means making inanimate artifacts or nurturing livings to utilize in Japanese)' was introduced. However, the extent of 'Monozukuri' was limited to the activities of experiments and observations connecting with the character of 'Shizen' (the Course of Study for elementary schools in 'Science (Rika)', 1998a: p.12). As one of the reasons, it was clear that 'Shizen' education have been greatly influenced by Japanese historical and cultural contexts.

It is worth noting that Japanese 'Shizen' is a different meaning from western nature (Ogawa, 1997). In 1889, Ohgai Mori and Zenzi Iwamoto discussed the concept of 'Shizen.' They were Japanese and thinkers. Iwamoto comprised the old Japanese, 'Sinin(idea)' or 'Waku(idea)' so on. In contrast, Mori did not comprise 'Sinin' or 'Waku' and implied substances from a scientific observation (Yanabu 1977). After all, the discussion was not solved at that time. In general, nature in which human recognize by scientific observation has been translated into Mori's concept.

'Shizen' is the ideal of what everything should be, and it is not compatible with human power. In other words, 'Shizen' has been based on the mysterious concept, in the sense, how human being coexists with mountains, rivers and plants etc. On the contrary, nature is compatible with human power and human has changed some parts of nature. Nature has given Westerners a negative image, 'no cultivated' (Ogawa, 1997). For those reasons, 'Shizen' education is the unique education to the Japanese. The overall objectives of 'science (Rika)' have been comprised the following two Japanese contexts: 'commune with 'Shizen'' and 'nurturing a rich sensitivity to love 'Shizen.'' Therefore, it seems that the activities connecting with the character of Shizen have been stressed very much. Shizen education is one of the natures of Science (Rika).

Design and Technological materials between Japan and Singapore

The following materials were used in this research:

- The Japanese Course of Study for elementary schools in 'Science (Rika)' in the 1998 edition
- The Japanese Course of Study for elementary schools in 'Fine Arts (Zuga-kohsaku)' in the 1998 edition
- Chong R (1998) PSLE Science
  Singapore, Pan Pacific Publications
- Curriculum Planning & Development Division
  Ministry of Education, Singapore (1997)
  Art & Crafts, Second Edition, Federal Publications

As shown in Table 3, there were technological materials in 'Science (Rika)' or 'Fine Arts (Zuga-kohsaku)' in Japan. For example, they were car models, which the energy source could be either a battery or a solar cell. And some kinds of materials were dealt in 'Fine Arts (Zuga-kohsaku)' in Japan. The most important part of this argument is that the Scottish Office Education Department (1992) reported no designing work was given. As only scientific activities were stressed, observation or experiment was taken in 'Science (Rika).' Moreover, Ogawa (1997) pointed out that there existed two components, in the sense, 'science' and 'Neo-science' education in 'Science (Rika)':

'Neo-science' education is the activities which model 'science' but are not actually 'science': Non-scientific observation, non-scientific experiment, non-scientific problems-solving, and non-scientific understanding of natural things and phenomena. In 'Neo-science' education, for example, pupils perform and enjoy activities such as 'observation' and 'experiment'. However, what they do is not guided by the spirit of science, but by other motives. What is worse, they believe, or even teachers believe that what they perform now is what scientists with the spirit of science perform in the laboratory (Ogawa, 1997: p.109 – 110).

Hence, it should be noted that pupils have not understood what or why they studied, that is to say, the relation between their study and real daily life.

On the other hand, in Singapore, there were technological contents and designing of 'Science' or 'Art & Crafts'. In their subjects, science and technological activities were integrated. For example, when pupils learned about an electric bulb and a battery, they were made to think why they have to write the circuit or why the electric bulb turns on. From the standpoint of bio-related technology, there were many technological aspects of cultivating. For example, methods of grafting or cutting so on and many methods to make pupil's activities connect with daily life. Additionally, in 'Science', there were contents that sought energy or electricity technology for its own, too. In contrast, in Japan, those the concepts of energy and energy conversion were introduced from the lower secondary schools.

Thus, education of Singapore was devised that pupils could have the significance or relation between what they studied and their own life. According to their evidences that this research was mentioned before, it seems reasonable to suppose that the results of the TIMSS in Singapore were much higher in most of items.

By the way, information technology as a subject has not been introduced in elementary schools both Japan and Singapore. In Singapore, it is said that Singapore's Masterplan for IT in Education have been laid out a comprehensive strategy for creating an IT-based teaching and learning environment in every school (RADM, 1997).

Conclusion

In concluding, two points were noted by this paper. The first conclusion is that as for 'Science (Rika)' or 'Fine Arts (Zuga-kohsaku)' in Japan, though there were technological contents, there were few technological activities. As for the second conclusion, there were many technological aspects of those subjects in Singapore and they were connected between pupil's learning activities and their daily life very much. As the results, it seems that pupils can understand the significance and relation of their study.

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A Comparative Study on Methodology of Research for Primary Technology Education in UK and Japan

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Introduction

The purpose of this study was to compare the methodology of research for primary technology education in U.K. and Japan. We focused on classification, content, composition, design and research methods in the articles reported by the Journal of Design and Technology Education (Vol.1 – 5, 1996 – 2000) and the Journal of the Japanese Society of Technology Education (Vol.37 – 39, 1995 – 1997). This study was summarised as follows:

- There were many articles about curriculum in the DATA Journal. In the Journal of JSTE, on the contrary, most articles were dealt with development of 'materials for making artifacts', belonged to a model of 'Research – Development – Diffusion' as an approach for study
  - In Japanese technology education, most teachers and researchers did not have the viewpoint of 'curriculum developer'
- In the DATA Journal, some primary school teachers contributed articles on school-based curriculum development.

From viewpoints of research methods of Japanese technology education, Moriyama (1998) investigated articles issued by the Journal of the Japanese Society of Technology Education (JSTE) during the period 1995 – 1997. His study found out the following:

- Although many articles for a 'materials for making artifacts (seisaku-daizai)' were reported by the Journal of JSTE, few practical educational researches, such as curriculum development, were reported
- A large number of their studies were used quantitative data rather than qualitative data.

Kondo (1998) showed that some research into Japanese technology education considered relationship between the subject's contents and teaching materials. According to leading research, the term of 'teaching material (kyouzai)' can be defined as 'a material selected to instruct contents of the subject' in this study. Nevertheless, most leading articles about technology education have dealt with a development of materials for making artifact; there was not an authentic research for teaching materials. The problem is that the meaning of 'teaching material' and 'materials for making artifact' was not exactly understood in Japanese technology education.

Japanese National Curriculum Council (JNCC)(1998) pointed out needs to encourage individual schools to show ingenuity in developing unique educational activities to make the school distinctive: *The national curriculum standards will be clearly specified and more flexible so that individual schools will be able to show ingenuity in developing unique educational activities to make the school distinctive. Specifically, each school will be able to make its own timetable and curriculum in accordance with the actual situations of the community, school and children. In addition, the number of elective subjects will be increased and the 'Period for Integrated Study' will be established to further promote each school's unique educational activities. Moreover, schools will be encouraged to establish a good relationship with families and communities and to be more open to them.* (JNCC, 1998 www.mext.go.jp/english/shotou/980702.htm)

There has been some research about technology curriculum development in Japan. The purpose of this study was to compare the methodology of research for primary technology education in UK and Japan.

Materials and Methods

- Objects
  – The Journal of Design and Technology Education (Vol.1 – 5, 1996 – 2000)
  The Design and Technology Association (DATA) Journal is divided into 2 sections; one being 'Research' and the other 'Curriculum Development'. 'Curriculum Development' renamed as 'Curriculum' from Vol. 4.
  – The Journal of the Japanese Society of Technology Education (JSTE) (Vol.37 – 39, 1995 – 1997)
  The Journal of JSTE was made up of 3 classifications; they were 'Original Paper', 'Practical Paper' and 'Technical Information'. The Society has defined 'Technical Information' as an article inferior to 'Original Paper' at the level of quality.
- Methods
  – This study used categories related to classification, contents, approach and construction. In order to compare this study with Moriyama's study, most of our categories were made to correspond to his study. These categories are taken up in the next chapter
  – This study counted frequency of emergence of articles that accorded with each category.

Results and Discussion

Classification

'Research' (69/172 articles, 40%) and 'Curriculum Development' (103/172 articles, 60%) were reported by the DATA Journal. 'Original Paper' (69/116 articles, 60%), 'Practical Paper' (14/116 articles, 12%) and 'Technical Information' (33/116 articles, 28%) were reported by the Journal of JSTE.

Primary Technology Education

There were total of 72/172 articles (42%) related to primary technology education in the DATA Journal, made up 'Research' 33/69 articles (48%) and 'Curriculum Development' 39/103 articles (38%). In addition, no article for primary technology education was contributed in the Journal of JSTE because technology education was not a subject in primary school.

Classification and Contents

Table 1 indicates 'Classification' and 'Contents' of an article in both the DATA Journal and the Journal of JSTE. In this table, 'Contents' classified by 5 types: These were 'Development', 'Investigation', 'Analysis', 'Concept' and 'Practical Report'. In 'Research' as a classification in the DATA Journal, most articles were 'Investigation' and 'Analysis'. As to 'Curriculum Development/Curriculum', most articles were 'Practical Report'. In spite of several Practical Reports in the Journal of JSTE, many articles were 'Development' and 'Analysis'. In JSTE, this main reason for this is that there are many chances for the reviewers to evaluate papers characterized by 'Investigation' and 'Analysis' as one of the contents.

Classification and Approach

Table 2 indicates 'Classification' and 'Approach' of a study in both the DATA Journal and the Journal of JSTE. In this table, 'Approach' divided into 7 types. In 'Research', most approaches of articles were classified 'Inquiry-Clarifying' and 'Analysis of the Actual Condition'. In the Journal of JSTE, most articles were 'Development-Presentation' and 'Inquiry-Clarifying' Under 'Curriculum Development', 'Development-Presentation' was in the majority in the Journal of JSTE. However, 'Development-Presentation' means curriculum development in the DATA Journal. In the Journal of JSTE, 'Development-Presentation' means development of 'materials for making artifacts'. From the viewpoint of concept of 'Development' it is important to not a difference between the DATA Journal and the Journal of JSTE.

Classification and Construction

Table 3 shows 'Classification' and 'Construction' of each article in the DATA Journal and the Journal of JSTE. In this table, 'Construction' was categorized 10 types. In 'Research', most articles were Type C and Type D. In 'Curriculum Development / Curriculum', there were many articles that dealt with curriculum and practice as Type G, F, I and J. In the Journal of JSTE, however, there was no article classified in those. In type E and F, the articles about teaching materials have separated from a curriculum research.

Figure 1

			Contents		
Classification	Development	Investigation	Analysis	Concept	Practical Report
Research	1 (3%)	14 (42%)	16 (49%)	2 (6%)	0 (0%)
Curriculum Development	1 (3%)	1 (3%)	6 (15%)	1 (3%)	30 (76%)
The Journal of JSTE	51 (44%)	17 (14%)	42 (36%)	1 (1%)	5 (5%)

Table 1 Classification and Contents

Figure 2

				Approach			
Classification	Theory Application	Hypothesis Inspection	Problem Conquest	Development Presentation	Analysis of the Actual Condition	Inquiry Clarifying	Classifying Literatures
Research	0 (0%)	0 (0%)	0 (0%)	2 (6%)	10 (30%)	15 (46%)	6 (18%)
Curriculum Development	1 (3%)	0 (0%)	0 (0%)	23 (59%)	8 (20%)	7 (18%)	0 (0%)
The Journal of JSTE	9 (8%)	3 (3%)	4 (3%)	46 (40%)	13 (11%)	35 (30%)	6 (5%)

Table 2 Classification and Approach

Figure 3

		Classification	
Construction	Research	Curriculum Development Developmental	The Journal of ISTE
Type A Introduction – development – conclusion	0	0	14
Type B: Introduction – theory – experimentation – conclusion	0	0	4
Type C: Introduction – method – result – discussion – conclusion	16	0	50
Type D: Introduction – description – conclusion	16	7	16
Type E: Introduction – teaching material – experimentation – conclusion	0	0	15
Type F: Introduction – teaching material – practice – conclusion	0	0	16
Type G: Introduction – practice – conclusion	0	13	1
Type F: Introduction – practice – discussion – conclusion	0	3	0
Type I: Introduction – curriculum – conclusion	0	9	0
Type J: Introduction – curriculum – assessment / discussion – conclusion	1	7	0

Table 3 Classification and Construction

Curriculum Development

Table 4 reflects the type of institution of authors who contributed to curriculum research in 'Curriculum development / Curriculum'. The institutions of authors were Primary school 5 (31%), University 4 (25%), others 4 (25%) and unknown 3 (19%). One of 5 primary school teachers was the principal. Two of 5 articles written by them were researches for school – based curriculum development written by some staff. In addition, 3 articles were reported by single teachers responsible for Design and Technology. In 3 articles, the process of research for curriculum was'designing – practice – reflection / assessment – development'. This process was different from practical educational research in the Journal of JSTE.

In the DATA journal, the aims of the research reported by universities were to introduce a curriculum for the development of design skills, or to clarify design process. However, no university researcher reported using a model of 'Research-Development-Diffusion'.

Judging from the above, primary school teachers rather than teaching staff of universities published papers on school-based curriculum development. A teaching staff training project was reported by a principal of primary school, as mentioned above, and some articles gave weight to staff cooperation.

Collection of data

Table 5 indicates the method of data collection related to 'Research' and 'Investigation' (all 14 articles) in the DATA Journal. As this result, most methods of data collection were 'Questionnaire' and 'Observation'. It is likely that the reason of this result was an encounter with 'Constructivism'. A large number of studies were used qualitative data rather than quantitative data. Many articles used 'Questionnaire' method of collection for quantitative data. In the method of data analysis, frequency and percentage were used rather than any statistical method. This may have been more convenient.

Table 4

Institution	Number
Primary school	5
University	4
Others	4
Unknown	3

Table 4 Institutions of Authors

Table 5

Method	Number
Questionnaire	6
Observation	5
Interview	2
Portfolio	1

Table 5 Methods of data collection

Implications

Were there differences between U.K. and Japan in methodology for technology education?

In Japan, most articles on teaching materials were separated from a curriculum study. In the Journal of JSTE, most articles have dealt with the development of 'materials for making artifacts'. This tendency was shown in the construction of articles of the form; 'introduction – teaching material – practice – conclusion' and 'introduction – teaching material – experimentation – conclusion'. In the UK, however, research for teaching materials has included some integrated aspects of curriculum research. In other words, some research for technology education did not consider the relationship between the subject's contents and teaching materials. This tendency was shown in 'designing – practice – reflection/assessment – development' as the process of research for curriculum development. In this respect, there were large differences of methodology of practical research for technology education in U.K. and Japan.

In general, there were two curriculum models, the one was the model of 'Research – Development – Diffusion' as a method of curriculum development. The other was 'Practice – Reflection – Development' (SATO, 1996). The question now arises: why has research for teaching materials been separated from curriculum study? There are several reasons for this question. The main reason is the 'Japanese misconception of the curriculum'. In Japanese technology education, most teachers and researchers have studied the curriculum from the viewpoint of 'curriculum users' who have followed the statutory Japanese national curriculum. In other words, they did not have the viewpoint of 'curriculum developer'. Therefore, they have focused on 'How should teachers teach?' rather than 'What and why should pupils learn?' The context is such that there is a focus on developing 'materials for making artifacts' rather than for 'curriculum development'.

Why were there so few Curriculum researches for technology education in Japan?

Japanese people recognise specialists in engineering and agronomy but not those who specialize in general school education at the primary and secondary levels. Thus, most Japanese technology researchers has become specialist engineers or agronomists rather than majoring in pedagogy. As there has been little researcher on a technology curriculum, most technology teachers and researchers did not have the viewpoint of 'curriculum developer'.

Conclusion

This study compared the methodology of research for technology education in U.K. and Japan. Our study was summarised as follows:

- There were many articles for 'curriculum development' in the DATA Journal. In the Journal of JSTE, most articles dealt with development of 'materials for making artifacts' and used a model of 'Research – Development – Diffusion' as an approach for study
- The cause of the serious problem in Japan is 'misconception of curriculum'. In Japanese technology education, most teachers and researchers did not have the viewpoint of 'curriculum developer'. Thus, it was difficult for them to study the technology curriculum
- In the DATA Journal, some research for school-based curriculum development was contributed by primary school teachers. Teaching staff training projects were reported by principals of primary schools, and, as mentioned above, some articles gave weight to staff's cooperation and leadership.

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Design and Technology curriculum from birth to age 11: A new design to meet both local and global contexts

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Introduction

As the field of design and technology (D&T) continues to grow and yield its rewards, so it is no less vulnerable to the change agendas which manifest themselves in education systems across the world. In reporting some of the issues, debates and considerations underpinning a particular development in D&T education, this paper describes some of the challenges encountered in trying to achieve a quality and futures – focussed curriculum design. While this paper presents overall curriculum design, a complementary paper (Keirl, 2001), gives further detail as well as outlining a key innovation in D&T.

Background to the South Australian Curriculum Standards & Accountability (SACSA) Framework

SACSA (DETE, 2001a & b) was originally commissioned by the South Australian Department of Education, Training and Employment (DETE), Catholic Education South Australia (CESA) and the Independent Schools Board (ISB) of South Australia in 1999.

SACSA provides the State's first coherent curriculum framework from Birth – Year 12. It builds on current good practice and frameworks (DECS, 1995; AEC, 1994a&b). These latter resulted from the first national agreement amongst the Australian States' and Territories' Ministers of Education in 1989. SACSA has also built on the accord of the more recent Ministerial summit (MCEETYA, 1999) in which there continue to be eight 'learning areas' (these are not subjects) one of which is Technology.

The development of SACSA took account of global and local contexts with particular attention to:

- The need for curriculum and pedagogies to be dynamic
- The centrality of an ethical dimension for curricula in changing times
- The fact that communities and societies no longer exist in isolation
- Calls for the creation of an international educational community (Delors, 1996)
- Constructivism as its theoretical underpinning.

Key foci

It is worth noting some key foci: Learning through Essential Learnings (EL's) with a constructivist basis. These Learnings are described as the understandings, capabilities and dispositions which are developed through all Learning Areas. Also, 'They are resources which are drawn upon throughout life and enable people to productively engage with changing times as thoughtful, active, responsive and committed local, national and global citizens.' (DETE, 2001b:7). The five EL's are:

- Futures – developing optimism to contribute to shaping preferred futures and capabilities to critically reflect on, and act on, shaping preferred futures
- Identity – developing a sense of personal and group identity and capabilities to contribute to, critically reflect on, and take action to shape relationships
- Interdependence – developing understandings of being connected to their world and capabilities to contribute to, critically reflect on, and take action to shape local and global communities
- Thinking – developing a sense of the power of creativity, wisdom and enterprise and capabilities to evaluate and generate ideas and solutions; and
- Communication – developing a sense of the power and potential of literacy, numeracy and information and communications technologies (ICT's).

Coherence in the Framework

SACSA is a curriculum framework. Its intention is not to prescribe programmes for educators but, rather, it respects and fulfils the role of the professional educator and facilitates local community-based interpretation. In line with its constructivist premise, it is holistic in nature.

Equity

Another common aspect which contributes to the holism and coherence of the SACSA Framework is a commitment to the belief that education is a major factor in the creation of a more just society. Thus, …consistent attention is paid to the centrality of (seven) equity perspectives… (DETE, 2001b:18)

In its consideration of Aboriginal and Torres Strait Islander peoples' perspectives, SACSA makes this statement:

The SACSA Framework and Reconciliation – The official curriculum is always an artefact and process of its time. The SACSA Framework is being implemented during a unique and significant period of reconciliation between Indigenous Australians and other Australians. The SACSA Framework consciously and systematically reflects this moment in time by requiring all educators to incorporate Aboriginal and Torres Strait Islander peoples' perspectives in their curricula and pedagogies. (DETE, 2001b:20)

Enterprise and Vocational Education (EVE)

Embedded in the Framework, from age five, are seven (nationally agreed) Key Competencies (KC's).

The structure of SACSA

The teaching, learning and assessment within the Framework are organised across four Bands which articulate the notion of progression. The span of knowledge, skills and dispositions associated with learning from Birth to Year 12 is described as the Curriculum Scope. It is organised into eight Learning Areas which have been transformed from their current make-up by the interweaving of the EL's, Equity Perspectives and EVE. Such is the *design that it is anticipated that educators such as those in D&T will, in turn, create similarly interwoven learning experiences for children and students. Learning Areas for children from Birth – Age 3 are: the psychosocial self; the physical self; and, the thinking and communicating self. From Year 3 onwards D&T gains identity – as it has held for a decade or so in South Australia. 'Young children bring a range of technological experiences and capabilities to early childhood settings.'* (DETE, 2001b:Early Years p58).

The R-12 Learning Areas are structured and organised through strands – the nature of which was a matter of considerable debate for D&T. Key Ideas comprise the fundamental concepts of a Learning Area, or strand of a Learning Area, and they develop in complexity across the Bands. Each Key Idea is presented with examples of the kinds of learning it might embrace along with notation of the particular EL's and KC's that permeate it.

The Standards represent the expectations held of all learners. *They provide a common reference point for educators to use in monitoring, judging and reporting on learner achievement over time. The Standards draw attention to particular aspects of performance (my emphasis) which are significant along the continuum from Birth – Year 12…* (DETE, 2001b:26 – 27)

With each standard come outcomes which describe what will be observed or inferred through a student's engagement with the curriculum scope, and examples of evidence, which represent qualities of performance which suggest the child or student has achieved the particular standard.

D&T in SACSA

Part of the design process involved the establishing of the Technology Experts Working Group (TEWG) which comprised 18 representatives from all levels and sectors of education and seven professional associations. This group, whose role was to provide advice which was ultimately passed to the curriculum writers, wrestled with many issues. Key considerations included:

- Revision and refinement. Revision was taken literally as looking again at progress and problems encountered during six or so years with the Statement and Profile (AEC,1994a&b). Refinement was twofold – qualitative to reduce complexity and build on established good practice, and quantitative, to reduce the numbers of strands and outcomes
- Allowing for local (demographic/community) curriculum interpretation and construction while meeting the SACSA design requirements outlined above
- Catering for the wide range of knowledge interests within the Learning Area – early – primary-secondary; hands-on-hands-off; ICT's; tradition; etc; and
- Initiating change that was not to be so radical as to burden the profession.

Technological literacy in SACSA

It was clear that the goal of a technologically literate society is a highly desirable one. However, this begged the important question of what might constitute technological literacy. The following elaboration emerged:

- Technological literacy can be viewed as having three dimensions, all of which are equally valid and important. All students benefit from all dimensions of technological literacy and must not be constrained in their learning to one aspect alone. The three dimensions are:
  - the operational, through which students develop skills and competencies at a technical level to use materials and equipment in order to make products and systems (they learn to use and do);
  - the cultural, through which students contextualise their learning in the world of designed and made products, processes and systems. They recognise the interdependence of technologies with people….and they apply their technical learning in practical ways to realise designs and solve practical problems (they learn through technology); and,
  - the critical, through which students are empowered to take a full and critical role as autonomous citizens in technological societies. They are able to make refined judgements about the worth of the intentions and consequences of technological products, processes and systems on themselves and others… (they learn about, and to be with, technology). (DETE, 2001a,b)

Revision, refinement and the strands issue

Pre-SACSA, Technology Education was organised around four interdependent 'strands' which ran through eight levels. In common with all Learning Areas, these strands were described as 'process' or 'content' strands. The process strand of 'Designing, Making and Appraising' (DMA), was central to all technology activity, and three content strands of 'Information', 'Materials' and 'Systems' were applied according to the curriculum being taught. While D&T in early childhood centres and Technology in primary schools had been broadly welcomed there had been mixed acceptance in the secondary sector.

The cross-curricular and the cross-sectoral

The requirement to incorporate the cross-curricular perspectives and the EL's was welcomed by the TEWG and the writers. There is natural correlation between these and best D&T practice and there is ready compatibility and synergy. Although the TEWG would have also preferred a strong ethical dimension to be explicit, this was facilitated as the Key Ideas and Standards developed.

For primary educators faced with organising learning across at least eight Learning Areas, refinement was paramount (although the existing D&T curriculum was credited with being one of the easiest to work with). Other concerns lay with the secondary sector where representation of 'subjects' was seen as important. This issue centred on two assumptions – first, that such 'subjectification' is necessary because of content difference and, second, that subjects must each have their own (named) place in the framework. There have been in the past, and there remain, 'subject' pressures from the secondary sector to influence primary curriculum.

The recognition that D&T is essentially a doing field provided the vehicle for a number of key developments, not least that content variations could affirm their home under common process while still maintaining their integrity. By focussing on process in re-designing the field, primary cross-curricular integration is further facilitated and a (potentially) unifying curriculum umbrella provides shelter for the secondary players.

Strand refinement

The refinement of the strands led to there being three, not four, and verbs being used to emphasise process and action in the Learning Area. In turn, there has been a potential reduction in Outcomes from 80 to just 30 across the years.

Since the TEWG valued highly any technology curriculum refinement that embraced ethical and futures perspectives, design, particularly in its senses as 'choice' and as 'intention', was confirmed as a powerful vehicle for this. Design is seen as central to technological activity. Both past best practice and perceived curriculum futures saw designing as a worthy strand. Further, making, although somewhat stereotyped towards certain types of manufacturing activity, was confirmed as another fundamental of the field.

