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PATT – 13
Pupils Attitudes Towards Technology
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Educational Research

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Edited by John R Dakers and Marc J. de Vries

Faculty of Education
University of Glasgow
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James Mcgonigal

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Brazil, England, Israel, Netherlands, Malta, Canada, Australia, Tanzania America, Japan, Russia, Botswana, New Zealand, France, Germany Finland, Sweden, South Africa

The conference proceedings have been ‘double blind’ refereed and this has required the considerable support of many people who have given up their time. Referees for particular papers must remain anonymous, but the names of the refereeing panel are shown below.

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**Conference Director**
John Dakers

**Refereeing panel**
Dr David Barlex
Frank Banks
Professor Clare Benson
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Dr Eddie Norman
Dr Marc de Vries
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Steve Keirl
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Wendy Dow

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Introduction
John Dakers and Mark J. de Vries

The thirteenth annual PATT conference held at the University of Glasgow in Scotland may prove to be one of the largest PATT conferences for some time.

PATT conferences started back in 1985 where a small-scale workshop on attitude research for technology education was held and became the start of a series of international conferences that still continues today. In that year colleagues from a variety of countries came together to discuss the possibilities for exploring the attitudes of young people towards technology, by using an instrument that had been developed in the Netherlands. What was appreciated about this workshop was not only the main topic of discussions (at that time attitudes were still a rather new topic in technology education research) but also the fact that the meeting was organised in such a way that there was ample opportunity for discussion (contrary to a lot of ‘sit-and-listen’ type of conferences). These two aspects, the attitude component in technology education research, and the format with ample opportunity for exchange of thoughts still characterises the PATT (Pupils’ Attitudes Towards Technology) conferences.

Over the years the scope of topics for discussion extended and all aspects of technology education became part of the agenda. At a certain moment it was decided to set focused themes for the conferences, such as ‘Teaching Technology for Entrepreneurship and Employment’, “Teacher Education for School Technology”, and “Technology Education and the Environment”. Another new element that was added to the PATT conferences was that not only conferences in the Netherlands were held, but also conferences in other countries, often with a more regional character. Such conferences have been organised in Kenya, Poland, and South Africa. With the International Technology Education Association (ITEA) in the USA an effort has been made to have PATT-USA conferences as part of the annual ITEA conferences. So far, three of these PATT conferences have been organised (Indianapolis, Indiana, 1999, Salt Lake City, Utah, 2000, and Columbus, Ohio, 2002). Traditionally the Proceedings of the PATT conferences were published to make the papers and discussions available to a wider audience. ITEA has put the most recent Proceedings onto their website (www.iteaconnect.org). Scotland is the next example of a PATT conference outside the Netherlands.

The papers show that the first characteristic of PATT conferences – an interest in attitude aspects – is clear and present. In the history of PATT there has been a point at which it was almost decided to stop the series. This was in the year that Jan Raat, who can be called the spiritual father of the PATT conferences, passed away and Ilja Mottier and Marc de Vries were left with the question whether or not to continue after this serious loss. Many colleagues worldwide pressed them to continue because they found the PATT conferences to be of a unique character that justified giving these conferences a place among so many other international conferences for technology education.

Over forty papers, to be delivered by over forty delegates, have been received for presentation in this conference. These represent thoughts and ideas on technology education from a wide range of countries and cover the conference themes of: “The place of design and technology in the curriculum”. The papers cover all aspects of the sub themes;

- What purposes do we value for Design & Technology?
- What values are important in making design decisions?
- What contributions to the value of Design & Technology education can be made by different disciplines?
- The impact of technology and the role of Design and Technology in raising awareness.
- Vocational craft skills or academic thinking? What is Design and Technology?
- Cross-curricular: the place of Design and Technology in a Faculty based setting.

The conference presentations shall take place over four days and we look forward to meeting everyone and hearing the various presentations.
Designing *can* be fun!
or why is Scottish Technology Education failing to meet the National Priority?