It was recognised that much valuable D&T learning can be generated through the deconstruction, physical and otherwise, of designed and made products, processes and systems. Students have much to gain from finding new ways to question, and make new meanings about, the built world around them. These considerations, along with those concerning technological literacy, brought about the formulation of a new strand entitled 'critiquing'. This innovation is developed fully in the complementary paper presented to conference (Keirl, 2001).

The final model is a three-strand arrangement of critiquing, designing and making (CDM). It is their interdependence that gives the framework its rigour and symbolises the necessary holism of quality D&T Education.

Key ideas: the fundamentals…

While the Key Ideas are the basis for the standards and outcomes, they were themselves shaped by a blend of experience of best practice, the overarching SACSA design requirements and perceived D&T education futures. The D&T Key Ideas for all school years are portrayed in Table One. This illustrates both progression across the Bands and the inter-relationships across the strands. The relative composition of the strands is also evident. It should be noted that D&T learning in the Early Years phase Age 3 – 5 is also expressed through Key Ideas. There are three:

- Children examine, identify and critique processes, products and systems
- Children use their imagination to generate ideas and participate in the processes of design
- Children use materials equipment and processes to design and develop products and systems.

The naming of the Learning Area…

This matter was discussed rigorously and matters of currency, definition, semantics, politics of meaning, public perception and image were all debated. Space does not allow elaboration here however the outcome was to move from 'Technology' to 'Design and Technology'.

Conclusion

The design brief for SACSA was multifaceted and the journey to its resolution a blend of challenge and complexity. To accommodate all variables and, yet, arrive at a refined D&T curriculum is one achievement. However, take-up is the next challenge. Whether school administrators and D&T educators share the vision and commitment to make it all happen will depend on many factors. As each of the Band Introductions states:

- The Design and Technology Learning Area aims to develop in all students:
  - ethical, critical, enterprising and futures dispositions towards their own and other people's designed and made products, processes and systems
  - capacities to identify and critique the values underlying the intentions, design, manufacture and consequences of any technology
  - capacities to consider and respond to the needs of diverse cultures in relation to developing technologies
  - broad-ranging design skills to create innovative solutions to design briefs and problems
  - broad-ranging techniques for manipulating materials to create products, processes and systems including Information & Communication Technologies
  - skills in communicating their thinking, ideas and plans for products, processes and systems
  - capacities of responsible management and duty of care towards themselves and others when designing, making and using

– capacities to apply their design and technology learning to other Learning Areas, to life in the wider community, virtual community, and in accessing further education and training. (DETE, 2001a,b).

Design and Technology has much to offer young people and society and it deserves greater prominence in any centre or school. The role of educators in the early and primary years is, as ever, central to the success of such curricula. As with all good education, good D&T education goes far beyond the immediacy of self and classroom. It is designed for the global as well as the local and for others as well as for self.

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Table 1			
Early Years Band Years R-2 Ages c5 – 7	Primary Years Band Years 3 – 5 Ages c8 – 10	Middle Years Band Years 6 – 9 Ages c11 – 14	Senior Years Band Years 10 – 12 Ages c15 – 17
Strand: Critiquing			
• Children develop understandings about people, diversity and the technological world, and they learn to question by assessing their own and others' products, processes and systems **T** KC1	• Students identify relationships between people, diversity and everyday products, processes and systems. They identify design characteristics which shape, and are shaped by, these relationships and suggest why the particular design criteria may have been used **In T** KC1 KC2	• Students analyse and explain the design decisions and thinking implicit in products, processes and systems made by themselves and others. They develop an initial understanding of the contestable nature of the designed and made world. **In T** KC1 KC2	• Students deconstruct technologies in order to expose the values which lie behind the intentions, design and manufacture of products, processes and systems. They critically examine the consequences of past technologies and speculate on the consequences of present and future technologies and their capacities to shape human existence. F In T KC1 KC2
Strand: Designing			
• Children recognise and use different ways of thinking, planning and preparing that are helpful in achieving and presenting their designs. They learn that by designing it is possible to effect change. **F T C** KC1 KC2 KC3 • Children use different strategies, including using a range of technologies, for successfully reflecting on, communicating and expressing to others their design ideas and thinking. **Id T C** KC1 KC2 KC6 KC7	• Students learn a range of specific design skills, which help them to design more effectively and develop their thinking and capacity to effect change. **F T** KC3 • Students reflect on their own work by clarifying and communicating their design ideas, and their thinking and planning for products, processes and systems. They use effective design methods, including appropriate digital and electronic technologies. **T C** KC2 KC7	• Students understand and value the combining of different design skills in order to create personal strategies strategies to become better designers of culturally, environmentally and socially defensible products, processes and systems **F In** KC6 • Students use a full range of communication skills, including information and communications technologies, to document and communicate effectively their design thinking, ideas and proposals **T C** KC2 KC7	• Students are self-managing designers who bring together experience, self-knowledge and appropriate design strategies to create ethically defensible products, processes and systems Id In T KC1 KC6 • Students communicate their design thinking and proposals effectively, efficiently and at a standard approaching community or industry practices T C KC2 KC3 KC7
Strand: Making			
• Children develop confidence in their capacity to use materials and equipment to make products, processes and systems and, in so doing, reflect on how they work. **T** KC1 KC6 KC7 • Children analyse and explain the uses and potential of equipment and materials. They recognise that a range of resources can be used to accomplish their ideas and to (re)shape their world. **F C** KC1 KC2 KC7 • Children analyse the importance of organisation and safety rules in order to use resources well and to consider the personal and social responsibilities involved when working with others. **In C** KC1 KC4	• Students learn techniques and demonstrate competence in using a broad range of materials and equipment for making products, processes and systems. They reflect on how they work with the equipment and materials they use and, in so doing, improve their practice. **Id T** KC7 • Students identify, explain and value the characteristics and uses of a range of materials and equipment. They use this knowledge when critiquing their own and others' designs for products, processes and systems. **In C** KC1 KC2 • Students understand, give reasons for, and manage resources responsibly and effectively, and work in ways which respect diverse personal and social identities. **Id In** KC3 KC7	• Students demonstrate skills in creating products, processes and systems that achieve consistent production outcomes. They apply these skills in enterprising and empowering ways to personal and group situations. **In T** KC4 KC6 • Students apply their knowledge of the characteristics of materials and equipment when creating solutions and designing to meet criteria related to function, aesthetics, sustainability and production. **F In** KC3 KC6 • Students describe and communicate principles of good resource management and duty of care, and integrate them into socially and environmentally sustainable designing and making practice. **F In** C KC2 KC3	• Students demonstrate skills that empower them creatively and independently to solve problems involved in making sophisticated products, processes and systems which approach community and industry standards. Id In T KC6 • Students make discriminating and responsible use of materials and equipment to create sustainable products. They use the knowledge gained to conceptualise, communicate and act for more ethical resource use in the wider community. F In C KC2 KC7 • Students manage their designing and making activities independently, successfully and with sensitive duty of care in their interactions with others. They are able to transfer this knowledge to new contexts and situations. F Id In KC4

Table 1 D&T: Key Ideas – Essential Learnings: Communication C, Futures F, Identity Id, Interdependence In, Thinking T and Key competencies KC1 – 7

Critical beginnings for Design and Technology education – why and how might critiquing be a key component of children's learning in the Early and Primary Years?

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Introduction

The recently developed South Australian Curriculum Standards and Accountability (SACSA) Framework (DETE, 2001a&b) is currently in its implementation phase (fully so for 2002). The redesign of the design and technology (D&T) component was a rich and challenging experience for all concerned. This paper describes the rationale and thinking behind the innovative strand of 'critiquing'. It also presents discussion of some pedagogical issues and detail of the kinds of learning anticipated for children aged 3 – 11.

A complementary paper (Keirl, 2001), giving more comprehensive description of the overall curriculum design, has also been presented to conference.

A place for critiquing in education

Apart from whatever critiquing might mean to D&T itself, there is a strong argument for its exploration as a component of general education – that which we would give all children and students in the compulsory years.

The case for encouraging such traits as critical thinking comes with the notion that a truly healthy democracy needs not only critics and sceptics as gadflies on the backs of 'experts' or those elected but, also, that a climate of critique and challenge amongst all participants is essential too. Such a climate facilitates and encourages free speech and tolerance but also raises levels of awareness and debate and empowers participants in democratic life.

If students are to engage in such a climate then any education that engenders reasoning and the interrogation of concepts, arguments, lifestyles, technologies, systems or whatever shapes our co-existence now and for generations into the future across the planet, will need a critical dimension – one which is actively, not passively, critical.

One author whose focus is 'critical thinking' (Paul, 1995) draws on Sumner's (1906) writings:

The critical habit of thought, if usual in a society, will pervade all its mores, because it is a way of taking up the problems of life. Men (sic)…are slow to believe. They can hold things as possible or probable in all degrees, without certainty and without pain. They can wait for evidence and weigh evidence, uninfluenced by the emphasis or confidence with which assertions are made on one side or the other. They can resist appeals to their dearest prejudices and all kinds of cajolery. Education in the critical faculty is the only education of which it can be truly said that it makes good citizens. (Sumner, cited in Paul, 1995:526)

We might argue that a 'good', and therefore democratic, curriculum design would be empowering for students, it would expand their understandings, knowledge, reasoning and even help them build a repertoire of critical strategies. Apart from any societal goals we might hold, these traits are personally invaluable for children and students. However, it seems to be the case that we manage not to create the right climate to cultivate such traits.

Appropriate curriculum, appropriate pedagogy…

Boomer (1999a:127) asks the question, 'To what extent has teaching in Australia changed over the past one hundred and fifty years?' In doing so he sets out to explore the joint issue of curriculum and pedagogy and it is the interdependence of these two phenomena that matters. Curriculum may be designed and redesigned but without new approaches by educators that which Boomer terms 'pedagogical inertia' renders innovation inoperable.

Part of the solution undoubtedly lies with how children and students are viewed and positioned by education systems. Curricula such as SACSA, espouse the empowerment of the individual and recognise that, for example:

Formal educational institutions no longer have the dominant role of knowledge generation and transmission in our society. As knowledge is 'democratised' through being generated and dispersed in multiple and increasingly accessible ways, …it is no longer sufficient to acquire new knowledge. It is just as important to have the capability to manage it, including the capability to bring critical understandings to bear on the selection and analysis of information and to understand the power of knowledge, the potential for both its positive and negative use, and the importance of ethical inquiry and action. (DETE, 2001b:5)

As Boomer also points out:

We urgently need to transform our teaching. We need to change the present balance of 90% transmission / 10% constructivism (a rough hazard on my part, which will no doubt be contested in the field) to 90% constructivism / 10% transmission…

…John Dewey laid out for us what a constructive/productive school would look like, one hundred years ago…We need to develop ways of removing the structural barriers to constructivism and then, as a society, insist on teaching which enhances rather than contains brain power. In this regard teachers must themselves be what Henry Giroux (1981) has called 'transformative intellectuals' – questioners, learners, constructive critics of the status quo. (Boomer, 1999b:78 – 79)

It can be said that we are all victims of our own education and, for some, breaking the perpetuity of the transmissive model may seem difficult. If we needed further reason to do so it is available from one historical perspective. Postman (1999) has drawn parallels between the issues and developments encountered during the Enlightenment years and those with which we are faced today. So far as education is concerned, he suggests three 'legacies' from the late 18th Century, the third of which is:

…the idea that a 'proper education' must have as one of its goals the cultivation of a skeptical outlook based on reason…Indeed, if the question is posed, What is the principal mind-set associated with the Enlightenment?, the answer would certainly be – skepticism. Modern educators do not usually use this word, preferring something like 'critical thinking'. But in any case, they do not do much about it. (Postman, 1999:159 – 160)

The place of critiquing in a new D&T curriculum

All of the authors cited, with their historical perspectives, have democratic practice and futures at heart. They all offer a home for the powerful notion of critique and criticism and for the benefits for society and individual alike. How then, does this sit with design and technology curriculum design?

In outline, SACSA takes constructivism as its theoretical basis and it embraces several foci, notably: its organization through Learning Areas across four Curriculum Bands; the interweaving of five Essential Learnings (Communication, Futures, Identity, Interdependence, and Thinking); a range of equity perspectives; and, enterprise and vocational education articulated, in part, through seven Key Competencies. Each Learning Area, of which D&T is one, is delivered through Strands and has its fundamental concepts expressed as Key Ideas, from which are drawn Curriculum Standards with Examples of Evidence.

D&T is delivered through three interwoven strands – Critiquing, Designing and Making – and for each Band these have, respectively, one, two and three Key Ideas. These are grounded in a particular construction of technological literacy comprising three dimensions: the operational; the cultural; and, the critical.

While the Strand of critiquing clearly has a strong relationship with the critical dimension, one can also see the role of critiquing in both the operational and the cultural dimensions. Considered and defensible judgements are needed here too. As Paul, referring to critical thinking in general, puts it, 'Critical thinkers critique in order to redesign, remodel, and make better.' (Paul, 1995:526).

The sense of critique as noun is well established especially in such fields as the arts. However, its use as verb in D&T sits uncomfortably with some. Indeed, this use was questioned during the drafting of SACSA. Nevertheless, it is a word that can be rich in meaning and has common roots with similar words and phrases. The action of criticising or passing judgement is highly applicable in D&T education as well as in life at large. It is something of value to be learned and to contribute to learning.

Walton (1992) argues that one might think of critiquing as torment, as opposition or as being supportive or empathetic. Genuine criticism is far from its polarised, and commonly misunderstood, sense of negative comment. It is bound up with reasoned opinion both inwardly and outwardly expressed. Critiquing can be seen as a way of doing or acting as well as a way of thinking. As Postman (1999), implies, the phrase 'critical thinking' is often used glibly as a catchcry for something desirable to happen in the classroom when the fact is that the thinking being engaged is anything but critical. Critiquing and critical thinking demand discomfort – discomfort in the mind of the thinker who, temporarily, displaces matters to look at them in different ways.

In fact, being uncomfortable with designs and technologies in our lives is something with which we are familiar but which we are ill-prepared to articulate. However, the discomfort of critiquing can also apply elsewhere – to the teacher who moves from being transmitter of knowledge to 'transformative intellectual' or, ultimately, to the social and political world beyond. A vital democratic society is one which embraces the discomfort of the critic rather than living by platitudes or, worse, suppressing criticism and marginalising those who criticise.

In its de-constructive sense, critiquing is taking things apart. However, critiquing is most usefully conducted in purposeful ways – a matter of deconstruction rather than destruction. The disassembly, dismantling, deconstruction or analysis of something may achieve no more than an exposure of the total components. However, judgements made when critiquing will expose the values and intentions behind designs, the hidden consequences of the use of technologies and the relationships between people and technologies. This offers another way of seeing, judging and living in the designed world.

Thus, critiquing is seen as a natural component of a quality design and technology education. Just as making and designing each are empowering educational enterprises for children and students, so critiquing, too, facilitates new learning, new meanings and new understandings. Together, critiquing, designing and making position learners to explore 'what if's', to apply creativity, to test reality and to contemplate ethically defensible futures.

In his concluding chapter on education, Postman argues that a 'major problem' facing democratic life today is that of 'How do you teach reason and skepticism?'. He offers five suggestions as his solution to this problem. And the fourth of these…? Technology Education (Postman, 1999:170).

Scepticism, too, has its place in our field. What better tool for checking one's own and others' designs? What better tool for helping establish uncertainty – albeit, optimistic, educated uncertainty, in a field which for too long now has claimed to provide 'solutions' while it fact it continues to create problems? It is, perhaps, that which is uncertain and unstable that will provide some depth for a dynamic curriculum.

Design and Technology	Strand: Critiquing
Band & Key Idea	Learning
Early Years Band – Age 3 – 5 Phase Children examine, identify and critique processes, products and systems. In T C KC1	Learning involves children: • being curious, asking questions, locating information and seeking clarification while exploring a technologies T KC1 KC6 KC7 • having opportunities to dismantle and reassemble T KC6 • experimenting with tools, processes, products and systems T KC6 • articulating and reflecting on the processes used in achieving a design goal T KC1 KC2 • reflecting on and accepting constructive feedback in order to modify ideas and processes T KC1 KC2 • identifying problem-solving alternatives to their own or group processes and products In T KC6 • demonstrating respect for the ideas, processes and products of others. In
Early Years Band Years R-2 ages c5 – 7 Children develop understandings about people, diversity and the technological world, and learn to question by assessing their own and others' products, processes and systems. T KC1	This includes such learning as: • sharing feelings and ideas about designs and technologies, by taking and using digital images to support opinions T C KC2 KC7 • appraising what they have made against their initial intentions T KC1 • telling others how they feel about what they have done. Children build a sense of accomplishment and self-understanding and develop confidence in communicating, using digital and electronic technology in presenting an idea to a wider audience Id C KC2 • collecting and analysing information (data) and expressing thoughts about the consequences that designs and products can have on people's lives past, present and future F In C KC1 KC2 • making judgments about products, processes and systems in order to identify patterns, connections, consequences and issues that impact on the present and can relate to their futures F In T KC1 • imagining future products and designs that would be personally, socially and environmentally useful, and providing a justification for them F T KC6 • understanding that designs and technologies change over time. T KC1 • making appropriate choices about the use of software and virtual tools
Primary Years Band Years 3 – 5 ages c8 – 10 Students identify relationships between people, diversity and everyday products, processes and systems. They investigate design characteristics which shape, and are shaped by, these relationships and suggest why the particular design criteria may have been used. In T KC1 KC2	This includes such learning as: • analysing products, processes and systems (eg cam recorders, search engines, chatroom/E-mail) to give reasons why they are the way they are T KC1 • comparing and contrasting versions of the same kinds of products, processes and systems to categorise common and uncommon features T KC1 • explaining relationships between diverse peoples; occupations; designed products, processes and systems; and natural environments In KC2 • discerning how some products (eg webpage advertising) are designed to appeal to certain groups and not others, and discussing the fairness of these practices T KC1 KC2 • identifying the positive and negative attributes of designed products, processes and systems, and assessing their own preferences and the values upon which these are based Id T KC1 • explaining and reporting on historical, work (paid and unpaid), cultural and social factors in the design of everyday products, processes and systems, and why some are prevalent or dominant in Australian life and others are not In C KC2 • identifying factors that contribute to the concept of quality in products, processes and systems, and understanding that this is largely determined by culture and context. In KC2
Middle Years Band Years 6 – 9 ages c11 – 14 Students analyse and explain the design decisions and thinking implicit in products, processes and systems made by themselves and others. They develop an initial understanding of the competitive nature of the designed and made world In T KC1 KC2	This includes such learning as: • analysing the sources of technologies in relation to the particular values, intentions and interests of individuals, occupations and organizations. Students construct arguments on related issues In T KC1 • appraising all products, processes and systems for negative attributes (eg cost, resource use, environmental and social impact) and that none is universally beneficial In T KC1 • identifying ways in which issues such as politics, profit, control, regulation, development and research affect technological innovation and application In T KC6 • considering values and attitudes, and analysing the social constructs of gender, class, abilities and culture, with regard to the development and use of technologies, including digital and electronic, locally and throughout the world Id In KC1 • appraising and communicating the importance of ethics and quality of life as dimensions of technological practice for a continuing and more mutually supportive coexistence of all the earth's species and places F Id In KC1 KC2 • making appropriate, responsible and constructively critical examinations of designs and technologies – past, present and future – in order to explain and critique how individuals and groups can be differently empowered F In T KC1

Table 1 Design and Technology: Critiquing: Key Ideas and learning Ages 3 – 11

Design and Technology Strand: Critiquing
Standards 1.1; 2.1; 3.1 with Examples of evidence
At Standard 1, towards the end of Year 2, the child:
Makes judgments about the significance of different characteristics of products, processes and systems made by themselves and others. **T** KC1
Examples of evidence include that the child:
• describes the roles of functional characteristics of specific items of traditional, ceremonial and contemporary clothing from diverse cultures **In T** C KC2
• expresses feelings and preferences for one kind of play equipment over another, with reference to aesthetics and useability, and provides some ideas about the reasons for their preferences **T** KC1 KC2
• critically explores why certain kinds of the same product (eg toys, television advertisements, food, computer games and CD ROMs) may hold more appeal for children, considering needs and purposes **T** KC1 KC2
• identifies and explains commonalities and differences in the design features and materials used in a variety of chairs, and provides conjectures about the reason for those factors **T** KC1 KC2
• recognises that some materials come more or less directly from natural environments (eg timber) and some are produced from natural materials plus a lot of energy (eg concrete and plastic). KC1
At Standard 2, towards the end of Year 4, the student:
Identifies a range of ways in which the design of everyday products, processes and systems is related to those who use them. **In T** KC1
Examples of evidence include that the student:
• describes why each of several significant factors (eg size, shape, strength, purpose) are important for a person buying a pair of shoes **In T** KC2
• explains how factors such as location, occupation, tradition and climate influence the housing design decisions made in a variety of cultures **In T** KC2
• draws up a list of things to think about when buying a gift (eg a case, camera, computer games) for a particular person Id **T** KC3 describes how some computer games are designed to appeal to girls, and some to boys, recognising the influence of the designer in what is available to young people and how choices can be limited **Id In T** KC2
• discusses a variety of products that wear out and a variety that last, in terms of such issues as durability, repair and maintenance.
• They analyse and suggest what this might mean for the products' users and for the natural environments from which source materials are obtained. **In T** KC1 KC2
At Standard 3, towards the end of Year 6, the student:
Describes the significance to diverse groups of people of the various criteria used in the design of particular products, processes and systems. **In T** KC2
Examples of evidence include that the student:
• analyses and reports on the empowering and disempowering design features of equipment and facilities available to people with disabilities **In T** KC1 KC2
• explains why certain colours, styles and materials are used in an extensive variety of clothing for different personal, social, work and cultural contexts **In** KC2
• analyses and reports on the fun, function and safety aspects, and potential for improvement, of the design of different kinds of multimedia technologies that young children use **Id T** C KC1 KC2
• describes the historical, current and potential future relationships between climate, culture, people and resources in the designs of different forms of shelter F **In** KC1 KC3
• explains how particular standards came to be applied to items of sports equipment. They suggest why, using such criteria as fairness, useability, function, size or sex, these standards matter to sports participants. **In T** KC2

Table Two Design and Technology: Critiquing: Standards 1.1 – 3.1

D&T curriculum and pedagogy with the learner at the centre

One of eight D&T aims in SACSA is to develop in all students' …capacities to identify and critique the values underlying the intentions, design, manufacture and consequences of any technology.' (DETE, 2001b:Primary Years, p 35).

These capacities are carried through the Critiquing strand and its associated Key Ideas. Table One presents these and begins to give the picture of how children can develop critical dispositions from an early age. So, a Key Idea is presented and the kinds of learning that can occur are noted. This learning embraces children's curiosity, creativity and imagination which are key contributors to design where proposals for ideas and change can be explored. As well as developing that critical capacity which comes from applying the age-old technological yardstick – Will it work? – children also learn to express to, and receive from, others, opinions of value concerning designs and technologies.

Table Two presents the Standards and the examples of evidence which might be sought. The standard is that point against which a child's or student's performance can be referenced. It is important to note that the examples of evidence are just that – examples and, indeed, ought to be taken collectively as one possible example. (A child's fulfilment of just one of the examples given would hardly be solid grounds for demonstrating learning. Repeated performance over a variety of projects is what is needed.)

The D&T Learning Area is concerned with any technology and the original intention was to write examples of evidence which, if possible, did not specify a particular technology and certainly did not offer such detail that a teacher might take just one to be a model for a project, or the collection as a syllabus. After all, the matter of teachers' professional judgement is central to this curriculum framework and, perhaps of greater import, student – centred learning and growth is not going to be helped if teachers detail the projects to be undertaken. That is hardly a constructivist approach. This is not to deny that some examples of evidence, even Key Ideas and Standards, do present particular technologies but this is a political matter beyond the scope of this paper.

There are notations in both tables. Those in bold indicate Essential Learnings and 'KC'indicates a Key Competency. The notations show which of these is predominantly delivered and enhanced through each particular aspect of the curriculum framework. They offer guidance to teachers in their planning and they bring the interwoven richness and holism to the curriculum – an essential if it is to stand up to the claim to be dynamic, ethical and futures focussed.

Experience has also shown that designing, and the child/student-as-designer, powerfully centre the learning around the individual. It is their design and the associated reasoning and justification for it must be their's too. Why they designed this way and not that is an ingredient of their experiences and education. Critiquing has a clear educational role to play. *'The act of critiquing ultimately involves presenting a defensible case outlining the merits or otherwise of the whole or parts of a product, process or system.'* (DETE, 2001b:Primary Years, p.39).

Conclusion

If design is pro-active, before the product, before the event, then critiquing is reactive – it happens not only after, but because of, the intention, thought, product or event. There are elements of each in the other and so they reflect the dynamics and holism of this vital field of education. Responsible design, ethically audited, has its underpinning intentions scrutinised before it even becomes a design, let alone when it is a manifest product with associated consequences. Responsible criticism is positive and democratic in purpose. It is also ethically grounded. It is neither vacuous nor destructive.

Today's is a world with an ever-increasing positioning of people by designed technologies and systems. It is a world where people, other fauna and flora can now being designed. When a fundamental of democracy is the notion of ethics, which in turn calls for an articulate and (technologically) literate society to engage in ongoing debate, then we need students who can graduate with a sense that they can shape the world and set limits to developments which adversely affect humanity and the planet. This calls for critical thinking of the richest kind.

In 'Learning to be' (Delors, 1996) in this world we, and our students might consider the very nature of being and what it means to be human. It is argued here that critiquing offers (Design and Technology) educational potential to help students understand concepts such as 'democracy', 'person' and 'human' as well as enhancing their potential as young designers and makers. The alternative is increased 'dumbing down', depersonalisation and alienation. These are not components of a defensible technological literacy.

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Teaching Technology in Culturally Diverse South African Classrooms – Discussion and Workshop

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Introduction

South African education is a paradox, 'liberated' from the distortions of Christian National Education, it is still suffering from 40 years of domination by euro-centric culture. Into this milieu Technology Education (DesTech) has been recently imported, drawing on models of technology, which, are essentially Western. In this paper, the problem of how cultural diversity impacts learning dynamics in South African classrooms, is unpacked both from the perspective of learning theory and from the apartheid history of cultural oppression. Approaches to opening up and valuing culturally diverse voices are then discussed with reference to the new Technology curriculum framework, and in particular 'communication' in technology.

The Challenge

It was a university class of 20 Xhosa speaking primary school in-service teachers from a fairly traditional part of South Africa. The teachers were in the second year of their technology re-training diploma. It was part of a 'communication' segment of the course – a conventional topic: 'design and make a message on a card'. The outcome was uniform; 20 versions of Xmas cards, Easter Bunny cards or Valentine cards. There were one or two Mothers Day cards as well! When I expressed my astonishment to one of the teachers privately, she said that the group were thinking of the sort of cards that they see at the high street stationers shop.

Just as 'African Science' educators are critically reflecting on the 'Western' nature of science courses, so technology educators should ask what is a (South) African Technology Education? A start has been made in this country; learning outcomes have been deliberately sketched with a broad pen so as to encourage localisation of curriculum.

Much remains to be done however to engage the challenges of teaching in culturally diverse classrooms. I offer this paper in the belief that these problems may be of concern in other countries. The problem of how cultural diversity impacts learning dynamics in South African classrooms, is unpacked both from the perspective of learning theory and from the apartheid history of cultural oppression. Approaches to opening up and valuing culturally diverse voices are then discussed with reference to the new Technology curriculum framework, and in particular 'communication' in technology.

Cultural Diversity and Learning Dynamics in South African Classrooms

As an analytical tool the term 'culture' is too diffuse, instead the idea of 'world view', as 'an individual's interpretive framework for the articulation of meaning', is perhaps more useful when thinking about learning processes.

Although it is not credible to over-compartmentalise the notion of worldviews, Ogunniyi's (1995) explication of two different worldviews gives some indication of the diversity, which may impact on learning in South African classrooms.

Within a Western world view, knowledge of the impersonal physical world, operating like a machine according to laws of matter in motion, is discovered by the unique rational activity of the human mind, which is concerned to know how rather than why phenomena occur. (Ogunniyi (1995:5).

On the other hand, traditional African worldviews do not hold humans as separate to the physical world,

…to the African the world is full of life …he (sic) cultivates a humanistic relationship with everything found in his environment. The world is not mechanistic but its functioning is understood in anthropomorphic terms. Phenomena and events do not simply occur, they are caused. Causalities can be understood by cosmologies that unite man, resources, ancestors, gods, supernatural and natural forces. Knowledge is not discoverable; it simply exists as …pragmatic, unequivocal, non-testable and non-falsifiable. (Ogunniyi 1995:6).

A key mechanism in the construction of meaning, conveyed within these very different worldviews, is language. Solomon referred to the construction of meaning as a process of:

…interchange, a dynamic during which meanings are chosen from a repertoire of language tools into which the speaker/ hearer have been socialised. (Solomon 1995:15)

Shotter (1995:45) talked of coming to know through a system of representation as language, Gergen (1995) proposed that what one knows as an individual becomes meaningful when it is assented to by others through language. Ernest (1992) referred to communicative processes in the social negotiation of meaning.

Broadly speaking there are two ways that communicative processes can be handled in the classroom. Wertsch (1991) pointed out that in the traditional, transmissive model of teaching the teacher's speech becomes univocal in that it is uni-directional, and dominant. The teacher's meaning is meant to be taken literally, and the purpose of the learners' contribution is simply to master that meaning. This situation sends messages to learners about the `invisibility' of their worldviews, the `inaudibility' of their voices. An alternative multi-voiced dialogue privileges learners' socio-culturally situated speech, thereby nourishing their ability to come to know and act on their own terms. Multi-voiced dialogue allows for the influence of the teacher's voice but provides the space for the learner to play an active role in shaping meaning.

Christian National Education (CNE) – the Dominant Voice in South African Class Rooms

The CNE policy of 1948 was one of the earliest expressions of the dominant, univocal 'voice' of the Afrikaner worldview. In contrast to white learners, over a period of 40 years CNE and its non-white arm, the Bantu Education Act worked to subvert the worldviews of black learners and emasculate their voices. The effect of CNE was the more invidious by claiming to value black culture by insisting that black education operate separately and in mother tongue. In reality black education was set up to fail through marginalisation – giving whites the self-justification for their 'sacred obligation' as 'trustees of the native' to lift him from a state of 'cultural infancy' through Christian principles (Enslin 1986).

The psychological consequences of Apartheid education on black learners (Abdi 1999; Sedibe 1998), are too numerous and complex for this account. What is significant here are the negative consequences of the dominant, paternalistic voice of CNE; internalised by learners through the invisibility of their worldviews and the inaudibility of their voices. Take the case of Umfundisi who started teaching in a black high school in 1991, the height of struggle by black students to throw off the shackles of Bantu Education. Umfundisi was convinced about the importance of teaching students to question and move beyond their positions as passive learners. Despite his good intentions to initiate a multi-voiced dialogue, Umfundisi's methods were not enthusiastically received, as quoted in Constas (1997:16)

…and the pupils said to me: "No sir! No sir, it looks like you do not know it. This question is being thrown to you, you have to answer it!" And my students said, "the teacher is incapable of teaching to us; the teacher cannot teach; we do not want him!"

Facilitating a Multi-Voiced Dialogue – Curriculum 2005

During the apartheid years, the principal challenge to Christian National Education's authoritarian, transmissive voice was 'progressive education,' a form of learner-centred education nurtured in the liberal universities and the English private schools. In the 1980s this progressive approach was linked to an egalitarian transformative project called People's Education, characterized by:

- An egalitarian political mission
- An anti-rote learning, critical thinking thrust
- A learner-centred approach to teaching
- Teachers as curriculum developers
- Group work rather than directive teaching
- Community participation.

In 1990s the main features of this framework survived successive versions of curriculum policy development, through NEPI (1993) and ANC (1994), and they are central to the current fully-fledged model of Outcomes Based Education set out in 'Curriculum 2005: Lifelong Learning for the 21st Century' (DOE 1997).

Outcomes – Based Education (OBE)

Because of its genesis in the struggle for liberation, equity and justice, Curriculum 2005 predictably has a strong transformatory character. Precedents can be found in the ANC's education policy framework (ANC 1994), which condemned the curriculum under apartheid as one, which has 'perpetuated race, class, gender and ethnic divisions'. The framework noted that one consequence has been 'the marginalisation of some forms of knowledge, such as the cultural and life experiences of the majority of our people', and called for a curriculum that would accommodate the cultural and local differences and needs of learners.

Bringing on to the educational agenda forms of learning based on learners' 'cultural and life experiences' is made possible by the structure of Curriculum 2005 through its outcomes-based design-essentially a distinction between Inputs and Outcomes. Outcomes are prescribed through central policy, while Inputs are discretionary, and generated locally. Outcomes condition the nature of Inputs by placing technical, constitutional, social, critical thinking and cultural concerns onto the educational agenda. By gaining control of Inputs, teachers and learners are empowered to table, their own particularities and priorities.

In contrast to the narrow circumscription of CNE, Outcomes in the new OBE curriculum clearly have the potential to liberate the process of learning. If we as Technology educators wish to enrich our practice by opening up and valuing culturally diverse voices, then the creative space can be found in the Technology Specific Outcomes.

The potential for a multi-voiced dialogue that privileges learners' socio-culturally situated speech, is apparent in all seven Technology Specific Outcomes. In the following list examples of types of questions that could be raised in this regard are in italics):

- Understand and apply the technological process to solve problems and satisfy needs and wants. (Can something be a need for this person and a want for another? What do you think are challenging problems for us to solve?)
- Apply a range of technological knowledge and skills ethically and responsibly. (Can the same action be ethical and unethical in different contexts? Can technologically responsible action be irresponsible in a different circumstance?)
- Access, process and use data for technological purposes. (Is data from one culture more valid than another? What forms of data are acceptable?)
- Select and evaluate products and systems. (What kind of product is acceptable for evaluation? Can we separate technological and social considerations when evaluating systems? What evaluation criteria are important to you?)

- Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems. (What is the history and current use of technology in your culture? How do you value technologies that are traditional to your culture?)
- Demonstrate an understanding of the impact of technology. (What are some of your own cultural activities that have been changed for better or worse by technology? If technology is changing your customary activities, what do you feel about that?)
- Demonstrate an understanding of how technology might reflect different biases and create responsible and ethical strategies to address them. (Do you see the same technology benefiting some people and harming others?)

So far we have been talking of the potential in the Technology curriculum for teaching in ways that are sensitive to cultural diversity. However all is not well in this regard for two reasons.

Last year a review committee report on Curriculum 2005 was commissioned, because of concerns that OBE was being implemented in an inconsistent and often ineffectual way. The commission noted that:
The success of OBE depends centrally on the quality of the teachers – their content knowledge, their facility with different teaching methods, and their access to learning programmes and textbooks. (DOE 2000:29)

The commission indicated that far too many teachers are inadequately prepared to cope with generating their own inputs.

Secondly, in the many instances across South Africa, where OBE Technology is being put into effect, there is a strong tendency to what Olsen (1997:387) called a technicist orientation. He challenged teachers to 'embrace the cultural and moral context of making things' to 'lead us back to where we live and how to live better'.

Oral Culture and Technology Education

Olsen's (1997) suggestion that Technology learning should occur in a cultural and moral context, was engaged by Jegede (1998:165) in the context of African Science and Technology education – 'to make learning meaningful, there must be an integration of science knowledge with the learner's world view'. Unlike the Western scientific worldview, which is abstracted from cultural reality, Jegede thought that African worldviews are conditioned by rural and oral culture.

This claim may be surprising in the rapidly urbanizing South African context, but the vigorous participation of urban Africans in orally mediated ceremonies such as 'initiation into manhood' tell another story. Why is it that we can see encampments of young men in the center of our cities maintaining, in the most incongruous urban circumstances, age old rural practices? Whose voice is being heard and how, during this intensive learning process that may last for several weeks? Jegede pointed to several African instructional strategies applicable in such circumstances that could be brought into the classroom; role-playing, story telling, songs and dance, ceremonies and rituals.

A Multi-Voiced Dialogue in Practice

The thematic organisers designated for the primary OBE curriculum combine well with one or more of Jegede's orally based strategies. These organizers are:

- The learner as communicator
- The learner as enquirer
- The learner as active, creative participant
- The learner in the environment
- The learner and personal development.

I would like to conclude where I introduced this discussion. I re-thought the initial 'message card' workshop by linking three elements; the cultural diversity amongst my group of teachers, the need to promote a multi-voiced dialogue, and the Technology organizer 'learner as communicator'. The teachers and myself returned to the outcomes of the previous workshop – they said that they had produced message cards that they thought I wanted. I replied that perhaps they could now give me something that they wanted! The ensuing debate ranged across Xhosa cultural ceremonies and the story telling that underpin them. We discussed an appropriate medium of communication and concluded that card is too limited. We needed to use objects and images as well as/instead of words. The revised workshop 'Cultural Communication Using Mobiles' proved fascinating. An opportunity for you to participate will follow the presentation of this paper.

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What pupils say about scientific and technological activities at school

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Overview of technological education within primary schools in France

In the curriculum (1994), "Technology" does not appear as a single subject but, in compulsory school, is included in an area which has progressive stages: for age groups 3 – 5 "to discover the world", for age groups 5 – 8 "discovering the world" and for age groups 8 – 11 "sciences and technology". The programme is as follows:

- To discover the world: discovering the world of things; discovering the world of shape; discovering the living world; discovering the natural and human spaces; awareness of hygiene, security, consumerism; the passing of time; the world of pictures
- Discovering the world: the space and different landscapes; the time and the life of people; the world of shape and things (water, air, using of thermometer in daily life); dismantling – reassembling, making, using tools; using electrical machines (4,5 or 9 V); the living world; the citizenship
- Science and technology: unity and diversity of the living world; human body and health education; sky and earth; things and technological making (electrical assembling, mechanisms); objects and products; computing.

This organization relates to a gradual differentiation of subject matter for pupils.

Research questions

At school, scientific and technological teaching can be described as a heterogeneous whole, composed of 'school moments' given to pupils as prescribed, organized and sometimes classified tasks. From the pupils' point of view, these school tasks are given names that ensure their identification, their characterization and their categorization as school subjects. If some of these names essentially depend on pupils and contribute to the elaboration of their identity relationship to subjects, others constitute indicators that each pupil spots to make his own representation of a whole, designated by a school subject and to distinguish it from others. This construction is based on a coherent structure identified by the pupil and which enables him/her to involve him/herself in the proposed teaching – learning task and to develop simultaneously a representation of the school subject.

Wishing essentially to explore the relationship of the pupils to the school subjects, we suppose that these pupils, through the activities they do and their diversity, give different names. We also guess that the practices of their teacher, in their double logic of teaching – learning and organization, have consequences on the constituted conceptions. According to indicators privileged by pupils, confusions could potentially be associated with the implementation of the scientific and technological teaching. The study has been done with 78 pupils from 6 to 11 years between 1998 – 1999. After a sequence of activities whose theme was chosen by the teacher, an interview of about 15 minutes with 3 or 5 pupils of the course was organized in order to talk about that 'moment' and enhance possible previous 'moments' that seem to be 'the same'.

Labelling, characterization and categorization

The pupils' conversations are different according to their relationship to school, to the learning and obviously according to their age. If some of them feel difficulties talking about what they have just done, others, on the contrary, express at the same time the aims of the sequence, the objects of the learning and the interest to grow up and be good at school. The presentation of the analysis of the pupils' thoughts about 'school moments' of their scientific and technological education first relies on their denomination, then on their characterization and eventually on the confusions which are known and whose source is identified

Labelling

The denomination of the 'school moments' is different according to the age of the pupils. Less than 1 pupil out of 3 (from 6 to 11 years) gives a generic term to describe the 'past moment'. The others simply use names of objects from the work to describe that 'moment', such as "calendar", "teeth"…No pupil from 6 to 8 years describes these 'school moments' as "discovery of the world" In addition, no pupil from 8 to 11 years mentions the whole as "sciences and technology". The names they spontaneously use are usually specific words such as "biology", "science" and "technology".

The pupils' answers reveal school practices that tend to designate school subjects by the names of the subjects. These terms belong to a school culture shared in the school community. Most pupils answer that they use labels given by the teacher, learnt before or corresponding to what the older pupils say. The differential use of these names enhances the progressive incorporation of norms at school for pupils from 6 to 11 tears.

Categorization

When pupils are asked about categorization of similar 'moments', they are different according to different pupils. Objects, tasks and knowledge are indicators that more or less clearly evoke the content, even though it is never explicitly expressed. The categorization made by the pupils is also highlighted by the pedagogical organization which defines the characteristics of the 'school moments' and this the pupils see as criteria of categorization. Thus, these modalities become indicators that the pupils express, particularly the place where to put written papers (when they exist), the existence of these papers, the color of the sheets, the inserts, the letter written on the slip, the slip's form and its drawings, its questions, the works to do… For some of the pupils, the schedule is an essential indicator of these 'school moments' that are often punctuated as the weeks go by. These temporal indicators determine the categories of the 'school moments' and are often associated with the different teachers who work in the class.

The identification of these 'school moments', their characterization and, if need be, their categorization does not work only from one indicator. In their answers, the majority of the pupils say that 3 or 4 characteristics make them choose the school subject and confirm a categorization that was made before.

Generally, the pupils mention in a privileged way the nature of the tasks, the objects of work, the learning and the tidying up accessories. They talk less about indicators, about the schedule and the 'school moment' organization. Of course, the reference to the teacher only concerns classes in which several teachers work (n: 46).

When we compare what the pupils from 6 to 11 years say, we can notice that if tasks and objects are mentioned by the majority, learning is identified as classification accessories. Categorization seems to be first constructed on the observable components of the 'school moments', then progressively on the learning that is more abstract. On the one hand, we can explain this evolution because of a clearer existence of the teaching for pupils from 8 to 11 years,and on the other hand, because of the fact that pupils of that age have more experiences.

For instance, when associated with the work of groups, the atmosphere of work is not often referred to, whatever the age of the pupils. On the contrary, the schedule is more often mentioned by pupils from 8 to 11years. This spotting is linked to classes in which several teachers work and where learning is more diversified.

Disruptions

The indicators, used by the pupils to give names and recognize subjects and their labels, contribute to the constitution of categories that are more or less stable. This process of construction implies cognitive conflicts, especially when some indicators become intruders as regards the categorization. Three main sources of conflicts can be clearly identified from the pupils' reactions during interviews. They essentially concern pre – established categorizations, and this independently from pupils; the arbitrary classification of the subjects, their changeable and uncertain designation and their compartmentalisation, a priori.

The pupils are surprised by some mixed activities because they do not clearly understand the mixture of characteristics. These reactions are particularly noticeable during interviews that followed a sequence of construction (of a folded box) or a sequence given over to the study and realization of kaleidoscopes. But the disparities between the pupils are particularly important. The different tasks are associated with different disciplinary contents. To identify these tasks implies that they have constructed a representation of the subjects' system and therefore have realized their interrelationships.

School practices

During the past ten years, studies and research about school subjects have permitted a better understanding of them, their structure, their principles of construction and development as regards their prescribed, real or even hidden curricula dimensions. Yet, not so many researches enhance the disciplinary curriculums that the pupils feel. One of the important results of this research is the emergence of the pupils' cognitive activity in primary school in their relationship to disciplinary curriculum designated as "discovery of the world" and "science and technology". The pupils become real cognitive subjects of the 'school moments' that are given to them. In their answers, they refer to regularities they identify so that they proceed to categorizations of distinct subjects.

The pupils' comments identify the different relationships of the 'school moments' and the contents within them. As soon as they go to school, pupils seem to identify distinctions similar to those pupils from secondary school. Some pupils find it difficult to place themselves as subjects of prescribed tasks. These tasks

Table 1

	Effectifs	Tasks	Objects	Ideas	Note book	Schedule	Groups	Teacher
		nature of subjects				teaching organization		
Pupils age 6 – 8 years	34	21	20	8	17	2	5	(8)
		62 %	59%	23%	50%	5%	15%	
Pupils age 8 – 11 years	44	34	37	28	18	9	6	(15)
	77%	84%	63%	41%	20%	14%		
Total	78	54	57	35	35	11	11	(23)

Table 1

are then essentially 'school moments' without an important cognitive investment. For others, they are simply times differentiated by the environment, the teacher, the accessories – objects, and also by actions. Yet, for some of them, they are 'moments' during which they construct knowledge, particularly in relation to their metacognitive activity. This helps pupils to be more successful. Thus, with no real surprise, some pupils decode the 'school moments' according to the fixed teaching whereas others do not see the learning included in the activities.

All the words of the pupils reveal the teachers' practice in the organization of the prescribed tasks. The exchanges show the influences of the teachers' gestures in relation to the characterization of the school subjects. Therefore, these methods of teaching are generally less effective and not clear to pupils, who are thus obliged to decode them, to look for indicators, to compare or distinguish 'school moments' when they wish to understand what they are doing and learning. Sometimes, the contrasts in the verbal accompaniment, and the differences from one class to another in the designation and in the classification imply conflicts which are due to the discrepancies between the pupils' real position and the position implicit in their conduct and organization.

Thus, what pupils say fundamentally questions teachers' practice and teacher-training.

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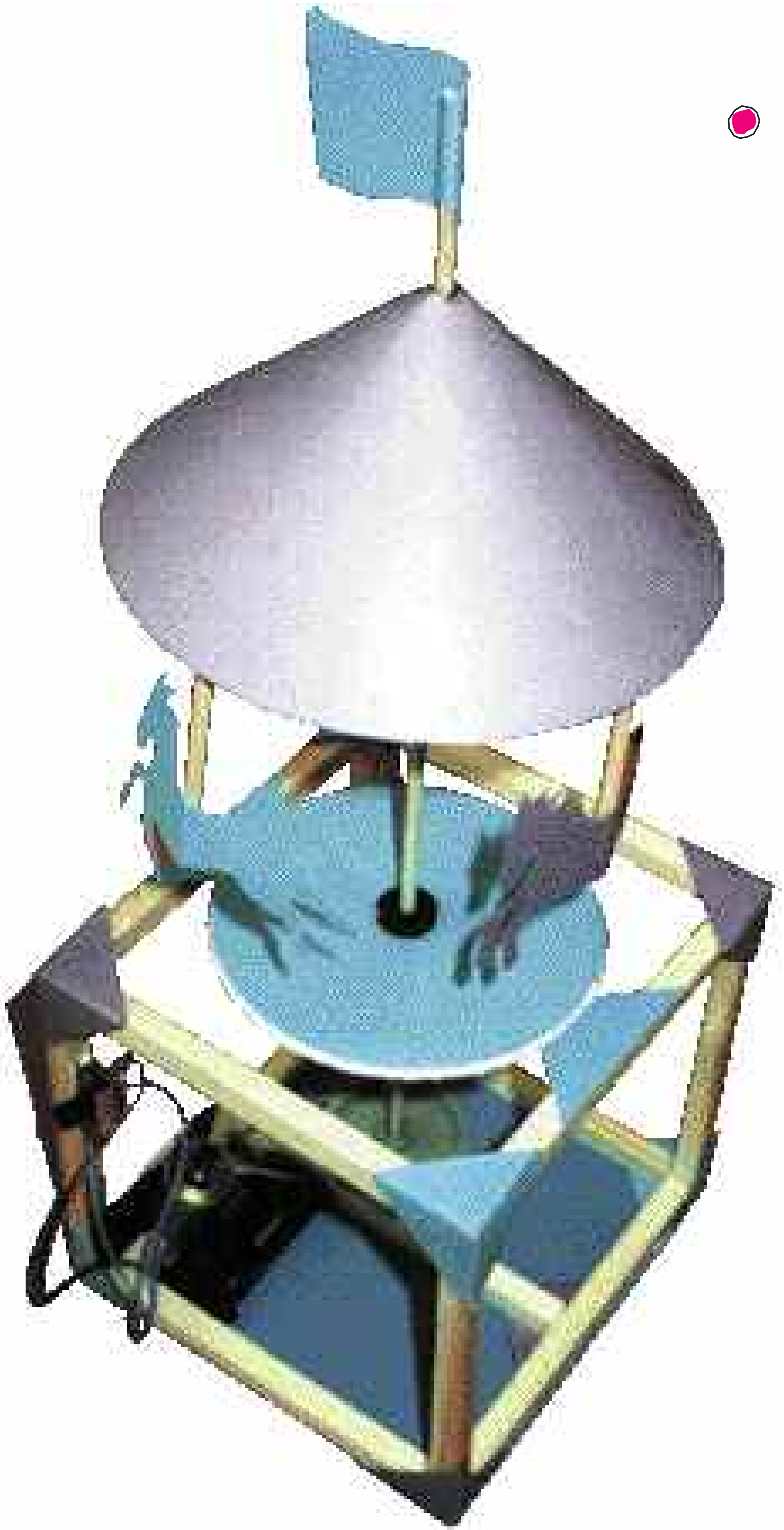

Consumer knowledge of product properties and technology education

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The questions and ideas behind the research

Craft and design has been a school subject about 140 years in Finland. As I look back I can say that Cygnaeus had the technology education idea in his pedagogy already in the 1860's. Today our craft design and technology is divided into technical work and textile work (National Curriculumn 1994). Technical work has taken responsibility over technology education (Alamäki 1999; Kankare 1997; Parikka 1998). Textile work has been seen as more aesthetic and because of that as a part of art education (Peltonen 1993). According to the law every pupil should study textile work and technical work. The way it has been organised in practice depends of the school. In some schools pupils choose at the 4th grade whether they want to study textile work or technical work. The consequence is that boys and some girls choose technical work and girls and very often none of the boys choose textile work. In some schools pupils do study both in mixed groups.

If we think that technical work can alone have the responsibility over technology education we admit that technology is best learned by hard materials. If we think of our every day life, we notice that we live among products. These products are made from various materials and in many cases with very high technology. We use and take care of very many products daily. When thinking of all the products, we can ask if they have something in common? Do we have or should we have some kind of common knowledge about the products we use? And if so, is it a matter of technology education?

From these questions and as a lecturer of textiles and clothing, I started to think about textiles in everyday life. Textiles, clothes and household textiles, are our closest environment. We use and take care of textiles on a daily basis but what do we actually know as consumers about the use and the care of textiles. Is there some kind of knowledge we should share?

Technological knowledge as practical knowledge

The consumer's knowledge and understanding of product properties arises from three components: 1) where the product is used, 2) why the product is used and 3) how the components of products combine and are modified to give a product (see Fritz & Cant 1994,1). There are two types of product properties: symbolic and material properties. Here we discuss material properties. Material properties are results of the scientific technological development. From this perspective, scientific technological knowledge of products is seen as practical knowledge (Wilenius et. al. 1991, 67). Technological knowledge represents knowledge that is altering all the time (Aittola & Pirttilä 1989, 33). Technological knowledge is practical common sense knowledge as the consumer needs it for solving everyday problems. To have this common sense knowledge the consumer has to have some kind of theoretical structure for thinking of product properties.