S.V. McLaren, Faculty of Education University of Strathclyde, Glasgow
Email: s.v.mclaren@strath.ac.uk

**Abstract**

This paper reviews current pedagogy and perceived impediments that seem to be thwarting the development of design and technology as a thinking, creative, physical and social and emotional experiential, education activity.

Through methods including case study, interviews with teachers, observation, advice to schools and literature the author identifies some of the key issues and challenges presented by design education and the teaching of design. It explores the attitude of current practice that portrays designing as equal to writing, not thinking.

**Key words:** assessment, challenge, core skills, creativity, thinking, pace.

**Introduction**

The activity and process of designing appears to have received some negative press in Scottish schools. Some of the pupils and the teachers of Scottish Technical Education departments seem to take the view that designing means writing. Where has the notion that ‘designing = paper work’ arisen from and why?

Effective Learning and Teaching Series, Technical Education (HMI, 1999) identified the lack of challenge, the lack of design skills, the lack of integration and slow pace as severely restricting the educational experience of pupils in the first stages of secondary education. The activities and processes of designing are wide, varied and active, yet there appears to be a common ‘template’ being superimposed and dominating the activity of designing. This, unsurprisingly, has created the notion that designing equates to jumping through hoops and not much fun at all. There seems to be a perception amongst some teachers and pupils alike that there is ‘correct’ way to approach and record design thinking.

**The issues in context**

**Curriculum Guidance**

National Guidelines for Scotland 5-14 Environmental Studies : Technology were introduced in 1993. Her Majesty Inspectors of Schools (HMI 1996;1997;1999) recognised the poor implementation across Scottish primary schools and the first two years of secondary schooling (S1 and S2), and subsequently the curriculum guidance was simplified. In the revised guidelines document for 5-14 Environmental Studies Society: Science and Technology (2000), there is one single attainment outcome for Technology; technological capability . Even with the rationalisation of the revised curriculum guidance implementation remains very patchy. Programmes of work written prior to the national guidelines continue to be presented, particularly in S1/S2. The shift in emphasis from making predetermined items to develop a skill base towards a holistic outcome of technological capability has largely been ignored.

**Current practice and common perceptions**

Anecdotally, it seems that teachers and pupils alike, find the design element of courses as tiresome chores that distract from what is perceived to be the real business of technology education: making. Technical technology teachers have offered the following responses and opinions towards designing in technology
education: ‘quality suffers when kids design’, ‘what kids want is something to take home’, ‘design is just the same thing over and over again - kids get bored…’

Current practice for S1/S2 in many secondary schools involves making standard models following a ‘demonstration and do approach’. Resources, processes, size and outcomes are teacher directed and determined. These tasks may be supplemented with time spent on developing isometric drawing, perspective sketching and perhaps orthographic drawing. There is little opportunity for pupils in S1/S2 to engage in design activities that offer design decision making and ownership to flourish.

Her Majesty’s Inspectorate for Education(HMIE): Reporting on Technology Education
That technology education is an area deserving attention is noted in a number of papers and publication, and individual school reports. Effective Teaching and Learning Series, Technical Education ( HMI, 1999) comments that it is ‘….important that pupils appreciate the integrated and progressive nature of their S1/S2 course and do not perceive it as a series of isolated individual experiences.’(p.8). This report goes on to say that ‘….many [S1/S2] courses over emphasised the craft aims at the expense of those related to design, graphics and technology’ ( p.12). It suggests that departments should make better use of open ended problem solving, design exercises.(p. 26) and address the current lack of challenge which is impeding progress for all and in particular discouraging a number of able pupils. As a priority, departments were urged to review their S1/S2 courses and bring them in line with 5-14 National Guidelines. More specifically, departments were asked to ensure that their courses:-

encourage and develop pupil’s creativity
extend pupil’s understanding of designing as a process
develop pupil’s ability to take design decisions
extend pupil’s knowledge of society’s use of technology
offer a coherent, interesting, challenging and enjoyable experience for pupils of all abilities. (p.12/13)

A more recent report, Standards and Quality in Primary and Secondary Schools (HMI 1998-2001) notes that similar and specific issues continue to arise at both secondary and primary level. Indications are that the revised guidelines for 5-14 Technology and the Higher Still design centred courses were implemented in a restrictive manner or not at all.