Education needs some substance area to achieve its goals. One among others is textile products. Because there is little research about textile product properties and the consumer I started my research by defining theoretically what are the material properties of textile products from the consumer's point of view. The earlier research has looked at the material properties of textiles from the industry point of view (see for exampleTextile Research Journal volume 37).

The following classification is defined on the basis of Lyle's (1977) and Taylor's classifications from the perspective of the consumer.

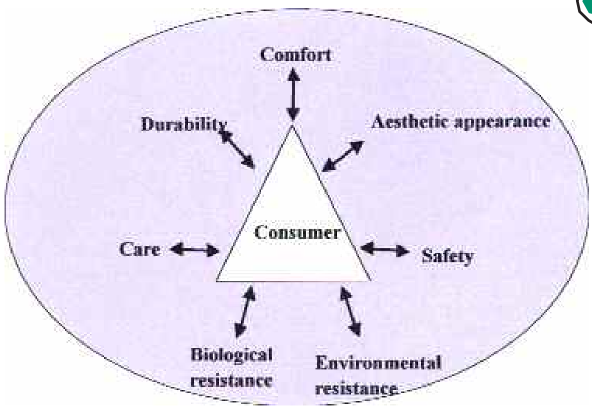

Figure 1 Properties of textiles from the consumer's point of view (Lindfors 2000, 311)

In figure 1 there are 7 classes of textile properties: 1) aesthetic appearance, 2) comfort, 3) durability, 4) safety, 5) biological resistance, 6) environmental resistance and 7) care. All the classes consist of many subproperties (Lindfors 2001).

In this research, the technological knowledge of products is defined as knowledge of material product properties. Textile technological knowledge is knowledge of material textile product properties (figure 2). Consumers need textile technological knowledge in everyday life as they use and take care of textile products.

The Delphi method and Bayesian modelling as tools for defining the central technological knowledge to the consumer in the area of textiles

The Delphi method is a tool for finding and creating research results with an expert panel (Dalkey 1975, 240). After the theory and the problems of the research are defined, the next step is to get an expert panel. Textiles are a very broad area in society and therefore it was very important to have the experts from different sectors of society.

In figure 2 there is a panel of 167 experts.

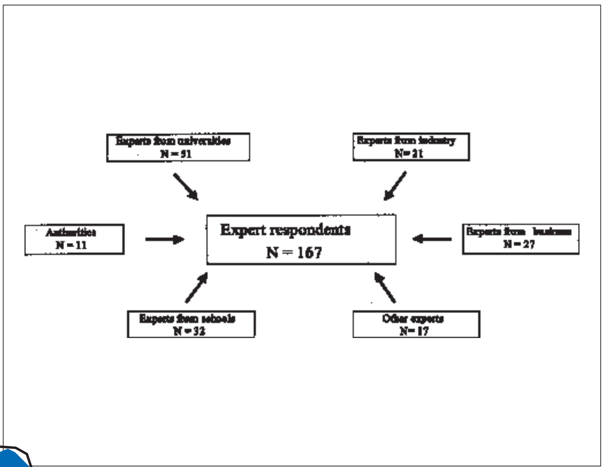

Figure 2 The Delphi expert panel

The panel consisted of experts who were supposed to be capable of evaluating the properties of textiles from the consumer's point of view according to their schooling and working experience. In the panel, there were experts from the textile industry, business, research, authorities and teachers from comprehensive schools and from universities.

The research was done with three questionnaires between 1999-2000 in Finland. The data was modelled with Bayesian modelling, a so called Finite Mixture Modelling (Lindfors 2000). Through Bayesian modelling it is possible to combine statistical data and expert knowledge in a natural way. After each questionnaire the experts got the results from previous questionnaire which is a precondition for the delphi-method (Linstone & Turoff 1975, 6). In this way they had opportunities to evaluate and check their previous evaluations. The Finite Mixture Modelling allowed the researcher to study the data through many different models and profiles.

The research results

The research results showed that the Delphi panel managed to evaluate the product properties from the consumer's point of view (Lindfors 2001). They showed also that the panel was broad enough to give a reliable evaluation on product properties.

The research results made it very clear that depending on the product the importance of specific properties was different from the consumer's point of view. Despite this it was obvious that some product properties were important in every product group. On the basis of the results, it was possible to illustrate them as shown in figure 3. Figure 3 shows how the experts evaluated product properties in using and taking care of textiles in everyday life from the consumer's point of view.

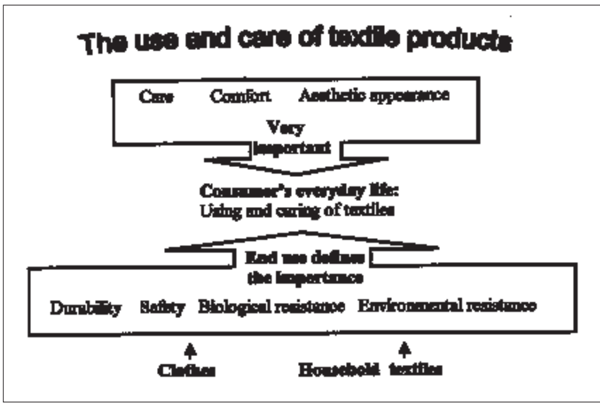

Figure 3 The importance of textile product properties for consumers.

The upper part of figure 3 shows that whatever the textile product is the most important material product properties for consumer are care, comfort and aesthetic appearance. The lower part of the figure shows that safety of use, durability, biological and environmental resistance are also important. The importance

Table 1

Clothes	Party wear				Everyday wear				Sportswear				Underwear				Outerwear			
Properties	Not important	Not very important	Important	Very Important	Not important	Not very important	Important	Very Important	Not important	Not very important	Important	Very Important	Not important	Not very important	Important	Very Important	Not important	Not very important	Important	Very Important
Thermal comfort	21	43	26	10	5	11	43	41	0	4	11	85	4	15	26	55	0	6	25	69
Handle	3	19	46	31	0	4	28	68	0	5	25	69	0	4	12	84	4	16	50	30
Aesthetic appearance	4	13	25	59	0	4	28	68	3	13	47	36	4	17	55	22	0	4	23	73
Durability	12	49	31	9	0	10	47	43	0	6	25	69	3	20	51	25	0	10	50	40
Safety	13	45	33	9	6	19	44	31	4	14	34	48	7	28	33	32	5	17	47	30
Bilogical resistance	21	43	28	8	6	32	41	21	5	18	31	45	7	22	39	32	9	45	33	12
Environmental resistance	49	36	10	5	23	36	26	15	9	24	28	39	44	35	17	4	7	23	30	40
Care	5	27	47	22	0	4	17	78	0	4	21	75	0	5	30	64	0	16	45	40

Table 1 The probability (%) of importance of textile properties in different end use groups

of these properties depends on the end use of the specific textile product. None of the properties evaluated by experts was seen as unimportant. None of the material product properties could be dropped out from the consumer's point of view as a result of the research results.

Table 1 shows the probability of the importance of textile properties in different end uses. There are five different types of 'end use' groups within clothes and seven product property classes. From the table we can see the probability of a specific property in a defined end use. If we look at the results we notice that the importance of the property varies more closely in different type of clothes groups. It is possible to see that some properties, environmental resistance for example, are not very important. Care is usually very important but in party wear it is not so important. Sports wear seems to be very demanding group. In that group, all the properties except aesthetic appearance are important or very important for the consumer.

The research results tell us that the consumer needs specific knowledge of product properties to be capable of using and taking care of their textile products. The importance of the material properties is different in different end use groups, e.g. sportswear and party wear. This type of knowledge is technological knowledge and so specific that the consumer cannot learn it by her/himself with the strategy of trial and error. It is obvious that to get some kind of theoretical base for practical common sense knowledge in textile technology the consumer needs to study these things somehow.

The research results and technology education

Consumers learn some textile product properties from experience gained when they use and care for textiles in their life. Such learning is usually a consequence of trial and error. Within the frame of technology education (e.g. Dugger 1997) textile products are solutions to problems that arise from specific human needs. In technology education pupils solve problems in a technological environment with technology. In concrete pedagogical school work (Alamäki 1999, 88) they model the technological world or they design a solution which can be a product or a system. A solution is always an answer to a human need. If the solution is to design a new product in defined end use it means that pupils are working with concrete materials and they are shaping the product. According to the research results (Table 1) the specific end use defines the central properties of the product. The models which describe design process (e.g. Anttila 1993, Den Buurman 1997, Seitamaa-Hakkarainen 2000, Zeisel 1984) tell how the design process moves between the stages in the design space. By studying and analysing the technological problem, pupils define the preconditions for the problem. By analysing the end use of the product they acquire the criteria as a checklist for going further in the technological learning process.

If we think of pupils' school work, a concrete example of a technological problem especially in Nordic countries in the area of textiles could be, 'How do I keep my hands warm in wintertime?' or in England, 'how do I keep my clothes dry on rainy days?' The solution is an answer to a concrete human need. To develop a solution pupils have to ask questions about preconditions of the end use. Preconditions lead them to ask questions about the properties of materials. How can pupils select the material to develop a solution to their human need?

In industry, the material for a certain product is selected on the grounds of material testing. The textile laboratories have high-tech equipment for testing. It is obvious that in comprehensive schools we cannot afford the latest technology equipment for testing. But we can use the idea of testing. By defining the frame of textile properties (see figure 1) it is possible to understand different dimensions of product properties on a material level. With this frame and by using textile standards it is possible to apply such material testing and create such equipment that pupils can use it in school. By testing different materials and evaluating the results, pupils apply critical thinking (see Mc Peck 1990, Siegel 1990). This type of learning allows pupils a research oriented critical dimension to use their creativity to design the solution for that human need they are working for.

This research was done according to the textile products. We can also ask, if there is any logical reason why we could not apply these results to a wider area of products. Experts were asked, "do you think consumers need the same kind of technological knowledge about products other than textiles?" The answer was: "Yes, consumers do need that kind of technological knowledge from electronics, chemical products (cleaning, cosmetics) and food". Logically thinking the results give us hints of other product groups too. It is obvious that we need more empirical research on the issue but the results in textiles offer important clues.

The future

We can suppose that the role of products in a consumer's life will not diminish in the future. The development of technology makes it possible to create products containing very high technology and quality. For example, in the textiles world the role of textiles in the consumer's life is increasing especially because of the development of technical textiles (see CIRFS 1999) and wearable electronics.

The future consumer who will be capable in the products world has to have a critical attitude to products on a social, cultural, economical and ecological level. One challenge of technology education is how we allow pupils opportunities to acquire technological knowledge that they can use as theory based common sense practical knowledge in every day life. Pupils need critical concrete experiences with many substances that belong their everyday life. The interests of pupils are different. It is equality (see DeVries 1997,23) for both sexes that they have opportunities to learn technology through those materials they use in everyday life. By learning to identify problems and solutions pupils learn technological thinking that allows them tools to live a good life as consumers in a changing world.

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Young Children's Learning while Building Water – Flow Systems

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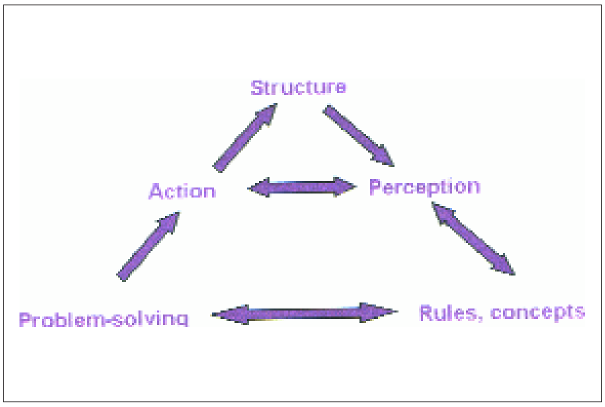
Introduction

Technology education offers a powerful way of learning for young children. Through building artifacts and discussing how they work, a great potential for learning can be seen (Piaget, 1956). Making technological products has been viewed as an important channel to understanding and perhaps appreciating the knowledge upon which they are based.

The making of objects that work involves one of the fundamental ways of learning, the cycling between constructive action upon reality and reflection on its results. This study attempts to uncover the processes taking place in the children's changing understanding of technology systems, while building them and increasing their own proficiency.

In an attempt to disentangle the different mental processes participating in 'learning while building', one can separate the following strands: (a) Motor action – the physical motions of construction, which change and shape the structure. (b) Perceptual information extracted from reality, channeling information from the structure into the mental system. (c) Rule – models or concepts – the causal relations between particular configurations and ways of operation on system behavior. (d) Problem-solving strategies.

The following conceptual map names and relates the mental processes that participate in building artifacts.



Conceptual map

The current research performed investigates three parts and their relationships: concepts, actions and perception. This paper describes one of these – the changes in rule-models while building water-flow structures.

This study concerns young children and their learning through building unfamiliar water-pipe systems. Younger children's causal models of physical phenomena are usually focused on a single causal dimension (Siegler, 1978; Case, 1989). On the other hand, experts build more complete representations of the problem than novices because of the extra knowledge they have available. This can be seen among young children in a comparison between expert and novice 5 – 7-year olds' knowledge of dinosaurs (e.g. Chi, Hutchinson & Robin, 1989). In this investigation, the children start out as novices in the content of hydrodynamics, but are expected to develop some level of expertise beyond the initial level.

The research questions we pose are: What characterizes children's rule-models of water-flow in pipe systems? What changes are seen in these models over a time period when they are building such systems?

Method

The sample included 29 children, 15 girls and 14 boys, selected out of 80 children in an Israeli middle class public school, and randomly assigned to experimental and control groups. The children's ages spanned 5y 2m – 6y 3m with a mean age of 5y 8m, SD=3'.

Two sets of instruments have been developed.

One is a construction kit for building large water-flow systems. It is modular and transparent, and its components enable the creation of various systems. One can control the water flow using diverse components (pipes, faucets, vessels, connectors and qualitative speed measuring devices) to determine the relationship between the streams' features and the following variables: height, exit-hole cross-section, resistance, hierarchical structure of the system and the system's water flow control.

The second is a series of tasks using this construction kit as a half-open learning environment, with the children building different systems. The tasks were designed as a progression of increasing complexity. For example, the second task was to create a plumbing system for a model house with two storeys, so that neither neighbour would complain the other was getting more water.

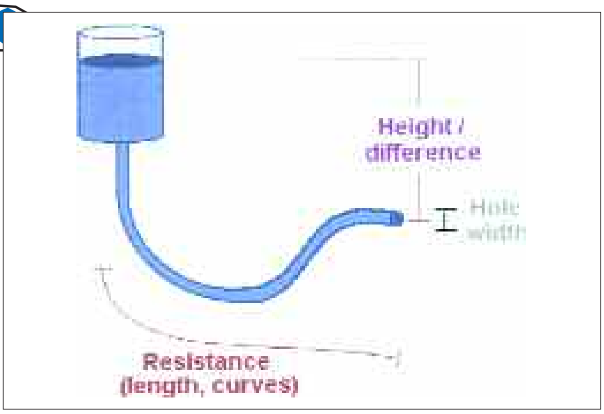
Procedure

The experiment took place during six meetings spaced slightly over one week apart. The first and last sessions were a pre-test and a post-test. The children built individually during four sessions. Interviews were conducted at the end of each session. The pre-test and post-test were also administered to a control group, who did not build any systems, but underwent alternative treatment involving mythology and astronomy. The building sessions were videotaped.

The interviews included questions, aimed at eliciting the children's rule-models regarding water behaviour in pipe-systems.

The questioning ran along the following lines: a real system is presented, described, its parts and routes are emphasized. The child is asked whether a particular variation/s which is pointed at makes a difference for the water streams, and if so – what kind of a difference. S/he is asked to describe the water streams for the two states of the varied feature, and explain this prediction. The same question is repeated later in the interview using a picture of the system. Here, the child is asked to complete the streams in the picture, describe them and explain why they are so.

The following variations were employed: pipe-exit height, hole-width and resistance. Single-variation tasks were used as well as dual-variations, usually in a compensating relationship. 33 tasks were administered during 6 interviews; each performed 3 times in a session (real system, drawing, explanation of picture).



Factors determining water-flow from pipe

Double-variation task: pipe-end height (higher pipe-end-less flow) and resistance to end (longer pipe – more resistance – less flow)

Results

The children's predictions and explanations in the different tasks were recorded, coded and analyzed as rules: If (variation, direction) then (water streams description and comparison).

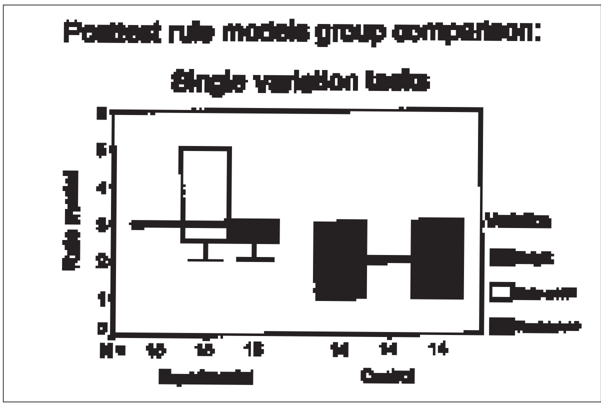
What is learnt?

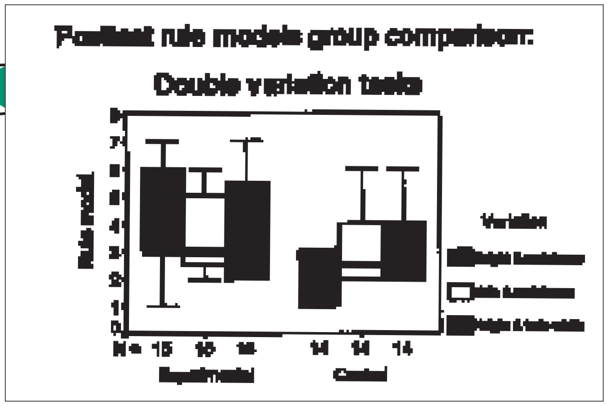
The children's rule-models were coded using the following scale:

- No rule
- Single rule, incorrect
- Single rule, correct
- Two different single rules provided in different contexts, at least one incorrect
- Two different single rules provided in different contexts, both correct
- Two rules, at least one incorrect
- Two rules, both correct.

The scale is based on Siegler's (1978) description for rule-models, with one addition: levels 5 and 6 reflect a transition stage, showing instability, while vacillating between two different and relevant single rules in different contexts of the same tasks. The placement of this response type on the scale is determined from the data, as will be shown.

In the pretest, no group differences are found. For height-variation and hole-variation, the median is the incorrect rule. For resistance-variation, the median is the correct rule. The following box-plot graphs describe the post-test rule-models for the two groups.





The thick line represents the group's median. The top and bottom lines in the rectangle show the 75% and 25% quartile

The experimental group's rule-models improve, but not the control group's. The final rule-models are correct for the single-variation tasks, but they are not integrated into a multiple-variation consistent model. Although the children show an ability to integrate two variations into a single explanation, this is not a general change.

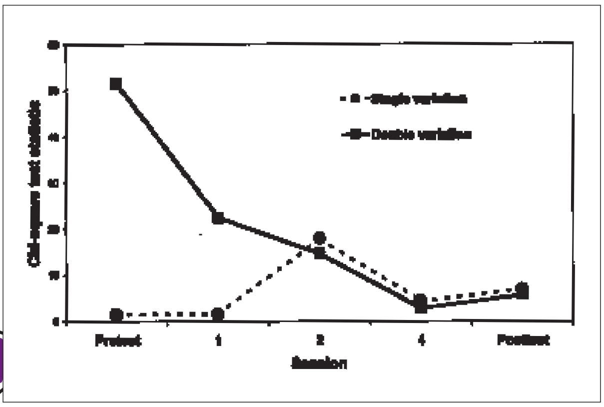
Task variation / Statistics	Test, Group	Height	Hole-width	Resistance
Median (inter-quartile range)	Pretest, all	Incorrect rule, 2 (2-2).	Incorrect rule, 2 (2-2).	Correct rule, 3 (3-3).
	Posttest Experimental	Correct rule, 3 (3-3).	Correct rule, 3 (2.5-3).	Correct rule, 3 (2.5-3).
	Posttest, Control	Incorrect rule, 2 (1-3).	Incorrect rule, 2 (2-2).	Incorrect rule, 2 (1-3).
Mann-Whitney test for group differences (Z)	Between groups	2.2, p<0.05	3.0, p<0.01	1.2, ns
Wilcoxon Signed Ranks Test for individual pretest-posttest shifts	Experimental	Z=2.5, p<0.05 (improvement majority)	Z=3.0, p<0.01 (improvement majority)	Nonsignificant
	Control	Nonsignificant	Nonsignificant	Z=2.33, p<0.05 (Regression majority)

Task variation / Statistics	Test, Group	Height and resistance	Hole-width and resistance	Height and hole-width
Median, (inter-quartile range)	Pretest, All	Incorrect rule, 2 (2-3).	Incorrect rule, 2 (2-3).	No tasks administered
	Posttest, Experimental	Correct rule, 3 (3-3).	Correct rule, 3 (2.5-3).	Alternating between rules, at least one incorrect, 4 (3-5).
	Posttest, Control	Correct rule, 3 (1-3).	Between correct and incorrect rule, 2.5 (2-3).	Incorrect rule, 2 (2-3).
Mann-Whitney test for group differences (Z)	Between groups	2.3, p<0.05	1.8, Nonsignificant	1.8, Nonsignificant
Wilcoxon Signed Ranks Test for individual pretest-posttest shifts	Experimental	Z=2.4, p<0.05 (improvement majority)	Nonsignificant (improvement majority)	No data (no question was asked in pretest)
	Control	Nonsignificant (Ties majority)	Nonsignificant (Ties majority)	

Tables 1 + 2 Single and Double-variation tasks, rule-models and statistics

What makes a difference for water flow?

The conditional 'if' parts of the children's rule-models are examined for the causal status of the different system features in determining flow characteristics. The proportions of these features in the single- and the double-variation tasks' responses are compared with the actual task variations. The difference between the two is termed the 'deviation from task-variations'. The chi-square test statistic was used to calculate this deviation, and to examine the deviations for significance. These statistics are viewed over time:

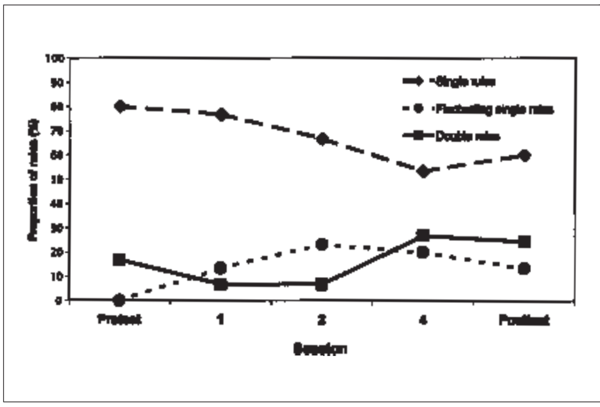


Statistics

One can see the children's causal models of water-flow in pipes going through two interesting processes: (a) Increasing correspondence between task complexity and the children's model complexity. (b) Intermediate strong deviation from task variation arises. It is due to a bias towards pipe-end width, as a single source of variation in water-flow. (c) The latter is not dependent on building, as it was observed for the control group too.

How many rules?

A rule structure denotes the number of rules and their stability, disregarding their correctness. Both an incorrect height rule and a correct height rule are 'single rules'. The other structures are 'fluctuating single rules' and 'double rules'. Their timelines are presented:



Time lines

In the temporal progression, single rules are dominant throughout, but are gradually displaced, first by 2 fluctuating single rules, and then by double rules. Thus the shift from simpler to more complex rule-models supports the proposed progression: single rule, fluctuation between two single relevant rules and double rules.

The biased response and the fluctuating rule structure were examined within individual progressions. In addition, a balancing' response pattern was found for 60% of the children, where irrelevant hole-width rules are provided together with the relevant rule. In most cases, the bias was exhibited before the fluctuating responses.

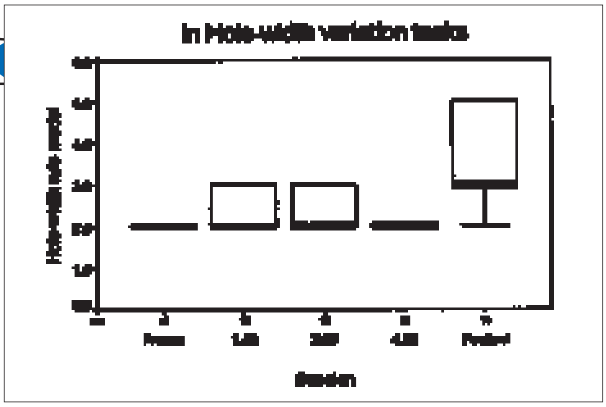
The two intermediate phases – bias towards a particular feature, and vacillating between two different rules – are examined for individual children. Most of the children (60%) who exhibited a bias towards hole-width did so before fluctuating between single rules. The fluctuating response patterns is an intermediate unstable phase, observed usually before attaining more complex rule-models, but also before more correct, but not more complex rule- models. The balancing and biased responses are distinct as, the first peaks much later the latter.

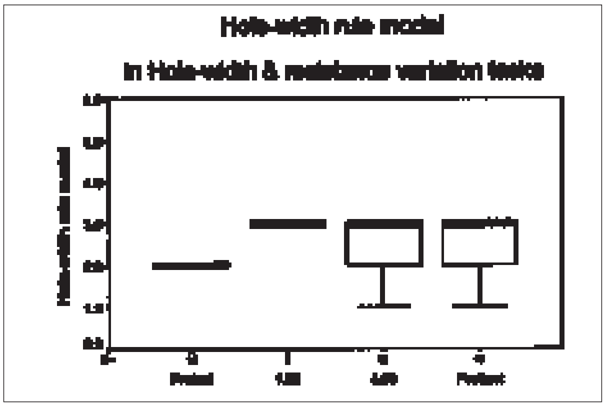
Children are reasoning mainly with single rules, even in double-variation tasks. During the building period, a biased response is first to appear – when the children focus on a single feature as explaining the water-flow. Following that, a fluctuating response pattern is seen when different relevant rules are provided in different contexts. At the end, the dominant rule during the bias is combined with the relevant rule when reasoning about water behaviour, and all the children can provide at least one double-rule.

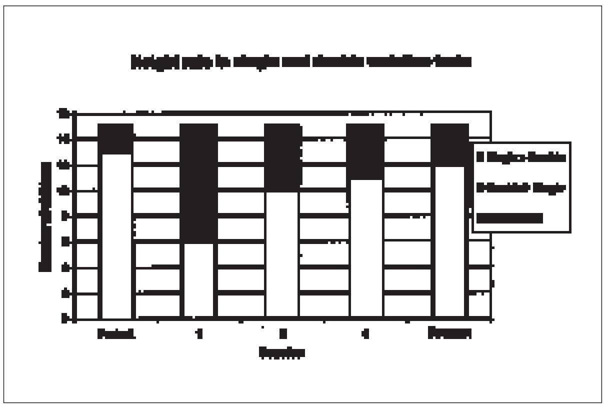
Simple and compound tasks

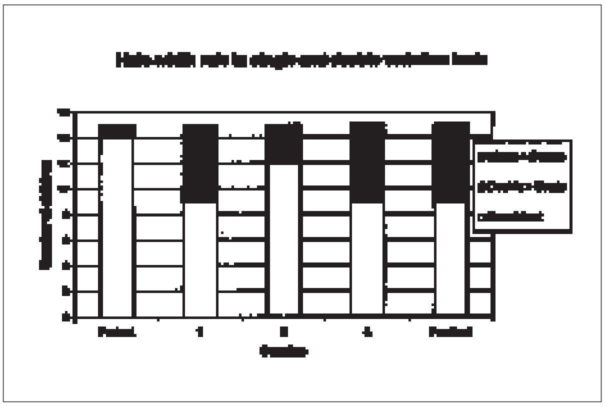
It has been found that most of the children held correct models for the resistance variable. Therefore the separate height rules and the hole-width rules are examined for the time of conceptual change in the various tasks and then compared.

Both group and individual results show a surprising pattern:









Results

In many cases, one can see a shift to the correct rule first in a compound task, which includes a variation for which the children hold a correct rule – and only later in the simple task.

The pattern is less clear for the hole-width rule. The same does not occur for the height and hole-width tasks, when both rules are incorrect at the start.

Discussion

Complexity: technology versus cognition

Technological systems which surround us everyday are complex objects. They contain many parts, are organized in different structures, and utilize a manifold of causal rules – being the fruit of many years of human-effort in accumulating and generating knowledge. The question that we pose here is: how does a single human, a young child in this case, approach this complexity, disentangling or constructing it in reality and in understanding.

When novices, the children use a single rule to explain system behaviour – be it simple or complex. Similar response types are seen in different physical (Siegler, 1978) or technological (Levy et al, 2001) tasks.

Following a period when the children are building such systems, complexity in reasoning tends to follow complexity in the systems, though not completely or consistently. At the end of the building period, the children are all explaining water-flow in the pipe-systems with complex rules. Nevertheless, this change is not general. The activity of building complex technological systems is seen to encourage children to go beyond their everyday abilities, as new rules are discovered, tuned to reality and integrated, finally replicating the causal structure of the artifacts they have been building.

When comparing responses to simple and complex tasks, a surprise was in waiting. We usually expect learning to occur first in simpler settings, and only later applied in complex settings. What has been found, is that the contrary may occur.

Not simpler systems, but more complex systems, where one rule was previously known, are those where learning of new rules occurs first. A possible explanation for this lies in the reinforcing character of correct rules. Model revision doesn't occur when a cognitive system is confronted with a totally confusing situation, even if simplified. In order to facilitate learning, the unfamiliar needs to be paired up with familiar phenomena, even if this means 'complicating' the situation.

Anchoring and then losing consistency on the way to achieving higher complexity in reasoning

As building progressed, the general trend was of increased coherence with task variations, associated with a partial shift from single rules to the more complex interacting double-rule explanations. The builders' ability to encode and in some cases coordinate two dimensions increased throughout the building period. A learning progression is proposed where a more robust rule model is achieved through the sequential enhancement of three abilities:

- Extending a rule model's applicability or increasing the consistency of its use
- Encoding multiple features
- Rule integration.

It is suggested that there are two factors encouraging these changes. One is the effortful building activity that encourages a decrease in the number of operations to solution by increasing the power of prediction. The other is the interview situation, which motivates the children to reflect on their responses.

Expenditure of effort in encoding more system properties and in the coordination of a larger number of rules is compensated for by economy in action.

Preliminary models: isolated single rules

Prior to building, any variation in system features was seen as changing water-flow. This is seen in the high degree of fit in the single-variation tasks. The differential causal status is seen only in the double-variation tasks, since usually only one rule was provided. Therefore, although the children provided rules regarding all system feature variations, these were isolated rules, in the sense that they cannot be mutually coordinated.

Increasing consistency: anchoring reasoning processes

The picture changed in the next interview. After the first building session and peaking in the second session, a rise in irrelevant hole -width rules was seen, with the children focusing on a single system feature, ignoring the others. This bias was transitory and later diminished.

It is claimed that before tuning into the complexity of the multiple variations, this temporary biased phase is necessary. Creation of consistency in reasoning is the first stage in rule model progression – anchoring the fleeting variations and their outcomes, by strengthening the strongest rule-model. Only then, can the individual detect conflicts between predictions based on this model and reality.

Thus their accomplishment at this stage is consistency, an anchor in a sea of variation.

Encoding multiple dimensions – and losing consistency

The consistency achieved did not satisfy the builders. Through building, the children are initiated into more complex situations, where a single rule cannot successfully predict system behavior. The next step is an increasing awareness that the explanations for water flow in their structures must involve more information. In order to increase the power of their models in guiding the building process, additional system properties need to be attended to. At this phase, additional system properties are viewed as causal, but not at the same time nor integrated into a single model. The children fluctuate between the previously preferred rule and another task-relevant one, inconsistently providing them in different contexts.

During this phase, encoding capabilities are advanced. Encoding is described as noticing potential explanatory variables. In learning, formulating new rules is preceded by the recognition that previously unattended dimensions may be relevant to the task or that their variation accounts for observed outcomes (Siegler & Chen, 1998). At this time, the formerly un-encoded features are now encoded and used in reasoning, but in an unstable manner. The price paid for increased encoding is decreased consistency.

Coordinating multiple dimensions in double-rules

After the children had enhanced their reasoning uniformity, they decreased it in favor of fine-tuning to more system properties. Still, they were not satisfied. Although they fluctuated between an increased number of dimensions, they had not yet integrated them in a single stable model. The need for consistency pushes the cognitive system beyond this transitory stage to more complex reasoning, which both encodes the causes and integrates their outcomes. This can be seen in the double rules, which were provided at higher frequencies in the later building sessions. After both consistency and encoding have improved, a robust model where integration of the two encoded dimensions in a double-rule can be achieved.

Conclusions

In summary, building complex technological systems encourages learning of new rules and their integration into consistent models. This learning is facilitated when an unfamiliar variation is coupled with a familiar reinforced variation, rather than in a simplified situation where only the unfamiliar is varied.

The complexity of reasoning is reached through a process of anchoring reasoning and increasing its consistency, and then by losing this consistency in favor of noticing more features.

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Using the QCA Scheme of Work for Primary Design and Technology

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Introduction

The Qualifications and Curriculum Authority (QCA) developed the scheme of work for primary design and technology in response to a demand for exemplar materials by primary schools. It was first published in 1998 and is still one of their best selling publications! The scheme includes an overview booklet, a page outlining all of the units of work and twenty-four separate units of work.

Unit layout

There are four units of work per year group for academic years one to six (pupils age range five to eleven years). Of the four units, one unit is an alternative to another unit with the same material focus for that year group. For example, in year five there is a food focus unit on 'bread', with an alterative of 'biscuits'.

Each unit is set out in a format that is standard to most of the schemes of work produced by QCA for different subjects.

Therefore, each unit has:

- A clear unit title, including the unit focus
- A brief introduction
- Prior learning requirements
- A vocabulary list
- Suggested resources list
- Expectations (differentiated)
- Learning objectives
- Possible teaching activities
- Learning outcomes
- Points to note (e.g. subject links – including direct referencing to other QCA schemes of work, use of ICT, class management, health and safety, homework ideas).

Meeting the needs of the National Curriculum

The introduction of the National Curriculum in England and Wales was at a time when many teachers in primary education had not had the training required to deliver the full curriculum. In particular, design and technology, being a relatively new subject, caused additional problems. Teachers who had been in the profession for some time had not been educated in the subject at school (myself included!). It was not surprising when the Office for Standards in Education (OFSTED) started to indicate a general weakness in the subject throughout the country. Fortunately, the situation has improved significantly. In my opinion, the introduction of the QCA scheme of work is one example of creating support materials that match teachers' needs. The detail of the scheme is sufficient to help subject leaders and class teachers who deliver design and technology.

How it has been used in my school?

I have been in the fortunate position this year to team-teach design and technology with colleagues. This has given me working knowledge of the scheme in every age group. We introduced the scheme in the summer term 2000. Although we had a scheme of work for design and technology that worked well, in line with other subjects, we believed that the integration of the QCA schemes would enhance our teaching. This was based upon the belief that the comprehensive detail and structure of the scheme, as outlined above, supported teachers. In general, the 'possible teaching activities' are used. We have lessons that concentrate on investigation, disassembly and evaluative activities (IDEA's) and focused practical tasks (FPT's) before pupils move on to design and make assignments (DMA's).

The school has a flexible approach to delivery of the subject. Sometimes longer sessions are required, and this is possible. In year six, the curriculum demands are such that the final unit of work is left until the final half-term and sometimes one or two full days are used to complete the unit. Usually, there is a range of time used throughout the unit. In general, classroom assistants or parent helpers are utilised under the direction of the class teacher. This means that there are frequently two adults working together.

What works well?

The scheme caters for the wide range of experiences required by the National Curriculum. The broad range of units cover materials, skills and requirements for knowledge and understanding.

The element of choice enables schools to select appropriate units. In general, I have been pleased with the units that we have selected this year. Due to the fact that the units are quite varied, it is likely that there will be something to appeal to most, if not all, pupils. This is important for gender, social and cultural considerations.

What does not work so well!

Whilst I have found that most units are well matched to intended age group, there are one or two that I would not try again with recommended age groups. In year Two, 'Joseph's coat' is rather specific. If teachers were using this unit, there are perhaps more motivating characters from story books that would provide a more stimulating starting point. In year 3, 'pneumatic monsters' was another unit that I found less than successful. Whilst the scientific experience of working with syringes and tubing was very rewarding, transferring the knowledge into a working model was less so! The skills required to make satisfactory working models required more teacher intervention than was realistically manageable.

We find as a school that we often exceed the suggested hours outlined in the scheme overview. In general, we seem to be able to deliver units where the focus is food or textiles in recommended time. Units where the focus is mechanisms, structures or control seem to take a little longer! Does recommended time allow for quality products? My feeling is that there should be a balance between developing skills, knowledge and understanding whilst producing worthwhile, quality products. To do this, each year group at my school only undertakes two major DMA assignments per academic year. This does mean that we have to ensure a balance across key stages to meet National Curriculum requirements.

The 'expected outcomes' for some units are quite challenging. With the 'Pneumatic Monster' unit, no pupil was able to match the higher level of achievement. I would find it difficult to take Year 3 pupils to the higher expectations in the time allowed. Whilst I now aim to meet the higher expectations for units, I am quite satisfied if the majority of pupils meet the expectations for 'most pupils will'.

Modification / adaption (overall / individual units)

One of the greatest advantages of the scheme is that it is free and easily accessible. Units can be downloaded free from the Department for Education and Employment (DfEE) website (www.standards.dfee.gov.uk). Since the units can be saved as word documents, teachers have the added advantage of being able to modify units to match requirements for their school. For example, in Year 6 there is a textiles unit on making slippers. Using edit / replace, and making other small text adjustments, I was able to quickly modify the unit to match the textile gift bags that our pupils made as an alternative.

Cross-curricular links and the use of ICT

Every unit has a suggested list of cross-curricular links. This is very useful in highlighting natural and appropriate links. Personally, I try to think of appropriate links to core subjects first (Literacy, Numeracy, Science and use of ICT). Whilst I haven't often used the recommended ideas, it is a helpful prompt.

Assessment

Assessment should be manageable and effective. It is important that assessment procedures are in line with a school's overall assessment policy.

There are many ways that we can and do assess pupils' work both formally and informally. Designing and making skills need to be assessed, as well as knowledge and understanding. How will schools decide upon a means of assessment and does it need to be evidence based? Schools could refer to the National Curriculum level descriptors and use these when assessing a child's level of achievement.

The 'expected outcomes' in the QCA scheme of work have been very useful as an assessment tool. It was very easy to modify the front page of each unit and use this for recording. Pupils' names were added to the statement that best matched their achievement.

This did have limitations in that there was no space for additional information. Therefore, we have developed an assessment proforma that is common to many primary schools in the country. Pupils' names are listed on the right hand side of a page and the 'expected outcome' statements are placed alongside them. Pupils' names can be highlighted to match the three statements and additional information included. For example, I had taught a pupil whose knowledge, understanding and design skills were far in advance of his making skills. I was able to record this on the assessment page.

Review

After one year of using the scheme throughout the primary phase, we have reviewed its effectiveness:

- We will continue to use the scheme
- We will modify use of units that have been less effective or consider replacing them with others.

Conclusion

The QCA scheme of work for design and technology is not a complete answer to the delivery of the subject in primary schools. However, it is a very comprehensive scheme. Schools, subject leaders and class practitioners need to exert their professional judgement in adopting and adapting the scheme.

Its' wide-spread use promotes dialogue between colleagues. This common ground of shared knowledge and experiences can only be good in promoting the development of the subject.

As expected, commercial support materials are being developed to support the scheme.

In conclusion, I consider the scheme to be an excellent starting point for schools.

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Figure 2

Year Group				
One	1A Moving pictures	1B Playgrounds	1C Eat more fruit and veg	1D Homes
Two	2A Vehicles	2B Puppets	2C Winding up	2D Joseph's coat
Three	3A Packaging	3B Sandwich Snacks	3C Moving Monsters	3d Photograph Frames
Four	4A Money Containers	4B Storybooks	44D Alarms	4E Lighting it up
Five	5A Musical Instruments	5B Bread	5C Moving Toys	5D Biscuits
Six	6A Shelters	6B Slippers	6C Fairground	6D Controllable Vehicles

QCA Units – Design and Technology

The place of computer control in the primary school

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Introduction

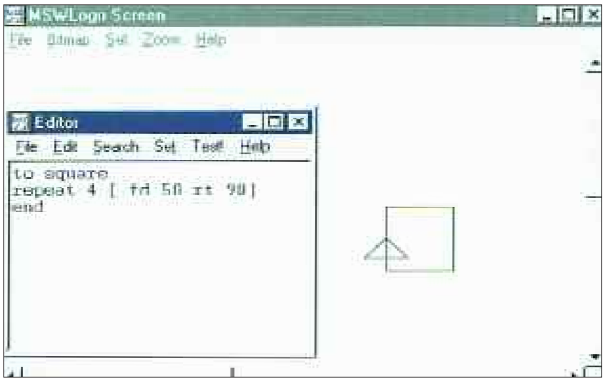
Computer and microprocessor controlled systems play a significant role in our lives from traffic management systems to cuddly toys that demand attention. In the world of designing and making, robots and flexible manufacturing systems have changed the way in which industry operates. It is no surprise therefore that increasing attention is being given to computer aided manufacture and computer control in design and technology education.

Computer control is one of the main areas of overlap between information and communication technology (ICT) and design and technology (D&T). The recently revised National Curriculum (QCA 1999) introduced computer control at Key Stage 2 in both the D&T and ICT programmes of study. For the first time, all children in England were to have an entitlement to develop a working knowledge and understanding of control from a young age: *'Pupils should be taught how mechanisms can be used to make things move in different ways, using a range of equipment including an ICT control program'* Design and technology programme of study (DfEE 1999).
'Pupils should be taught to create, test, improve and refine sequences of instructions to make things happen' Information and communication technology programme of study (DfEE 1999).

This entitlement raises a considerable number of issues including the availability of hardware and software, teachers' own knowledge and skills development, progression, differentiation and assessment. This paper explores a range of these issues and offers suggestions of activities, planning considerations and an agenda for curriculum development and research for the future.

Historical perspective

It is important for teachers new to this area of work to understand that there is a long history of computer control within education. Since the 1960's, the programming language Logo has been used to control 'turtles' on the computer screen and small maneuverable robots. Movement is achieved by writing a series of statements and saving them as a procedure.



A simple logo procedure to draw a square

Apart from the ability to enable children to move a 'turtle' around, Logo had a very important role in developing problem solving and thinking skills (Papert 1980). It also allowed children to 'teach' the computer and reflect on the feedback that the computer provides.

A development of this type of software came with LEGO Logo, Co-Co (Commotion) and similar software that allowed the user to control electrical components such as motors, lights and buzzers using an interface box linked to the computer. The Logo-based language used for this type of software was difficult for young children to understand and use effectively. For example:
To display
Talkto (motora sound b)
Onfor 40
End.

The only control that primary children could realistically engage with was by using floor turtles such as the Roamer (www.valiant-technology.com).

Five year olds learning to program the Roamer

What was needed was the development of more visual and easier to understand software that could be handled in simple stages. Several manufacturers have been developing control software marketed for educational use, although only a few programs have been suitable for primary school aged children.

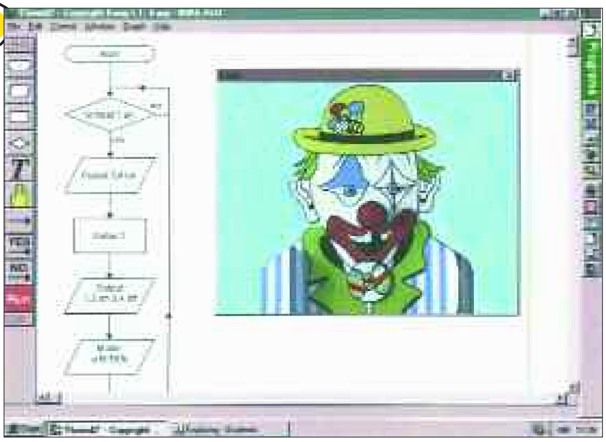
Recent developments

Control has always been about a series of changing events which can most easily be thought of as story telling. When using a Roamer, children could give a verbal description of its movement and even pretend to be the Roamer in order to illustrate what they thought would happen.

One stage on from programming the humble Roamer is to use a control box such as LEGO's Control Box or the more recent and simpler Learn and Go (Data Harvest). These battery/mains boxes can store a sequence of up to 32 actions, and allow children to control 6v components such as bulbs, motors and buzzers, and record a series of actions that can be played back. It. They are easy to use and do not require connection to a computer.

Software

The development of control software that uses pictorial flow charts, rather than text, has made control a lot easier. Programs such as Flowol (Data-Harvest) or RoboLab (LEGO) are extremely easy to use and have enormous potential for use by primary age children. Flow charts are constructed from building blocks with limited choices of command. Although there is no feedback the software has other strengths such as the ability to simulate control situations on-screen.



The clown mimic can be controlled on screen, and an actual similar looking model with electrical components is also available which can be controlled

Possible activities

Simulation

With the introduction of mimics by a number of software providers (most notably Data Harvest with their product Flowol), it is now possible to enable children to control simulated situations. An advantage of this, is that the process of developing children's understanding of control is possible for most teachers and is easily affordable. Another advantage is that where schools have a computer room or several computers available close together, a large number of children can learn to use the program at the same time.

A disadvantage is that there are a limited number of mimics available. Another is that the children's experience is limited to what happens on the screen, and it is important that teachers recognise the importance of children proceeding onto making actual components function.

Using kits

Pre-made models, and kits of components are produced by several companies that can be used to put together pre-defined models or to work with particular software. Advantages are that these are more likely to work successfully and guidance on developing the flow chart is supplied. They are also useful as focused practical tasks in developing children's knowledge, skills and understanding in using the control programs.

The disadvantages are that the models are not the result of children's own design and making, and there is a danger that children will miss out on the opportunity to research, design and make their own products using electrical and mechanical components.

Beyond kits

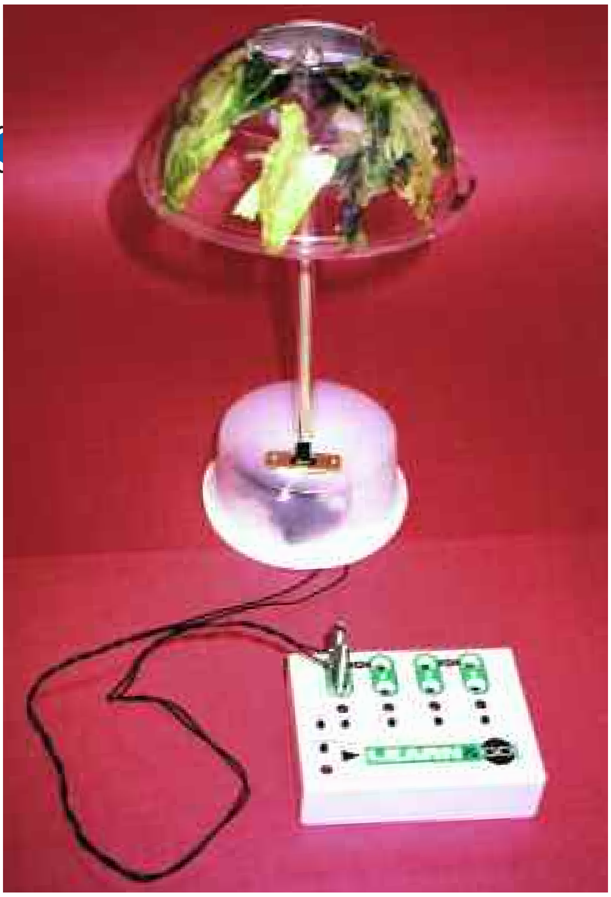
The real potential of control, in design and technology education, is in enabling children to control what they have made. This has been demonstrated by students in their third year of the BA(Hons) with Qualified Teacher Status (QTS) degree course at UCE. Students built their models to work initially with switches, and then linked them to an interface box to program a sequence of events.

Model playground with equipment controlled through the use of a control box linked to a computer

QCA Scheme of work

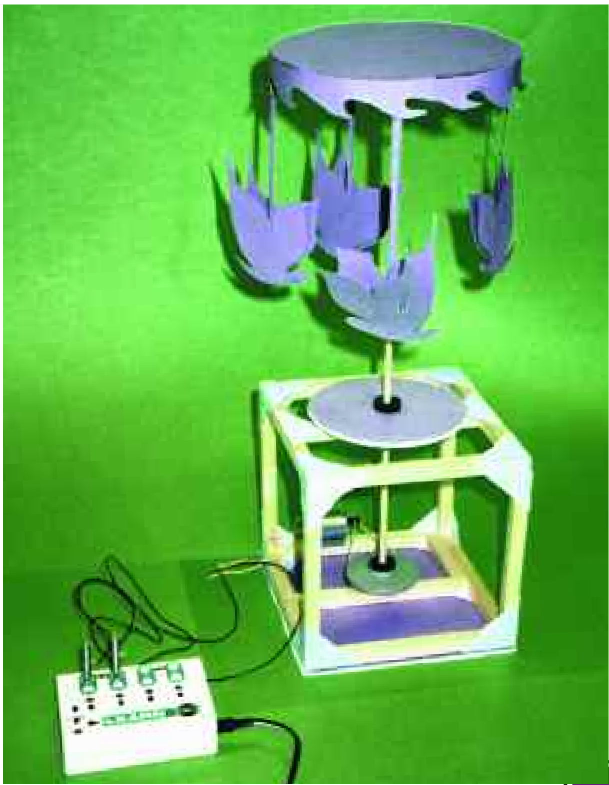
In 1998 The Qualifications and Curriculum Authority (QCA) published Schemes of Work for both design and technology, and information and communication technology for Key Stages 1 and 2 (5-11 year olds). These include suggested units of work for each year group, although these can be adapted depending on the ability of the children. Although it is not compulsory for schools to follow the scheme, most schools are using it either as a whole, in part, or by adapting units to suit their own school's needs. Several of the Key Stage 2 units of work incorporate computer control activities:

The Year 4 (8/9 year olds) D&T unit '*Lighting it up*' provides children with the opportunity to research, design and make a battery powered light for a specific purpose such as a providing a light source to read by at bedtime. The light can be initially operated manually, although with the appropriate equipment children can then write a program to control the light. Tasks can be set such as 'can you make the light stay on for three minutes?' An extension of this activity is to incorporate a light sensor as an input device to turn the light on and off depending on the external light level. Another Year 4 D&T unit is '*Alarms in*' which children can design and make an alarm for a specific purpose.