Scottish Qualification Authority(SQA): Principal Assessor’s reports and observations
There is sparse evidence of pupils engaging in design tasks that encourage creative thinking and developing ideas which they themselves analyse even at Standard grade and Higher level. The principal assessor’s report for craft and design (SQA, 2001& 2002) notes that presenting centres are submitting batches of individual pupils design assignments which contain a number of common pages. In submissions where an individual pupil had been exploring a unique design brief, there was evidence of a class approach being to research which rendered some submissions nonsensical due to the inappropriateness of the research in relation to the design brief.

Such evidence of ‘game play’ continues. Successful folios i.e. those that have contributed strongly to a pupil being awarded a grade A for the externally marked SQA Design Assignment are being used as templates for following year groups. Thereby negating the individual process or design journey undertaken by individual pupils tackling a specific brief. Design folios all too often comprise sketches and diagrams that have been redrawn and presented in a highly overworked graphic style indicating that the folio is not a representative body of work as it progressed.

Impediments to development

What teachers say
Common themes have emerged from in-service sessions, Principal Teacher network meetings and discussions with local authority advisors. Materials, resources and management are often used as reasons why teachers do not devise authentic design experiences as part of the learning programme and why a formulaic approach to design is adopted. The notion of ‘allowing’ pupils greater freedom, autonomy in design decision making and ownership of their design ideas is, to many teachers, not welcome in many
technical education departments. The following list notes some of the impediments teachers cite as further reasons for not being enthused towards a design centred pedagogy.

- assessment of design activity- physical outcomes predominate the current practice not process and thinking skills
- Limited time available; ‘can’t fit design in with time available’
- assessment of teamwork
- need to develop workshop skills and material handling before craft and design standard grade
- no common framework for 5-14 Technology curriculum
- no exemplification provided for expected levels and standards
- no content or subject discipline defined in 5-14 Technology guidance
- blame the pupils – no maths, very illiterate, ‘can’t even…. and you expect them to be able to….’

Limitations of assessment
The highly structured and subdivided mark scheme applied by the external markers for SQA Higher Craft and Design certificate courses has impacted on teacher attitude towards design activity. The result of a marking scheme that states the number of pages to be included in a design folio and further subdivisions for each ‘design stage’ is that designing as an iterative and very active thinking process has been reduced to page filling. E.g. The assessment guidance includes advice that for 12 marks ‘an example of work may include 12 initial ideas which are simple, or 6 which are more detailed.’ (SQA, 2002 p.5) Modelling will not even be considered as a worthwhile tool for idea generation since the guidance note asks that ideas should be conveyed using annotated sketch and diagrams. A high proportion of overall marks (22%) is given over to graphics, i.e. for the quality in the sketching, use of tone and colour or media etc. This can result in an inappropriate amount of time being devoted to this aspect at the expense of the thinking that underpins the design development. Graphic technique and presentation being the ‘easy bit’ by comparison to the intellectual challenge of design thinking. Marks are awarded for what teachers often call ‘colouring in’.

In contrast, there is 5% allocated to modelling. Candidates are required to explain through detailed description the purpose of the model, materials and techniques and explain how modelling helped them reach their design decisions. A half mark is awarded for each valid statement. Writing is demanded for something that serves a purpose at a specific time in the design journey. The various models may have resolved spatial and visualisation problems and refined thinking and this will be evident in the design development thinking. However, for assessment it is deemed necessary that pupils write words about such processes, reducing and active and purposeful process into a retrospective chore.

Pupils and teachers are developing techniques and strategies to meet such criteria and it is not any great surprise that pupils and teachers equate design activity with hoop jumping and equate design with writing. This problem is not unique to Scotland and literature [McCormick and Hennessy, 1997; Kimbell, 2002; Ive, 2002; Atkinson, 2000] indicates that an algorithm has been adopted for the teaching of design. There is very little evidence that teaching and learning programmes are developing technological confidence, which includes the ‘willingness to take intellectual risks’ (SCCC, 1996) Assessment frameworks such that of the SQA Design Assignment may be creating strategic surface learners who cannot operate as autonomous beings and find it hard to engage deeply with an appropriate degree of flexibility in design and problem solving activity.