Battery powered light being controlled by a 'Learn and Go' box

For Year 6 (10/11 year olds) the related D&T units are *'Fairground'*, and *'Controllable vehicles'*. As with the light, children can initially control their models manually using switches. A motor can be used to turn the ride using a pulley mechanism, and lights and buzzers can be used to add extra features. By controlling the output devices separately the ride can be programmed to operate the output components in a sequence, and an input device such as a pressure switch can be used to start/stop the ride. The children can also operate their models using Learn and Go, and/or then go onto controlling their work in a more sophisticated way using the computer linked through an interface or control box.



Fairground carousel being controlled by a 'Learn and Go' box

Fairground carousel being controlled by a computer linked to the model through an interface / control box

Challenging control

Purpose?

It is particularly important, with control in design and technology, that a clear purpose is established. If the aim of the activity undertaken with children is just to learn how to use the software then it is effectively ICT that is being taught. Enabling children to explore a context where a control outcome might be useful will make sure that the software is used as a tool and not an end in itself. It is where children control a product that they have researched, designed and made that the real links between ICT and D&T are exploited.

The very nature of control technology asks some significant questions of design and technology. For example, must control activity always involve making a product, how about a system or an environment? Establishing suitable outcomes for design and technological activities that involve control need to be explored and disseminated.

Social impact

Technological systems literally control our lives and children need to be made aware of the social implications of control, both historically (such as the mechanisation of spinning and weaving) and potentially for the future. Consequently there needs to be some discussion of implications alongside the fun of making something work by itself.

'Through the use of a simple interface, children can begin to appreciate the way in which the computer can be used to replace a switch box and a human operator.' p 132 (Blythe et al 1996)

Where is this discussed in the curriculum? Skills and knowledge, related to control, are expected to be imparted to our young people but where is the critical awareness of such technology developed? We are in danger of promoting and passive and deterministic view of technological development, where technology is seen as inevitable? There is a need to challenge pupils' perceptions of the role of control when designing and making?

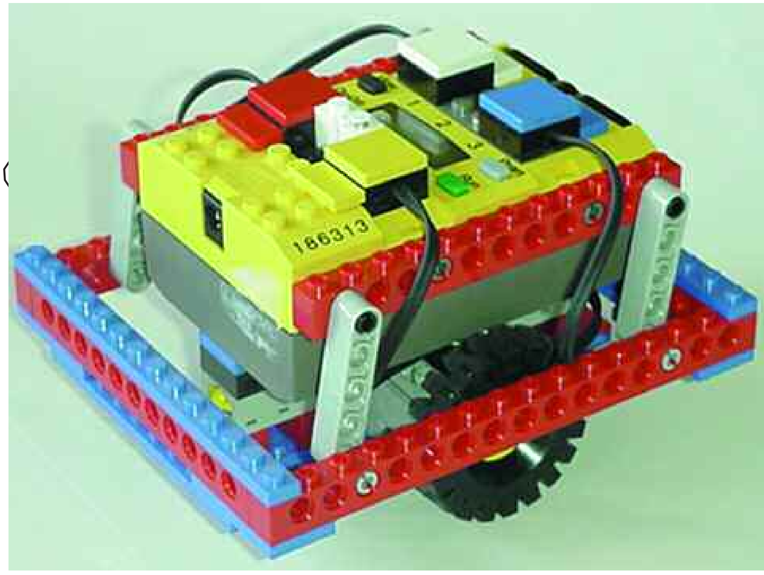
Curriculum development

There are a number of issues to be considered by organisations responsible for curriculum development including The Qualifications and Curriculum Authority (QCA). The include progression, assessment, staff development and funding for software and hardware.

Progression

Before children are introduced to actually using a computer to control products with electrical components, there is a level of progression by which the children should develop their skills, knowledge and understanding of the concept of electrical control. Using a computer to control devices should ideally build on children's earlier experiences with programmable items such as Roamer and programs such as Logo. It is also important that children should understand how to make a simple circuit and be able to control electrical components manually. With any activities involving electricity (even low voltage) it is important to explain about the hazards of using electricity and the need for suitable safety precautions.

One of the problems which teachers soon find when they are introducing children to computer control, is that children like to build models (eg vehicles) which they want to operate some distance from the computer. The distance that this can be done is limited by the length of wires linking the model and control box. LEGO produce 'Robolab' that is slightly different in that a large electronic version of a LEGO brick replaces the need for a control box. This 'RCX' brick can be incorporated into a larger model (such as a buggy) using other LEGO components. Once a control procedure has been written on the computer this can then be transmitted using an infra-red link to the model. Because the brick contains batteries the model can be operated independently from an external power supply and its range is not limited by the length of electrical leads that usually link models to a control box.



Bumper car constructed using the LEGO Robolab RCX reprogrammable brick and components

Professional development

Since 1998 The National Grid for Learning (NGfL) initiative has been funding the introduction of computers and internet connections for schools. Although this has not targeted funding for control resources, the fact that schools now have more, and higher specification computers clearly should enable teachers to introduce control activities once the software and specific control resources have been obtained.

Research based on interviewing participants on three 10 day D&T In Service Education and Training (INSET) courses held at UCE for serving teachers between October 1999 and May 2001, has shown that very few teachers are familiar with computer control. Considering that children now have an entitlement to learn about this area this shows that there is a real need for ensuring that control is included in initial teacher training (ITT) courses, and that appropriate INSET is available for serving teachers.

Research

With the inclusion of a statement about control in the National Curriculum, the obvious question is where do teachers look for information? Beyond the manuals and booklets provided by hardware and software companies, there is very little guidance available. Certainly in the Journal of Design and Technology Education (published by DATA) and International Design and Technology Education Research and Curriculum Development (IDATER) Conference proceedings, there has been no published research on the use of computer control technology in the primary phase.

Future research agenda

There are three significant areas of research that need to be explored in order to throw light on the role of computer control in primary schools. Firstly, that which relates to teachers' skills and knowledge, fears and expectations. Secondly, looking at how children use hardware and software. Thirdly, there is a need to research implementation issues such as classroom organisation, appropriate management style, resources required, progression and assessment.

One of the most exciting areas of research will be the exploration of possibilities. What can primary children actually achieve? To what extent are they able to control complex systems and develop their understanding of how things work in our controlled world?

To answer some of these research questions, staff of CRIPT are planning to work with children and their teachers on control projects in the forthcoming year.

Conclusion

Computer control is likely to be a significant feature of children's design and technology education in the future. It is, we believe, here to stay. What has emerged from the exploration of the area undertaken through this paper, is that we need to be clear about the purpose of undertaking controlling activities with children in primary design and technology. The way in which it is taught will be crucial to develop children's education and, as usual, the role of teachers' professional development is key.

Simply making a mechanism that can move is an achievement for children. Controlling it by computer for a purpose brings it to life and links what children do in school, and to their lives outside in a fun, interesting and relevant way.

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- MSW Logo (free software)
  www.softronix.com/logo.html
- Papert
  www.papert.com
- Valiant Technology
  www.valiant-technology.com

Technology education comes to Khayelitsha through ORT-STEP

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Introduction – What is ORT?

ORT (The Organisation for Educational Resources and Technological Training) is the largest non-governmental education and training organisation in the world. ORT was founded in Russia to train Jewish communities in basic skills and trades with the aim of restoring dignity and independence in the face of oppression.

ORT extended its educational horizons to developing countries in need of technological and career skills. These initiatives have been undertaken in full consultation and creative partnerships with communities concerned, in order to promote the principles of self-sufficiency and sustainability.

ORT-STEP Institute was established in the Western Cape in 1994 and began training in Khayelitsha in 1999. They are the only Institute to deliver technology education training in Xhosa.

The Khayelitsha project

Background

Khayelitsha, Cape Town's largest African Township has a population of a million people, predominantly Xhosa speaking who are crammed into iron shacks in conditions of poverty. Khayelitsha is situated 28km from the central Cape Town and is bordered by the N2 in the North, False Bay in the South, Mitchell's Plain in the West and Kuils River in the East. Schools are overcrowded with the average class having 50 learners.

Figure 1 Map of Western Cape – Khayelitsha area

Educators whose teacher training lacked basic skills and who are using the chalk and talk method of teaching are obliged by the concept of Curriculum 2005 to implement Technology Education in their classrooms.

To many educators technology education means computers or man in space, certainly these are some aspects of technology but in fact this is a limited view. Technology education combines the skills, knowledge and attitudes used by human beings to tackle the problems. Problem solving is at the heart of technology education, but to handle problems effectively the technological method is required. The emphasis of the technological process is more important than the end product, which enables the educators to become critical thinkers and problem solvers. The education received by black educators under the apartheid regime lacked all of these criteria.

ORT-STEP, therefore, addresses one of the greatest challenges facing this country to develop, empower and equip the under qualified educators to provide effective technology education and prepare today's learners for the world of tomorrow. The ORT-STEP training promotes personal growth, confidence and competence. Once the educators have acquired these skills and attitudes they become valuable to both the education system and the community in which they live.

Year 1999 – Group 1

ORT-STEP came to the rescue of frustrated educators who feared Outcomes Based Education (OBE) by starting a project in Khayelitsha on the 22 July 1999. Isiphiwo Primary School, where the project is run, is in the middle of an informal settlement where there is not even a sign of trees. The whole area is covered by soft beach sand, which becomes unpleasant for outside activities. The school has all the necessary facilities as far as accommodation is concerned, but no equipment. The proud parents, who are mostly unemployed, take charge of guarding the school against vandalism. A donor was kind enough to sponsor the project with a fully equipped technology room. An independent sponsor provides the salaries of the two lecturers. A third donor sponsors the educators by paying $^{2}/_{3}$ of their course fees. This made the impossible possible.

Khayelitsha is divided up into five sections and one school from each section was selected to become part of the project. The first group of 23 educators was selected from these five schools. Two educators from the foundation phase and two from the intermediate phase were introduced to technology education. Technology by its nature is outcomes based and so the training laid a solid foundation because it offered educators both the theory and hands-on practical skills. These educators had no knowledge of tools and equipment and could not even handle a junior hacksaw. By the end of the foundation course the educators were able to investigate, design, make and evaluate models of various kinds.

Table 1	
Number of educators enrolled	23
Number of drop outs	3
Number of educators who completed the 300 hour course	8
Number of educators who have not yet completed the 300 hour course	12

Table 1 1999 – Group 1

Year 2000 – Group 2

In 2000, 21 self-motivated educators from different schools in Khayelitsha heard via the bush telegraph about the training and enrolled in the project. Most of them are language educators who did not have any basic practical skills as far as technology education is concerned. These are the proud educators who are going to complete the course by the end of June 2001. They have motivated their learners to collect waste materials, which they use for their projects. It is thrilling to note that this learning is passed on to many learners in the classrooms.

Figure 2 Learners at work on a technology education activity

Year 2001 – Group 3

High school educators felt the pinch of not knowing what to do in the classroom as far as technology education is concerned. Principals buy technology textbooks and appoint educators to implement technology education in their classrooms. Some educators, out of desperation, simply apply their craft skills, which they then call technology education. Out of 13 educators enrolled in this group, 11 are high school educators. We are proud to say that by now many educators know the difference between a technology lesson and a craft lesson!

Achievements

- 17 out of 33 primary schools in Khayelitsha are involved in the project
- These educators can distinguish the difference between a craft and a technology lesson
- Some primary schools have been confident enough to enter the provincial competition in technology education run by Sanlam
- Penny Hoffman who graduated last year will present a workshop on working with corrugated cardboard at a mini conference in Cape Town on 12 May 2001
- ORT-STEP now offers an ACE (Advanced Certificate in Education), which is accredited to Rhodes University and some educators have enrolled for this qualification.

Problems

- Educators do not pay their fees in time, the amount accumulates and they become frustrated and demotivated
- Some do not attend lectures because of memorial services that they have to attend
- Some attend lectures at other institutions, which clash with the ORT-STEP programme, and the workload becomes too much
- Some do not attend when their friends are not attending
- If lectures fall on pay day the educators go shopping and to pay accounts
- Some educators would still like to see a white face to believe how creditable the course is
- The lack of resources in schools makes it difficult to be ambitious and start technology projects in schools.

Conclusion

While there have been problems in the implementation of the course in Khayelitsha we have seen a slow but steady change in attitude amongst the educators. As the educators are sent on many INSET (in service teacher training) courses that do not always benefit them in the classroom, they have become sceptical of the value of courses offered. The successes now outway the failures as educators realise the value of learning about technology education to both themselves and their learners. ORT-STEP will continue to deliver the training in Khayelitsha with the help of donors.

A Question of Questioning: The extent to which teacher – pupil interaction, during practical problem-solving activities, promotes the development of top junior aged children as 'reflective practitioners'

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Introduction

This study is focused on a consideration of the extent to which teachers use 'metacognitive questioning' (see below). More specifically, to examine the ways in which teacher questioning encourages pupils to self-interrogate-monitor their own thoughts or actions, to engage in verbal monitoring-challenge the suggestions or progress of others, evaluate developing lines of thought or action and identify, clarify and justify alternatives. In short, to act as 'reflective practitioners': to 'think' before 'doing'.

Classroom observation is be concentrated on teacher-pupil dyads, during small group collaborative work. The notions of 'metacognitive questioning' and 'reflective practice' are referenced to an analysis of data from transcribed video/audio-recordings, field notes and post observation – stimulated recall sessions with classroom teachers.

To date, whilst acknowledging the probability of other questions/hypotheses emerging, the following underpins the research undertaken:

- To what extent are teachers utilising 'metacognitive questions' as a means of encouraging reflective practice in the context of the designing phase of design and technology activities?
- In what ways is 'reflective practice' evidenced in pupils' verbal responses and or practical actions?
- Where limited 'reflective practice' is noted, what are the observed consequences in terms of pupils' thinking and action? And, how do these differ from contexts in which pupils are being encouraged to act reflectively?
- What might some of the reasons be for teachers' limited use of 'metacognitive questioning'?

Coupled to this line of practical inquiry is a consideration of the ways 'metacognitive questioning', can be seen to be linked to the notions of the 'zone of proximal development', 'scaffolding' and 'contingent teaching'; themselves connected to the development of pupils' associated procedural and conditional knowledge.

Key Concepts

Metacognition, Metacognitive Questioning and Reflective Practice

At the outset of this section I would wish to note that I have come to view 'metacognitive questioning' and 'reflective practice' as mirror images.

Many authors (Gilhooly 1990, Adey and Shayer 1994, Hacker 1998 Meadows 1999) have developed definitions related to what Schraw (1998) sees as two major forms of metacognition: 'knowledge of cognition' and 'regulation of cognition'. The first, Schraw suggests, is connected to the notions of declarative, procedural and conditional knowledge, whilst the latter to planning, monitoring and evaluating. However, he saw these aspects as closely related and, in the context of design and technology this might be exemplified as follows: whilst planning ahead: selecting a particular strategy or skill (procedural / declarative knowledge), a pupil could be encouraged to clarify and justify related decisions (conditional knowledge) – how, when and why issues.

All definitions considered to date shed light upon the importance of reasoned judgements, decision making, monitoring, selection, alternatives, evaluation and forward planning. These issues can be referenced to a pupil's ability to recognise and deal effectively with salient problem features or what Beradi-Coletta et al (1995) refer to as 'critical task components'. For them,

'answering a question such as 'why did you do that?' invokes a shift in attention from focusing on aspects of the problem itself to a focus on what one is doing to solve the problem. Solvers must take themselves out of one mode of processing – the problem level – to another – the processing level – and observe themselves as a problem solver.'

Fisher (1998) argues that metacognitive thinking is a key element in the transfer of learning and that teachers have a key role in mediating children's use of metacognitive strategies. Elsewhere, Fisher (1995) talks of the need to engage children in active learning situations where they are aptly challenged through teacher questioning that stimulates levels of high cognitive demand.

This brings me to the notion of metacognitive questioning. Mevarech and Kramski (1997), noted that control and regulation are to do with decision making in terms of 'when, how and why to explore a problem, plan a course of action, monitor one's own actions and evaluate one's own progress' (p.368); arguing that 'metacognitive questioning' helps pupils to develop these aspects. An example, is questions, that seek to have pupils explain their main lines of thought or intended mode of operation. Similarly, Dominowski (1998) suggests that encouraging individuals to 'reflect', to justify intentions often results in improved task performance. Likewise, Gagne and Smith (1962) note that,

'requiring subjects to verbalise during practice has the effect of making them think of reasons for their moves'.

'Metacognitive questioning' will, at times, be seen to be closely related to 'cued elicitation' (see below) but only when related visual or verbal clues seek to prompt pupils to 'think' before 'doing' yet still leave them with the responsibility of resolving associated sub-problem.

Thus, 'metacognitive questioning' is to be seen as a form of questioning that encourages children to:

- Identify, clarify and justify alternatives
- To plan ahead
- To evaluate their current position, thoughts and actions and

- To demonstrate an ability to monitor their own or other's suggestions and progress.

Whilst the nature of teacher questioning is in part mutually generated I would contend that it need not necessarily reflect typical 'authority relationships' within classrooms. The argument here, is that teachers may not be acting as 'more knowledgeable others' in terms of their perceived confidence in relation to subject specific skills, declarative, procedural or conditional knowledge. Rather, their willingness to promote autonomous learning, through forms of questioning that require higher order thinking and, in particular, 'reflective practice', is considered essential to pupils' efficient practical problem solving.

As a 'mirror image' of metacognitive questioning, pupils' will be adjudged to have operated as 'reflective practitioners' if they are observed to utilise decisions and actions stemming from measured deliberation. In short, to demonstrate the 'metacognitive skills' of:

- planning ahead
- monitoring the suggestions or progress of oneself or a peer, including cross checking demonstrated by aspects of doubt / a willingness to challenge views etc
- evaluating in terms of judging one a line of thought or action against another
- identifying, clarifying and justifying alternatives.

Reflective practice can now be linked to concepts outlined at the beginning of the paper:

- *Self Interrogation* — *Monitoring ones own suggestions or progress*
- *Verbal Monitoring* — *Challenging thr suggestions / progress of others evaluating lines of thought oe action identifying, clarifying and justifyingh alternatives*

Rationale

The newly published National Curriculum for Design and Technology in Wales (2000) states that pupils should:
'develop and apply their skills of asking questions, making predictions and coming to informed decisions' (p.5)

The National Curriculum for Design and Technology (1999) that the subject should provide opportunities to promote 'thinking skills' (p.9)

Robert McCormick (1999), discussing the link between 'procedural' and 'conceptual' knowledge stressed the importance of teachers encouraging what he termed 'qualitative reasoning' as an aid to effective 'designing' and 'problem solving'. For him, practical knowledge is qualitative in nature and is,
'not just to do with how situations are described but how actions are reasoned about.' (McCormick and Paetcher 1999 p.127).

Hunkins (1996) suggests that students engaged in reflection will probe themselves or their classmates to determine why particular statements are being advanced. And, lastly, Kimbell et al (1996 p.31) have argued that:
'Design and Technology not only enhances the thinking and decision – making powers of young people, it also enhances their conscious awareness of those thought processes. They not only learn to think and make decisions, they also know (and can see) that that is what they are doing.'

In this context, teacher-pupil interaction, as a catalyst for pupils' disposition toward 'reflective practice' and their developing ability to think for and by themselves is critical here and reflects, in the case of 'autonomy', a well-established position. Indeed, since the late 1970's many authors (Alyward 1973, Eggleston 1976, Kimbell 1982), have referenced the notion of responsible and autonomous decision making as one of the key aspects of the learning associated with children's interaction with the design process. Importantly, as Kimbell (1982) noted,
'there is no magical point at which children suddenly become capable of thinking for themselves, for this is a quality which develops gradually as a result of continued experience.' (p.15)

Furthermore, he also saw the function of the teacher as one of 'scaffolding' this process, by:
'Steering children towards the goal of independent thought and action along a tortuous path of guided or supported freedom.' (p.16)

Whilst I am not wishing to suggest that teacher questioning is the only stimulus to autonomy I do believe that teachers' verbal interventions are significant. As Kimbell (1982), quoting Downey and Kelly indicates:
'judicious questioning serves to orient the child towards phenomena that might otherwise be overlooked or even taken for granted. This kind of questioning is very different from that employed by teachers who merely want to find out whether a child has learnt (or can repeat) what he the teacher has just said.' (p.22)

Ritchie (1995 p.40) also indicates the importance of:
'asking the right questions at the right time, encouraging the child to explore ideas further and clarify existing ideas, making appropriate interventions to challenge existing ideas'

However, doubts have existed for sometime as to how well this 'effective questioning' is carried out in practice. Her Majesty's Inspectorate (cited in Fisher 1987) and others (O.D.W. Hargie, cited in Stubbs and Hillier (Eds.) 1983, David Wood, cited in Norman K. (Ed.) 1992, Bennett 1994, Cecil 1995 and Davidson & Sternberg 1998) have expressed concerns about children being insufficiently challenged by a preponderance of questions, often closed in nature, invoking lower order thinking skills; a lack of encouragement to exercise initiative; and restrictions in working towards their own problem solving solutions as a means of developing inquiring minds and reasoning skills and inadequate time to provide answers prior to more direct forms of teacher intervention.

Whilst acknowledging that effective and efficient 'questioning' is neither straightforward or easily managed, if used effectively, it should offer, as Socrates promoted, the possibility of motivating, sustaining and directing the thought processes of pupils.

The importance of reflection

Raths et al (1986) suggest that the prime concern of teachers should be teaching children 'how to think' and that 'reflective thinking' is at the core of teaching for thinking interactions (p.171). I would argue, moreover, that encouraging a disposition towards reflection, a willingness to be self-critical, is vitally important for capable, practical problem solving. As Raths also notes that 'reflective thinking' is linked to the notion of 'suspended judgement' (p.160), the gap between the recognition of a problem and one's response. Thus, the importance of giving time to reviewing one's current state of affairs is crucial to the effective development of solutions. Dewey, cited by Max von Manen (1995) noted that, 'reflective thinking' is important not only as a tool for teaching, but also as an aim of education, since it enables us to know what we are about when we act. Burden and Nichols (2000 p.300), related it to pupils' ability to break down and solve problems and to 'think before rushing in'. In similar vein, Jeni Wilson and Lesley Wing Jan (1996) have suggested that in order for children to become active and responsible learners (willing to make their own decisions, choose appropriate strategies, assess their own work and set their own goals) they need to become aware of and control their thinking processes. For them, 'reflective processes' are an essential ingredient of effective teaching and learning, providing children with opportunities for analysing and making judgements about the progress of their own work.

Lastly, Matthew Lipman (1991), contrasting the standard and reflective paradigms of the educational process, notes that in the latter, students should be expected to be 'thoughtful and reflective, and increasingly reasonable and judicious' (p.14). Indeed, Lipman suggests that if we are to be concerned with education for higher order thinking then curricula and pedagogies should aim to 'educate for judgement and deliberation'. (p.51)

The importance of language in the classroom, particularly teacher questioning

Questioning, as many authors highlight (Brown G & Wragg E C 1993, Dillon J T 1988, Harlen W (Ed.) 1985 Hunkins F P 1995, Strother D B 1989, Wilen W W & Ambrose A C Jnr 1986, Wilen W W 1987, Winne P H 1979) is a fundamental constituent of everyday classroom practice and influences the level of student thought and action.

As Wilen (1987 p.9) notes,
'in many respects, the primary effectiveness of the teacher lies in his or her ability to stimulate and guide students' thinking and involvement in interaction related to topics, issues and problems'.

This is defined, succinctly by Harlen (1985), who recognises that the purpose of teachers' questions should be to promote children's activity and thinking. These include 'what if types' of questioning that may require, amongst other things, the need for predictions in relation to practical outcomes. Closely associated are 'can you find a way to' questions and 'reasoning questions' that seek some form of explanation. The latter, usually pre fixed by 'how' and 'why' should, in Harlen's view, be used most thoughtfully as, whilst they do in part seek reflection, pupils may feel that a model answer is required and therefore resist responding. Without doubt, as Brown and Wragg (1993 p.3) indicate, the reasons for asking questions, in cognitive and cognate terms are to,
'stimulate recall, to deepen understanding, to develop imagination and to encourage problem solving'.

Effective questioning, then, should be seen as a key element in relation to efficient practical problem solving and the learning that takes place during associated activities. Indeed, in social constructivist terms any lack of purposeful discourse would seem, at least in part, to work against the view that learning is optimised through talk in co-operative settings and, as such, teacher's talk, particularly questioning strategies, requires thoughtful consideration if the suggested optimisation in Design and Technology activities is to be achieved.

For Mercer (1995), knowledge is shaped primarily as a result of 'peoples' communicative actions' (p.19) and 'questioning' can be seen to be an important vehicle as a means to this end. In describing ways in which teachers attempt to guide learning he refers to the notion of 'cued elicitation', the drawing out of information, in 'learner-centred ways', using strong visual or verbal clues – in essence, asking questions whilst simultaneously providing heavy clues to the information required, in terms of providing 'right answers'. In relation to aspects of designing 'right answers' should be seen to equate to strategies, emanating from the pupils, which will move them towards an optimised solution to the problem in hand. This said, for Edwards and Mercer (1987), cued – elicitations are a form of initiation – response – evaluative feedback exchange, often referred to simply as IRF, through which: *'pupils actively participate in the creation of shared knowledge'* (p.142)

In the context of my current research 'shared knowledge' is viewed in terms of both pupils and teachers recognising the benefits of 'reflective practice', and its associated links to the effective use of both 'procedural and 'conditional' knowledge. However, cued elicitation will only be seen as a form of 'metacognitive questioning' when related visual or verbal clues seek to prompt pupils to 'think' before 'doing' yet still leaves the need to resolve sub-problems, in a creative way, with the child.

What remains important to the research study is the hope that by encouraging 'reflective practice', in seeking to promote children as critical purveyors of alternatives, forward planners and evaluators and monitors of their own and others' thoughts and actions, they will be more able, through reasoned judgements, to move toward the optimisation that underpins 'good' design.

Broader Links to the notion of 'Thinking in Education'

Berardi-Coletta et al (1995 p.222) have recommended that, *'becoming aware of what one is doing and why, need to be emphasized when problem-solving skills, in any domain, are being trained'.*

Whilst I do not see the focus of my research in terms of 'training', per se, I am setting out to assess the extent to which pupils are encouraged toward the disposition of 'reflective practice', as part of teachers' standard classroom practice during practical problem solving activities, and indirectly, in broader terms, the extent to which 'thinking in education' is being supported. As such, appropriate teacher-pupil interaction within the context of Design and Technology activities ought to be able to support what are termed, 'infusion approaches' – the development of thinking skills across the curriculum where context are identified in which particular thinking skills and strategies can be effectively developed

For McGuiness and Nisbet (1991), the acquisition of thinking and problem solving skills should be seen to be an accepted primary aim of education. Moreover, such thinking, in developing what they refer to as aspects of self-regulation, should help to promote a child's use of metacognitive processes including 'orientation, planning, monitoring, self-testing, reflecting and judging' (p.176). Indeed, for them, 'good strategy users', need to be 'reflective'

What is of further importance here is the more direct relationship between thinking skills programmes, of whatever type, and the development of children as autonomous decision makers. As McGuiness, in Gilhooly (1990) notes, most thinking skills programmes seek to develop metacognitive activity to varying degrees and, furthermore, highlight the importance of social interaction relative to cognitive change.

Theoretical Background

Fisher (1998 p.2) identified an important association between 'reflective practice' and social constructivist theory noting that,

'Vygotsky was one of the first to realise that conscious reflective control and deliberate mastery were essential factors in school learning.

In support of this view Edwards and Mercer (1987 p. 23) citing Bruner, saw 'scaffolding' as the means of aiding a pupil to 'internalise external knowledge and convert it into a tool for conscious control.'

As Maybin, Mercer and Stierer (cited in K.Norman (Ed.) Thinking Voices, 1992) suggest, 'scaffolding' is about more knowledgeable others, 'reducing the scope for failure in the task a learner is attempting'. Here, I would argue that teachers'metacognitive questioning is a means by which pupils' procedural and conditional knowledge develop as a consequence of reflective practice.

In similar vein, Rogoff & Wertsch (1984) note that mental functions, including thinking, reasoning and problem solving can be aided by collaboration during social interaction. They contend that 'scaffolding', is a concept closely related to that of the 'zone of proximal development', and refers to a process in which more knowledgeable others support children in their mastering of a problem. Whilst teachers may not necessarily feel wholly competent in respect of their subject based knowledge and skills, their interactions with pupils can encourage a more measured approach. However, though I may question the role of the teacher as 'expert' design technologist, I am affording recognition of their capabilities, as adults, to develop the importance of 'thoughtful action' based on encouraging reflective practice.

However, Wertsch (1984) has identified limitations in Vygotsky's notion of the ZPD particularly in terms of what constitutes 'problem solving under adult guidance'. Wertsch, therefore, proposed three additional theoretical constructs. Of these, the notions of 'situation definition' and 'intersubjectivity' are most relevant here. With regard to the former, Wertsch argued that within the ZPD adults and children, whilst collaborating, would tend to represent objects and events in different ways. Here Wertsch was referring to objects in a concrete sense, for example, the construction of a replica model. He contests that when, at the outset of such problem solving tasks, children define the task differently from a supportive adult, the consequence will be a variation in perceived 'action patterns', or logically structured solutions. For Wertsch, it is the relinquishing of an existing situation definition, and its associated action pattern, in favour of a new one that is a fundamental quality of movement within the ZPD; a 'qualitative transformation' that, as I understand it, augments pupil's cognitive development. In the context of designing activities, I would argue that the 'objects' referenced by Wertsch should be viewed as the 'products' of thinking leading to efficient action. Moreover, I would contest that it is not simply the differences which may exists between adult and pupil that are an essential prerequisite to the development of appropriate action patterns, but rather a disposition on the part of children to be willing to think before doing, and on the part of the teacher, to use 'metacognitive questioning' as an encouragement to what Wertsch refers to as 'situation redefinition'.

Thus, whilst pupil and teacher may begin at either different or comparatively similar starting points, what is important to the development of an optimal solution is that currently held positions are modified on the basis of reasoned judgement such that, *'the dyad can attain intersubjectivity (an agreed situation definition / acceptance of suggested action pattern)'* (Wertsch, p.13)

Finally, in this section, I wish to turn to the notion of 'contingent teaching'. Roy Corden (cited in K.Norman (Ed.) Thinking Voices, 1992) draws out the connection between a teacher's willingness to operate contingently and a teacher's ability to use interactional dialogue appropriately. Corden notes that in prompting children to 'clarify' their own understanding a teacher is 'scaffolding' their learning. In the context of design and technology such scaffolding should support pupil's developing procedural and conditional knowledge. In essence, what is being suggested here is that when teachers and children interact in the ways outlined above, new schemata, or versions of progress, can be developed as a result of the shared interaction. If one assumes that children will be approaching problem-solving activities with a degree of uncertainty about how best to move forward efficiently then any encouragement to 'think' before 'doing' must, I would argue, be beneficial. Indeed, as Wood (1991 p.106) notes, *'without help in organizing their attention and activity, children may be overwhelmed by uncertainty.'*

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Puppets – Bringing them to life

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Armed with my Design and Technology specialist subject lecture notes, I was looking forward to applying them in the classroom on my first teaching practice in the Summer of 2000. I was placed in St Chad's CE Primary School, in Lichfield, Staffordshire, where I was allocated a year 5 class to work in.

The choice of topic was left entirely up to me, so I decided to look through a range of published materials rather than to develop my own scheme. I selected the QCA Scheme of Work for Design and Technology as it provides a varied range of units with suggested activities and key action points to note and carry out. The QCA scheme focuses on a range of aims and purposes with a strong progression throughout the key stages. The units are divided into year groups, with the learning outcomes highlighted and each individual step outlined.

After some discussion with the class teacher, I found that the only significant design and technology activities which had been conducted previously with the class that year were related to food technology. The unit *'Moving Toys'* was my initial choice, although after looking through the entire collection of units my final decision was *'Puppets'*.

'Puppets' is a unit which has been aimed at year two. However, I was convinced with some adaptation it could become an interesting and exiting project for myself and the children. I began my scheme by revising the objectives so that they provided a challenging target for the higher age range and different ability groups within the class. The objectives needed to be attainable but at the same time not too easy. The individual tasks needed to differentiated, and suitable adult support would need to be arranged.

Puppets – Where to begin?

To broaden the emphasis of the scheme I looked at different subjects throughout the curriculum. One main focus through literacy was drama, and I thought that this would give me an opportunity to ask the children to plan and carry out a performance using their puppets while reinforcing their script writing techniques. With this in mind I designed and put together a booklet to enable the children to record their ideas and findings. The booklet was differentiated by task allowing the children to chose their method of recording either by drawing or writing.

The School provided a range of materials, although there were some resources however which I still needed to collect. The school had some sewing needles but these were unsuitable for the task, but I was able to find donors who provided needles of different sizes that were easy to thread.

I was looking forward to carrying out the scheme but I had no puppets to demonstrate with. During my serial visits I informed the children of the project and asked them to bring any puppets and equipment from home and with permission. Before long I was inundated with cardboard tubes, boxes and puppets of each and every kind. I also decided it would be useful to design and make some teaching aids. I felt that these would help teach skills and techniques and help overcome common misconceptions that the children may have. I found these teaching aids very beneficial during the lessons as I was able to show the children examples on what they could produce when making their puppets. I also hoped that this would avoid the possibility of getting thirty eight 'Pokemon' puppets at the end of the project!

Week by week summary of activities and learning objectives

- IDEAs = Investigative, (Disassembly) and Evaluative Activities
- FPTs = Focused Practical Tasks
- DMA = Design and Make Assignment

Week One (IDEAs and FPTs)

- (IDEA) Look at puppets? What is used to construct the puppet? How does it work? What do you like about it? What would you change on the puppet?
- (FPT) Practise and carry out basic sewing techniques including; starting, ending and running stitch.

Objectives

By the end of the lesson the children will;
- Be able to examine and discuss a selection of hand and finger puppets
- Be able to practise basic sewing techniques including; starting, ending and running stitch
- Be able to use appropriate vocabulary associated with the use of textiles.

I began my introduction to this scheme as a whole class. Using the teaching aids I had created, as a whole group we evaluated and discussed each puppet. What was similar? What were the main features? The children then moved into mixed ability groupings which I negotiated with the children before the lesson. This method of working was effective it allowed me to rotate around the classroom, offering support where required and to carry out assessment. The children were able to work collaboratively and support each other.

Week Two (FPTs and DMA)

- Begin initial designs of puppet, looking at criteria
- Using paper build a mock up of their puppet, evaluate and discuss with group.

Objectives
By the end of the lesson the children will;

- Know the criteria required for their puppets
- Be able to create and record initial designs for their puppets
- Be able to make a paper mock up of their designed puppet.

This lesson allowed the children to discuss their ideas within individual groups and also approach myself and the classroom assistant with any queries. I began the lesson with some brainstormed ideas and displaying resources that would be available for use. This was very important and it emphasised the fact that although there were varied resources many were limited. Some resources could be used similarly to demonstrate particular ideas.

The children were shown where to obtain resources at the front of the classroom. They were also shown and expected to use tools safely and effectively.

Week Three (DMA)

- Begin constructing the puppet.

Objectives

- Be able to mark out, select and join materials in order to construct their puppet
- Be able to work collaboratively and safely when using resources.

Week Four (DMA)

- Complete and evaluate puppet.

Objectives

- Be able to successfully complete a puppet within the discussed criteria
- Be able to evaluate their puppet against the criteria
- Be able to present their puppet to the rest of the group.


Left Children proudly showing off their puppets
Right A display of the final products

Although the last two sessions were very noisy (and an organised chaos!) they were actually very productive. The children were motivated, excited about the project and focused on task. They adapted well in discussion and I was also quite surprised to hear children voice opinions and help each other to develop their puppets. A good working environment was developed and I enjoyed working with both staff and pupils.

The last session had a literacy focus, where the children formed into small groups of two or three and devised scripts using their puppets as characters. These were later performed at the 'Local Puppet Theatre' at half price viewing!

Discussion with the children about the scheme was very important. I found that some children struggled with some of wording when relating to tasks. Looking back I realised that some of the wording was difficult for some children. It was also important to reward and acknowledge each child's work throughout the scheme so they could also realise their achievement and also provide guidance for other children.

Action Points for the Future

There are many key points I learnt from this teaching practice. Firstly I appreciated that adequate support for practical lessons is very important. I was very fortunate that after conferring with the teacher I moved the last two sessions into the morning, which enabled more adult support to be available. I recognised that organisation is also very important, and that it is important to think ahead about what materials the children might want to use and anticipate sources, or suppliers. It can also be favourable that if you are completely stuck then ask the children! They are an endless supply of resources!

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A framework for conceptualizing teacher professional knowledge

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Introduction – setting the context

In New Zealand there has been a keen interest in technology education initiatives since the late seventies. By 1988, some proposals for the inclusion of technology as a core curriculum subject had been made but these were overtaken by the 1989 education reforms. In 1992 the Centre for Science, Mathematics and Technology Education Research (CSMTER) at the University of Waikato produced a framework for technology education. This was adopted by the Ministry of Education in New Zealand and went on to form the basis of the draft curriculum statement for technology education.

The (CSMTER) team lead by Dr. Alister Jones won the contract to produce the materials and in 1993, the draft curriculum was published. At the same time a video television series was produced to support the draft curriculum called 'Know How'. It went to air in mid 1994. By 1995, submissions on the draft had been received and the final statement was published in October 1995. Implementation concerns were central to a decision taken by the Ministerial Consultative Group on workloads that met in May 1997; subsequently the revised date for implementation became 1999. This allowed for a facilitation programme to be run nationally. This contract was funded by the Ministry of Education and aimed at supporting the implementation of this new curriculum in schools.

A current topic of debate for those involved in technology education in New Zealand is "what should we teach?" This question may sound strange but technology is such a new curriculum area with no established culture, particularly in the primary school. The debate occurs at a time when the qualifications at senior high school are just being developed and teachers around New Zealand are trying to devise programs, which fit the new curriculum document. The debate is still in the early stages and there are many differing positions. At this juncture no clear direction is emerging. However there is one particular education sector that is being asked to see through the mire and prepare the technology teachers of tomorrow. Currently there are a number of teacher education institutions throughout New Zealand offering courses in pre service technology teacher education. How can they possibly be successful in such a climate of change and uncertainty?

Background to the project

This paper is about one particular institution's work as part of an international project looking at the self-awareness of teacher knowledge in pre-service technology student teachers. This project has developed from earlier work carried out by the Centre for Research and Development in Teacher Education (CReTE) at the Open University in the United Kingdom. There are representatives involved from many institutions. The United Kingdom, Finland, Hong Kong, Australia, Israel, South Africa and of course New Zealand. The work at Massey University College of Education in New Zealand follows on from work carried out in a joint project by the Open University and Brunel University where an empirical study was carried out looking at the impact of an enhanced awareness of teacher professional knowledge on school technology teaching and learning. Both of the Universities in the United Kingdom are engaged in offering initial teacher education courses with a technology focus.

A graphical framework was produced by linking together four clusters of ideas; these ideas came from the curriculum work of Shulman (1986); the cognitive work of Gardner (1983,1991) the interrelated tradition of didactics and pedagogy Verret (1975) and Chevellard (1991) finally from the situated learning developed by Lave (1988,1991).

The outcome of this graphical representation can be seen as a model of teacher professional knowledge (figure 1).

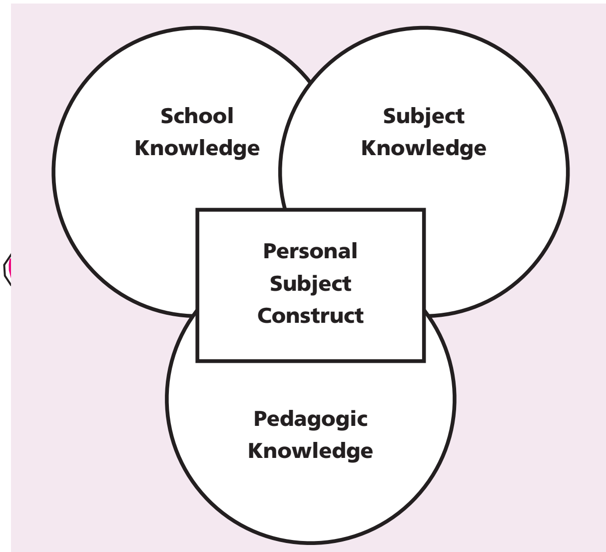

Figure 1 Banks F, Leach J and Moon B (1999), Teachers' professional knowledge

Subject knowledge: can be described as what teachers know of their subject. In technology this can be knowledge about certain aspects of technology such as structures and mechanisms, and also knowledge about what technologists do i.e. their practice and how this relates to society. This knowledge will also reflect the training the subject specialist has received and their personal interest within the subject area.

School knowledge: will include the school philosophy, and any curriculum policy statements that have been developed, the school systems for programme development and assessment, and essentially how the subject knowledge is to be applied in this particular school setting.

Pedagogical knowledge: includes knowledge about learning theories and learning styles. Methodologies for incorporating subject and school knowledge to effect meaningful learning. According to Banks and Barlex (1999) at the heart of this dynamic process are the 'personal constructs'

Personal constructs: are developed by students. Banks and Barlex (1999) describe these constructs as; 'a complex amalgam of past knowledge, experiences of learning, a personal view of what constitutes 'good' teaching and a belief in the purposes of the subject'.

Primary Technology Teacher Education at Massey University New Zealand

Massey University offers a number of teacher education programs. The focus of this paper is the Bachelor of Education (Teaching) Primary. This degree is a prescribed programme of study allowing clear focus on the theories and practices behind learning and teaching in New Zealand primary and intermediate schools. It is a professional qualification and as such the majority of the papers to be studied are compulsory. The degree is a three-year, 300+ points programme. The papers available are divided in to 100, 200 and 300 levels. Some flexibility is allowed to students and they choose their pathway through advanced curriculum electives and also subject studies options.

Every student must do a compulsory 100 level technology education curriculum paper. For most of the students involved in this degree, this forty-hour paper is their only exposure to technology education. There are however a favourable number of students proportionate to other subject areas who go on to take other technology papers. There are two pathways within the degree to gaining additional experience in technology education. Firstly there are additional curriculum papers offered as electives one at 200 and one at 300 level. Each of these papers build on the previous one and together they give a comprehensive overview of technology education in New Zealand.

In addition to the curriculum pathway students can take optional subject study papers. There are five papers available, two at the 100, two at the 200 and one at the 300 level. These subject study papers worth 12.5 points are designed to develop the student's own personal expertise and confidence in the subject area. Currently these papers consist of:

- Exploring technology education 100 level
- Information and communication technology for teachers 100 level
- Materials and construction technology for teachers 200 level
- Food and biotechnology for teachers 200 level
- Technology education resource development for teachers 300 level.

Students involved in the BEd (Tchg) program who are interested in developing their own expertise will select from subject studies papers up to 75 points. 37.5 of these points must be in a common subject area such as technology and will include 25 points at 200 level or higher.

The Massey University study

This empirical study was conducted alongside the delivery of the 300 level subject study paper. Nineteen 3rd year BEd Teaching students at Massey University College of Education were introduced to the graphical representation (figure 1) and asked the following questions:

- What subject knowledge (about technology education) do I have / need to get to teach?
- What pedagogical (knowledge about teaching and learning) do I have / need to get to teach?
- What school knowledge (about ethos, procedures etc.) do I have / need to get to teach?
- What is my personal subject construct?

These questions were similar to those used in the Open University study, the main difference between the two is that the Open University study was carried out with secondary specialists and the Massey study involved primary specialists. That said, the students in the Massey Study had completed a number of papers in technology education as part of their degree, some as many as six. This gave them sufficient background knowledge in technology education to make the study worthwhile.

Results

A range of responses were received with differing levels of sophistication. The students had completed their final teaching practice and most felt comfortable about their school knowledge. This may be due to the organisation that goes on in the university to ensure that students get access to school procedures during their practice. It is also a requirement in their practice portfolios so the students endeavour to find out as much as possible.

Previous technology education lectures included work on stakeholders (see Layton 1993) views of technology education and the students felt that this helped immensely when they were trying to develop their own personal constructs about technology education. A number also reflected on what they identified as my position, thus their lecturer was also a big influence on them. Quite a sobering thought! Recent research suggests that practising teachers' perceptions of technology are very limited and narrow (Jarvis & Rennie, 1996; Jones and Carr, 1992; Jones 1997). This makes the work of pre-service course even more important. The students must leave their programs with robust personal constructs, which are based on both practice and research, if the subject is to be sustainable in schools.

The students felt very confident about their pedagogical knowledge. This again reflects their primary programme where a significant amount of time is spent developing this understanding, perhaps more so than the secondary programme study carried out in the United Kingdom. Trying to create links between their pedagogical knowledge and technology teaching was also a focus of this final course in technology education.

Unlike the Open University study, perhaps the area of most concern was the variety of subject knowledge that was required for them to teach technology. Many of the technological areas mentioned in the New Zealand Curriculum statement;

- Biotechnology
- Electronics and control technology
- Food technology
- Information and communications technology
- Materials technology
- Production and process technology
- Structures and mechanisms.

are unfamiliar to them. Research by (Campbell, et al 2000) supports the view that exposure to what they called 'content' of technology education was important as many pre-service primary students initially express a limited understanding of what actually constitutes technology education. There was however, in the Massey study an expression by those who had taken subject studies papers (papers which focus on particular technological areas and try to develop content knowledge) that at least in those technological areas they felt quite comfortable. This was a marked difference from the Open University where the students in most cases were entering in with a good deal of content knowledge and required just topping up on the areas of weakness.

Most of the personal constructs identified what technology offered in terms of a different approach to teaching i.e. much more student centered involving critical thinking, problem solving and creativity 'thinking outside the square'. This was in contrast to earlier research in New Zealand which had highlighted practicing teachers' constructs as narrowly technical i.e. technology as things or involving practical skill (Jones & Carr, 1992).

What happened next was a bit of a surprise and not really intended at the outset of this study. The students were asked to evaluate a existing school program of technology education in preparation for a major assignment on implementing technology education in a 'new' school. A number asked if they could use the graphical model as a starting point. Working in pairs they went off into schools of their choice to evaluate the existing technology education programs.

The findings of those who used the model were much more focused and more in depth than those who did not. Using the headings from figure one the students categorized and evaluated the information they found.

Subject knowledge: Most of the schools were unclear as to what constitutes technology education. Those that identified activities generally looked at materials technology, food technology, and ICT There was very little evidence of real student centered problem solving; most were very contrived practical based activities, which occurred on Friday afternoons, if at all.

School knowledge: The schools that were involved in facilitation contracts run by the Ministry of Education scored well in terms of technology education policies and unit plans etc. However, it was expressed by students that beyond the paper evidence there was very little teaching and learning actually taking place under the umbrella of technology education.

Pedagogical knowledge: The schools again were quite knowledgeable about different learning styles and some made reference to individual needs. However, students again noted that it was a paper exercise as their lack of content knowledge and personal constructs restricted any real progress in technology education.

Personal Constructs: More than anything else this was the major downfall as far as the students were concerned. Even the people who were responsible for technology in the schools could not articulate a personal construct and those that did were clearly confused between technology education and ICT (O'Sullivan 2000).

Conclusion

It is very difficult to draw conclusions from such a small limited study. However there were clear indicators as to where future research is necessary. The graphical representation in figure one clearly helped the students evaluate their own strengths and weaknesses and in the Massey study helped focus students when looking at actual school practice at a later stage.

Another indication was that where facilitation contracts had been successful in getting the ball rolling in New Zealand follow up work was clearly needed. Those that were touched by the contracts had some understanding, however narrow, but this was not widespread throughout the staff at the school. Comments were made by the students that they felt the technology co-ordinator or designated responsible person was somewhat isolated and working in a vacuum and needed ongoing support and education if things were to change.

The Massey study findings confirm what Banks and Barlex (1999) identified:

The positive impact on pupil learning in technology due to student teachers that are better able to reflect on their practice seems clear from the extracts presented. As McIntyre (1993) suggests, reflection by novice teachers is very difficult. However we believe that this study has shown the framework is a simple yet effective 'way in' to begin the discussion of the different aspects of teacher knowledge. (Banks and Barlex (1999) p. 10)

Although the model was originally intended for use with secondary pre-service teachers, the Massey study has highlighted its value within primary pre-service technology education programs. At the very least the study has shown some potential and therefore the model is worthy of further exploration and research.

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Providing evidence of capability in literacy and Design and Technology in both Year 2 and Year 6 children: alternative frameworks for assessment

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Introduction

In this paper we outline the development of a tool for assessing both literacy and design and technology (D&T) through designing activities. The format for the activities had been successfully used in other contexts, other countries by the Technology Education Research Unit (TERU) team, but with older children, certainly none as young as Year 2 (age 6) (Stables & Kimbell 2000). Although not discussing the evaluation project in detail, as this can be found in the project report (Stables et al 2001), we describe the process of how the format was adapted and developed to provide an assessment tool for literacy and D&T and share our findings in the context of how successful the outcomes were. We argue that the assessment tool used also provided the children with the opportunity to monitor their experience of the way the activities were conducted, providing unique insights into their preferred learning styles and how they viewed literacy and D&T tasks.

Background to the project

In 1999, Middlesbrough Education Action Zone (EAZ) commissioned an education consultant to conduct a two year project which aimed to explore the potential for using design and technology (D&T) related activities as a vehicle for developing children's levels of attainment in Literacy and D&T. The EAZ also commissioned the Technology Education Research Unit (TERU) at Goldsmiths College, University of London, to research into the impact of the development project for the first year (1999 – 2000).

The activities developed and supported by the project were based on the use of 'handling collections' and product analysis, an approach for teaching D&T developed successfully by the team during previous consultancies. In the year being evaluated, the project was carried out with Year 2 and Year 6 teachers from six schools, providing training, resources and curriculum support materials with a small amount of classroom support as appropriate.

The aims of the evaluation

The aims of the evaluation project were to explore the effects of the activities on the teachers and the children engaged in the project. With the children we wanted to assess their performance in aspects of Literacy and D&T. With the teachers we wanted to chart changes in terms of their own perceived confidence and competence in teaching literacy and D&T, and on the way their classroom practice had changed as a result of their involvement with the project. The evaluation of the project also included an exploration into the extent to which D&T and literacy could be effectively linked in the classroom with an inevitable link to the impact of the literacy hour on D&T curriculum time. While we explored the impact on teacher's practice of introducing 'handling collections' as a formal strategy for learning and teaching in D&T through interviews and questionnaires at the beginning and end of the project, our main strategy for assessing changes in the children's performance was through two design tasks.

Using handling collections of pegs, greeting cards and lunch boxes as the focus we asked the children to analyse and evaluate the collection selected. This led the children into designing their own version of this product to suit the needs identified in the brief e.g. a card for a specific person, a lunch pack for a particular sport. This gave the children opportunities to 'utilise (and thus demonstrate) literacy skills embedded within the activity' (Stables et al 2001, p5). The format for these activities, the 'test instrument', was adapted and developed from that used by the Assessment of Performance Unit (APU) team for D&T (Kimbell et al 1991). The APU model was recently developed in assessment projects carried out with elementary teachers in USA (UPDATE, a project funded by the National Science Foundation) and a project evaluating the impact of a technology education project in South Africa (Stables & Kimbell, 2000).

At the start of the year we carried out two activities with each of the project intervention schools ('A' schools), one with Year 2 and one with Year 6. At the end of the year we carried out another two activities with both the 'A' schools and the control schools (the 'B' schools), again, one with Year 2 classes based on greeting cards, the other with Year 6 classes based on the design of snack packs. Each of these activities was planned to last for approximately 75 minutes. There were elements of group work in the product analysis aspects of the task set. However, the activities were predominantly carried out as individual work. We aimed to guide the children through an authentic task which enabled us to work with the whole class, in a relatively short time thereby collecting evidence of the skills the children had developed as a result of the project.

Activity assessment framework

Each activity was structured in such a way that the separate frameworks for detailing D&T dimensions of capability could be used to assess the children's skills. The detail required for the evaluation was more than could be gained by using the National Curriculum Level descriptors, a more subtle differentiation through which we could chart progress demonstrated between and by individuals from the beginning to the completion of the project. To achieve this we developed a series of assessment strands containing characterising statements against which we could mark and cross-mark. An example of this can be seen in the rubric for assessing the children's ability to analyse products. The 'novice' identifies basic features of products when prompted. An 'average' response would be where the child 'can recognise and describe characteristics of familiar products and adopt them in their own designs'. A 'good' response would be one where the child 'can recognise and describe characteristics and functions of familiar products and adapt them in their own designs'. What could be seen as an 'excellent' response is where a child 'shows a good understanding of the features of a product and how these work and can adapt and develop features in their own designing'. This process was repeated with the literacy dimensions as reported by Kelly and Fokias in the Final Report (Stables et al 2001, p 5).

Opportunities for assessing literacy and D&T

As described above, the assessment framework for D&T capability made reference to the National Curriculum Level Descriptors for Designing (DFE 1995), for Design and Technology (DfEE 1999) alongside the experience gained in developing progressive rubrics in previous projects (APU D&T (Kimbell et al 1991), Project UPDATE, NWPTEP Evaluation Project (Stables & Kimbell, 2000). In developing the framework for writing for the project Kelly and Fokias considered the National Curriculum Statements of Attainment for writing (DfEE 1999); the Writing Scales developed by the Centre for Language in Primary education (CLPE 1996) and the Croydon Writing Development framework (Schools Advisory Service Croydon 1995). Included in the framework (with the exception of 'making' with 'planning' included only in the summer testing activities) were the following key procedural aspects of Literacy and D&T (see Table 1: Key Procedural aspects in Literacy and D&T).

Table 1	
Literacy	D&T
Year 2	Year 2
Genre	Generating and developing ideas
Writing for a reader	Communicating
Sentence structure	Evaluating
Spelling	Addressing the task
Punctuation	Planning
Independence	Product analysis
	Identifying and specifying users and needs
Year 6	Year 6
Genre	Generating and developing ideas
Writing for a reader	Communicating
Sentence structure	Evaluating
Spelling	Addressing the task
Punctuation	Planning
Editing and drafting	Product analysis
	Identifying and specifying users and needs

Table 1 Key Procedural aspects in Literacy and D&T

Research carried out by the APU team in D&T (Kimbell et al 1991) identified two dimensions of the process of designing. One, the active dimension (confronting reality outside the head), where action is taken to develop the design idea and the other the reflective dimension (imaging and modelling inside the head), where actions and the needs involved in the task are reflected on (see Figure 1: The APU model of the interaction of mind and hand).

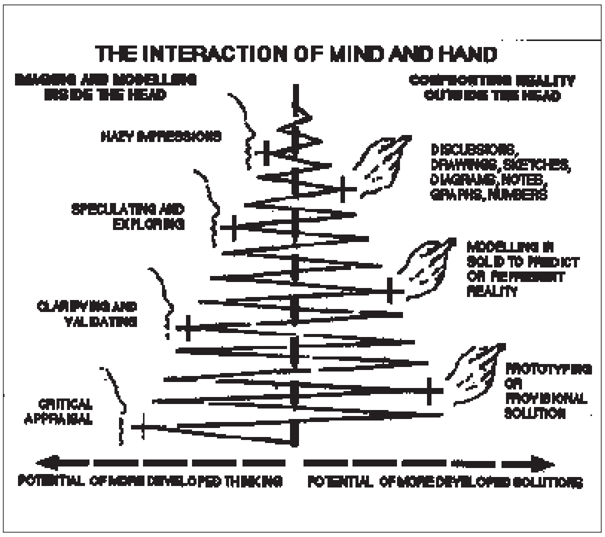


Figure 1 The APU model of the interaction of mind and hand

Of the aspects of designing listed in the framework, three can be classified as active: generating and developing ideas, communicating and addressing the task. Four can be seen as more reflective: identifying and specifying users and needs, product analysis, planning and evaluating own procedures.

Generating and developing ideas

The children were asked to generate ideas based around the products they were evaluating, for example, a peg with a purpose other than pegging clothes on the washing line. Through this we looked for evidence of the children's abilities to propose alternatives which linked directly to the needs of the user, to draw on their own experience and to be bale to modify their ideas. We also looked for evidence of the children's awareness of constraints while they were designing.

Planning

This was a specific requirement of the second activity for both 'A' and 'B' schools where each child was asked to record a plan of how they would make their design. We were particularly looking for evidence of their ability to identify what they needed for making, an idea of sequence and the suggestions of manufacturing techniques.

'get the paper, pencil, scissors, colour pencils, glitter and felt. I will plan design on a scrap piece of paper then draw the front draw the inside' (6A2010). In addition, we looked for evidence of forward thinking and issues raised in other aspects of the booklets, for example, annotations.

Example of child's anotated designs

Communicating

The children were asked to use a variety of literacy and D&T techniques and skills for communicating their ideas. We particularly looked for the children's ability to use labels, notes, sketches, and diagrams to describe, explain or justify their ideas.

Product analysis

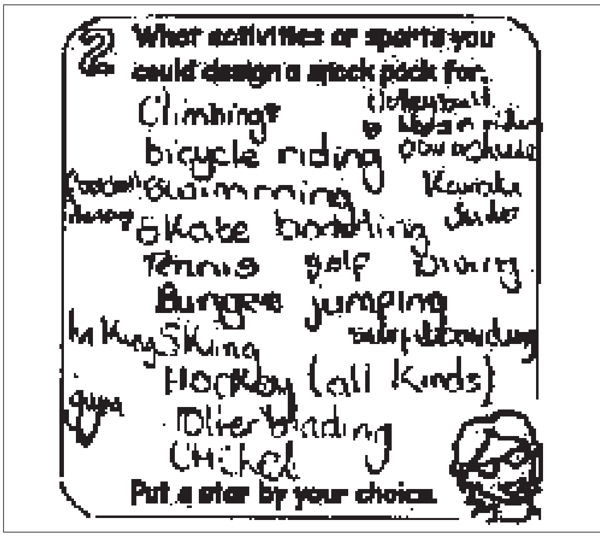
As each activity started with analysing products we looked for evidence of the children's ability to use the skills developed by this experience in developing their own ideas or promoting their product through a poster, letters and publicity flyers. We were particularly looking for evidence of their ability to identify the characteristics of products, describe how they work, identify strengths and weaknesses in the products and use the insights gained when re-designing. An example of this can be seen in the booklet of a Year 6 child who noted that the lunch box analysed did not have an ice pack although it had different compartments for food and drink items. In the design idea produced, the child included an ice pack strapped to the back as well as different compartments. The handle was also developed from the product analysed 'handle so it is like a bag' (5A602)

Evaluating

While the children employed similar skills and abilities in evaluating to analysing products in this aspect we looked specifically at how the children were able to identify the strengths and weaknesses of their proposals. We also looked for evidence of how they had used these insights gained to make decisions about their product.

Identifying and specifying users and needs

As each task required the children to identify who they were designing for, and what the specific needs were of this person or group of people, we looked for evidence that they could make links between the ideas being generated and the needs of the potential users.



Addressing the task

This aspect of the assessment framework allowed us to make a more 'holistic' assessment where we were able to consider how well the children were able to understand the task, make an appropriate response and persevere with the task to a final resolution.

Conducting these activities was carefully structured so, whichever of us led the session, the children would be given exactly the same instructions. To this end we wrote 'scripts' and organised the provision, distribution and collection of resources and equipment down to the nearest minute. In our planning for the sessions we also allowed a short amount of time for the children to fill in an evaluation questionnaire.

Table 2
Year 2 & 6 Evaluation questions to indicate:
• How successful each activity had been by the pupil's terms • Different learning styles • How the children felt about being asked to work as a class on tasks, e.g. brainstorming with class tasks, working on small group tasks followed by their individual design generation.
Additional Year 6 questions to indicate:
• How they felt about D&T lessons • How they felt about reading and writing lessons • How they saw their own ability • If they felt that the activity showed how good they were at designing and writing.

Table 2 Evaluation questions for Assessment activities

The assessment data

The data collected through the activity was combined so that the average performance of each cohort of Year 2 and Year 6 pupils could be compared. It was also analysed for gender differences and tested for statistical validity. An analysis of the data collected from the Literacy Assessments revealed that, although these were less clear than the D&T assessments, in some areas the general trend was for the 'A' schools to outperform the 'B' schools on the second task. The D&T Assessments revealed that the intervention had major impact on the development of capability. There was a significant development in the 'A' schools from September tests to June tests and there was a higher performance of 'A' schools compared to 'B' schools in the second task (Table 2: Significant indications from the assessment activity outcomes).

The two aspects which reveal the greatest difference between the two Year 2 cohorts is 'identifying and specifying users and needs' followed closely by 'evaluating own procedures', both requiring more reflective skills, and developed through the product analysis activities, the central focus of the intervention project. More importantly, the boys in the 'A' schools showed significant development in reflective activities. Comparing this data with the evaluations the children filled in immediately after completing the assessment activities reveals an overall preference of the boys to work collaboratively and the 'A' school boys enjoying working on their own significantly more than the 'B' school boys.

All the Year 2 children enjoyed the activities, the boys and girls in 'A' schools, however, reported greater enjoyment of all aspects of the activity than those in 'B' schools. The children in the 'A' schools produced higher responses particularly in designing and drawing, much less so in doing the writing. Both cohorts of children indicated low enjoyment of writing. The children in the 'A' schools responded more positively to working collaboratively and working on their own.

Comparing the average response to Task 2 of all the Y6 pupils in the 'A' schools with the 'B' schools there are significant differences in each question except writing. While the pupils in the 'A' schools enjoyed writing at the end of the project marginally more than the pupils in the 'B' schools they indicated a higher average response to whether the activity showed how good they were at designing and writing. The response of the Year 6 boys in the 'A' schools is worth noting, particularly alongside the activity assessment data. In all but one of their responses, the 'A' school boys indicated more enjoyment of the activities than the 'B' school girls, particularly in designing and ideas.

Conclusion

As has been demonstrated the assessment activities provided us with a rich database to explore the children's development in literacy and D&T. Their use also allowed us to provide a more graduated and explicit profile of the 'A' and 'B' school pupils than could have been compiled through the standard measures of the National Curriculum level descriptors. As a result of the assessment framework developed for D&T we were able to chart the massive impact the project has had on the children's performance both in active and reflective aspects. The evidence of the development of the more active aspects in the 'A' school girls is of particular interest as is the development of reflection in the boys.

The evaluations carried out at the end of each assessment activity also indicate the need for further studies.

Table 3

	Literacy Assessments	D&T Assessments
The most significant indications for Year 2	• progress in 'writing for the reader', 'spelling' and 'language structure'	• 'generating and developing ideas' and 'addressing the task' from September to June
A schools compared with B schools	• 'genre' – most significant progress from start to end of year in 'A' schools	• 'identifying and specifying users and needs' and 'evaluating own processes' – greatest difference between the two cohorts
The most significant indications for Year 6	• difference in 'writing for the reader' • D&T and Literacy mutually enhancing	• 'communicating', 'evaluating own processes', and 'identifying and specifying users and needs' – A schools growth in own capability
'A' schools compared with 'B' schools	• 'punctuation' – a marked difference	

Table 3 Significant indications from the assessment activity outcomes

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In-Service in Context: Learning Technology with Students in an Elementary Classroom

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Introduction

The Standards of Practice for the teaching profession in Ontario (Ontario College of Teachers, 1999) require teachers to engage in a range of professional development activities to maintain and extend their professional knowledge and skills. These activities may include courses at a Faculty of Education, graduate studies, education conferences, and In-Service in the form of school-based workshops provided by a school board.

The Elementary Science and Technology Partnership (EST) is a three-year project that has, as one of its primary goals, the provision of professional development for a group of teachers implementing a new Grade 1 – 8 science and technology curriculum (Ministry of Education & Training, 1998). This curriculum poses significant challenges for elementary school teachers about how to teach the subjects, how to assess students' learning in the subjects, and how to use the document to plan units of work (Welch et al., 2000; Barlex et al., 2000). This is especially so for those teachers who do not have a science or technology background. EST provides a variety of novel professional development opportunities to help teachers develop the expertise to answer questions for themselves about teaching elementary science and elementary technology.

During its first eighteen months EST has provided a range of professional development (PD) experiences, including design and technology, science, and writing workshops at the Faculty, individual tutorials, and conversations by telephone and email. This paper reports the preliminary results of a study designed to investigate the effectiveness of an In-Service experience given in a classroom while a group of Grade 6 students completed a Design and Make Activity. The study addressed two research questions: (a) To what extent does In-Service given in a classroom context help teachers acquire subject knowledge in elementary technology? (b) To what extent does In-Service given in a classroom context help teachers acquire a pedagogy for elementary technology?

The next section of this paper provides an overview of the literature describing professional development (PD) for teachers. Next, the 'In-Service in context' experience for six elementary teachers is described, along with the method used to collect and analyse data. This is followed by discussion of the results, and the implications of these for future professional development of teachers charged with implementing a new curriculum.

Review of Literature

Single-event professional development activities (e.g., daylong sessions), what Shanker (1996, p. 223) refers to as 'one-shot workshops' and what Little (1993, p. 132) calls an 'implementation-of-innovations' model, are the most frequent form of professional development for teachers. Osterman and Kottkamp (1993) have shown that while such PD may be useful for introducing ideas, it does not facilitate change or noticeable improvements in classroom and professional practices. Furthermore, these single-event activities typically assume an inappropriate stance toward teacher change. They present ideas, give tips, provide handouts, project a certainty about the topic, and assume that the giving and receiving of public knowledge will lead to behavioural change. According to Little (1993) single-event professional development activities 'can, at best, be used to suggest new classroom practices' (p. 156).

A number of crucial elements in effective professional development, that is, development that leads to positive change in the classroom, have been identified. Carney (1998) claims that professional development must provide a challenge to teachers' frames of reference. While new professional demands (e.g., created by the introduction of a new curriculum) can make teachers receptive to new understandings and practices, they may lack frames for these situations and seek help in structuring new routines. Ball (1996) claims that professional development must challenge teachers to investigate, experiment, consult, and consider outcomes: to take a stance of critique and inquiry toward practice. Teachers must use an inquiry and problem-solving paradigm that results in their producing new knowledge, rather that a training paradigm that results in their consuming knowledge.

Carney (1998) also suggested that new knowledge would not likely be learned and applied unless it is situated in relevant contexts. The notion of situated cognition (Brown, Collins & Duguid, 1989) is a basic cognitive principle of constructivist theory. Grossman (1992) argues that this type of learning is important for teachers; they must be able to situate new knowledge and understanding in the specific context of classrooms. Vukelich and Wrenn (1999) believe that professional development should be based on the participants' interests and needs. Cameron (1996) has suggested that professional development must be relevant to actual classroom work and to what students need to know and be able to do.

Collaborative support has been shown to greatly increase the likelihood that changes in practice will be sustained (Fullan and Stiegelbauer, 1990). Smylie (1996) has noted that since learning is incremental and teachers do not change their practices overnight, professional development should be long-range and ongoing. According to Ball (1996) teachers need time to unlearn as much as they learn. Teachers need colleagues with whom to focus on problems of teaching and learning, to work out how to deal with new subject matter, and to engage in innovative work aimed at curriculum reform (Olson, 1997; Shanker, 1996).

Reflection is a basic source of learning and change (Louden, 1991). Schön (1987) demonstrated the importance of reflection-in-action and reflection-on-action for the development of professional practice. Professional development must provide opportunities for teachers to form 'communities of practice' (Lave & Wenger, 1991) that encourage them to reflect on the content and contexts of their pedagogy. A collaborative approach is based on notions of teachers as colleagues engaged in inquiry about practice (Lieberman & Miller, 1990; Smylie, 1996).

Method

Two faculty instructors taught a Nuffield Design & Technology unit entitled "Will this story surprise you?" to a class of 27 Grade 6 students for one school day. The teaching occurred in a large classroom in the school of one of the EST teachers. The design brief for this unit reads as follows: Design and make a pop-up book that will amuse and intrigue a particular reader. The book may be for you or for someone else. Prior to tackling this Design and Make Activity (DMA) the students completed eight Support Tasks to learn a variety of paper engineering techniques, illustration styles, and how to write a design specification (Barlex, 2000). The unit met the expectations of part of the Ontario Ministry of Education Grade 1 – 8 Science and Technology curriculum (Ministry of Education & Training, 1998).

A group of six teachers worked alongside the students to complete the Support Tasks and Design and Make Activity. This afforded the teachers the opportunity (a) to participate in an approach to teaching technology, (b) to acquire technical knowledge, skills, and understanding, and (c) to reflect on issues related to teaching and learning in elementary technology education.

Data was collected in a variety of forms and in three phases of the study. Phase 1 occurred prior to the unit being taught. A written questionnaire was used to identify (a) teachers' current technical knowledge and skills, and (b) teachers' current knowledge about teaching technology. Phase 2 of data collection occurred while the students and teachers were completing the Support Tasks and DMA. Teachers were asked to record their thoughts about teaching and learning technology in a prepared field notes booklet. Phase 3 occurred after the unit had been taught, and had two components. First, a second written questionnaire was used to identify (a) teachers' post In-Service technical knowledge and skills, and (b) teachers' post In-Service knowledge about teaching technology. Second, the researchers conducted a focus group interview with the teachers.

Data from the first questionnaire guided the nature and structure of the focus group interview. Analysis of focus group interviews involved thematic analysis and concept analysis. Etic categories were derived from an analysis of the relevant literature, and emic categories from our analysis of the data (Miles & Hubermann, 1994; Silverman 1993; Strauss & Corbin, 1990).

Results

Teachers' prior knowledge of designing and making

The first section of the pre In-Service questionnaire asked teachers to describe their knowledge of generating, developing, and communicating design ideas, their 2D and 3D modelling skills, and their technical knowledge of structures. Five of the six teachers reported little or no prior knowledge in these areas. These teachers reported feeling insecure about their lack of knowledge of technology content contained in the curriculum. The sixth teacher had taught Industrial Arts at the secondary level and described in detail a high level of competence.

The second section of the questionnaire asked teachers to describe their approach to teaching technology and the kinds of experiences they provided for students prior to joining the EST partnership. Teachers' responses included:

- *I only taught from prepared purchased units that didn't have an end purpose. Each activity was an entity unto itself – neither rhyme nor reason for why it happened in the unit where it did.* (Teacher 1)
- *I would find something and think 'this looks like fun' and then dive in. We would all sort of muddle through and hope things would work in the end.* (Teacher 2)
- *I used to do a lot of board notes and found that I was intimidated by doing a lot of hands-on activities. Those hands-on activities that I did do were usually teacher-led demonstrations at the front of the class.* (Teacher 5).

Figure 1

In response to a question that asked what they hoped to learn from participating in this research project, three teachers wrote:

- *I hope to learn how to facilitate technology learning in a classroom with a large group of students (rather than teachers). I also hope to learn about the effectiveness of providing In-Service in classrooms.* (Teacher 3)

- *I hope it will …help me see what things …work, what may need to be added or possibly eliminated, what needs further clarification, what needs more time allotted to it.* (Teacher 4)
- *I hope to acquire a better understanding of the delivery process and the student's experience, as well as more technology content.* (Teacher 6).

Figure 2

Field Notes Booklet

Each teacher was provided with a field notes booklet. The booklet contained separate pages for comments on designing, on making, on organizing a classroom for designing and making, and on their professional development. All six teachers indicated that observing two experienced faculty instructors engage students in making design decisions helped them understand an aspect of teaching and learning in technology education with which they had little or no familiarity. Teachers also reported that the experience was successful in helping them acquire teaching strategies for helping students to make what they had designed.

Figure 3

Comments on the effectiveness of the day as professional development included:

- *As a learner, I find it much more successful and appropriate to be learning with the kids, rather than just being told how to teach it. I …feel like this is a much wiser and applicable method of "teaching teachers how to teach!"* (Teacher 1)
- *Well, great to …see what works – what might be changed. Always wonderful to see something done, tried out before you have to do it yourself.* (Teacher 2).

Learning with the students

A post In-Service questionnaire focused on the pedagogical and subject knowledge teachers had learned. Additionally, teachers were asked for their affective response to the day. The six teachers reported that the day was "very worthwhile and rewarding" and a "wonderful experience." The following comments provide insights into the distinctions that teachers perceived in their learning on this day compared to their learning on a PD day in a Faculty of Education classroom.

- *The learning today was in context. Seeing the students go through the activity, observing their actions and interactions allowed me to assess each stage or phase. Participation allowed me to judge the difficulty of the activity as well.* (Teacher 6)
- *It was great to be able to interact with the students and see what issues would arise. There are always things that you cannot prepare for, but by doing it in context you are more likely to get a real feel for how things will/should really run.* (Teacher 5)
- *You could learn along with the kids through trial and error experiences. You could see and hear their reactions and interactions. You could see things that may need to be changed or adapted because actual students are doing the stuff, not teachers* (Teacher 4).

Discussion

Recent calls for educational reform recommend that universities and schools form and strengthen educational partnerships (Cole & Knowles, 1996). The nature and scope of university – school collaboration needs to be investigated in order to understand what teachers and faculty members learn and how these partnerships may be sustained (Lieberman, 1992). The view of the authors is that one area with potential for collaboration is the provision of sustained PD for teachers.

The Elementary Science and Technology Partnership has, since its inception, fostered a team orientation among participants, and has encouraged teachers to continue their interactions beyond the project through personal contact and email. This participation 'in a professional community' (Mclaughlin and Talbert, 1993, p. 15) has provided the opportunity for teachers to discuss materials and strategies in an environment that supports the risk taking and struggle entailed in curriculum implementation.

In the early days of the EST project, teachers described how many of their PD experiences were too removed from the day-to-day work of their teaching lives to have a meaningful impact. The approach adopted in this study was to ground teachers' learning experiences in their own practice by conducting the activity in the classroom of one of the participating teachers.

As Putnam and Borko (2000) have described, a focus on the situated nature of cognition suggests the importance of authentic activities in classrooms. Brown et al. (1989) defined authentic activities as the 'ordinary practices of a culture' (p. 34) – activities that are similar to what actual practitioners do. While the teachers in this study indicated that as a result of the PD, they were feeling more empowered to teach technology, they also indicated a need for continuous support in the area of improving their knowledge and understanding of technology. They wanted more practice in tools skills, as well as knowledge of available classroom equipment and materials.

Putnam and Borko (2000) suggest that the most appropriate professional development site depends on the specific goals for teacher learning. Evidence from this study suggests that In-Service situated in a teacher's classroom may be effective in facilitating teacher understanding of new instructional practices.

The importance of teachers' knowledge of subject matter and pedagogy is well established in the literature (Banks & Barlex, 1998; Rosebery & Puttick, 1998). Yet subject matter knowledge and pedagogy are often fragmented in teacher education and in professional development for teachers (Ball, 2000). This study investigated the effectiveness of In-Service in context as a way to provide teachers with both subject knowledge and appropriate pedagogy in an integrated way.

Preliminary analysis of the data indicates that while In-Service in context may be a powerful way to introduce teachers to a new area of the curriculum and its associated pedagogy, it may not be an effective method for teaching new subject content. As one teacher wrote:

At first I was a little disappointed that we were doing paper technology because although I'd never taught that stuff, it's not something that's hard for any of us to learn from a book. But on looking back I think it was actually probably helpful because it allowed me to concentrate on the pedagogy. I wasn't so worried about trying to figure out how to do it myself. (Teacher 3)

Conclusion

The Elementary Science and Technology project is providing multiple contexts for professional development, including design and technology, science, and writing workshops, individual tutorials, and conversations by telephone and email. The In-Service reported here provided teachers with an opportunity to explore the nature of technology, of learning, of classroom practice, and of teacher professional development 'situated in classroom practice' (Laurialia, 1998). This combination of experiences is designed to provide teachers with a deep understanding of teaching and learning in technology education. As Lieberman (1995) has suggested, the 'conventional view of professional development as a transferable package of knowledge to be distributed to teachers in bite-sized pieces needs radical rethinking' (p. 591). Evidence from the EST partnership is suggesting that a combination of approaches situated in a variety of contexts hold the best promise for fostering powerful, multi-dimensional changes to teachers' thinking and practices.

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