It seems that many of our schools have opted to hold on to the familiar and traditional. There are those, a quiet minority, that recognise that a design centred pedagogy devised to develop ‘technological capability’ may be of benefit to youngsters and re-engage them in the education process. However, it seems as though there remains a continuum of the ‘Saber-tooth Curriculum’ (Peddiwell, 1939) The fundamentals which have long since been overtaken in terms of purpose, life skills and technology remain leaving no curriculum space for those more relevant for operating it the society, community and work place of today.

Creative Event Case Study

Aims of the event
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To explore the concerns identified, the University of Strathclyde decided to engage more directly with the Technical departments of the local schools. This proactive plan included the following case study design event which catered for pupils from lower secondary school. It was intended that observations and evaluations would help explore some of the anecdotal comments pertaining to pupils design skills, attitudes towards design and the various reasons cited by school staff for not planning design centred and team tasks in school thus giving rise to the observations and key issues noted in HMI reports. The results were analysed and relationship to classroom practice and implementation issues investigated in terms of technological creativity; scenario setting and stimulus; research and accessing information; technological confidence: core skill of team work; communication methods including the role of modelling.

The Creative Design Event task was devised to:

- **challenge** the novice designers;
- constrain them to work to a tight deadline so a momentum would have to be developed and that **pace** would have to be sustained throughout the day;
- demand **design thinking** in terms of analysis of the scenario to redefine the brief and arrive at key specification criteria to frame their conceptual ideas;
- require **creativity** in exploring the potential resolutions;
- **integrate** technological elements with needs of various user groups in a coherent way;
- demand application of **core skills** of communication, team work and problem solving.

Working in teams of 4 or 5, the young designers responded to a presentation by a client, used analytical and creative thinking, idea generation, problem solving and enterprise skills to arrive at a conceptual proposal. They then presented their concept to client in sketch model and graphic format. The presentations were judged on the basis of the clarity and structure of the presentation which had to convey the imagination and creativity of the ideas. The team had to demonstrate a high level of consideration of the needs of the client, effective communication and teamwork.

**Teacher and Pupil Response**

The data collected in post event evaluation questionnaires (16 teachers, 80 pupils,) was analysed. It was unsurprising, although disappointing, to note that only three teachers stated that the pupils had tackled anything like this before. And yet, the focus, approach and skills involved in the team design activity audit well against the outcome and strands of the 5-14 National Guidelines for Technology. From the pupils’ responses and evaluations it was clear that they had enjoyed their participation in such design activity and wanted more. 91% stated that the experience had made them think about ways of trying to be more creative in design and technology. It was very apparent that modelling ideas and making the model was considered to be the favourite part of the day for the majority of the participants with second highest rating for most enjoyable part of the day’s event being ‘designing’.

The pupils were very able to identify what they had learned from the experience. Comments included that they had learned how to be more creative, how to develop ideas, to be more open-ended about ideas, to think about what it is that is to be designed and that designing can be fun.

It may have been that the 12-14 year old youngsters were creative because there was no pressure of assessment. They may have been less inhibited because they were in the university studio environment away from school. The warm-up techniques signalled ‘permission’ to be creative and this together with the brief, the medium for modelling, the facilitators, the presentation of the brief the clarity and the authenticity of the tasks, the values, the balance of technical subtask with reflective and empathetic issues may have triggered a positive energy. There was no need to write. There was the presentation to large groups of strangers. There was no requirement to produce paper work, although all groups chose to produce some annotated graphics and detailed flatwork in addition to modelling concurrently.

Evaluation and analysis of the event indicated design can be fun. It also provided a thinking challenge that pushed the pupils to apply their technological learning, their problem solving skills, their spontaneity, their logics and so on to a level that impressed their school teachers.
Conclusion
The issues discussed in this paper and explored in the case study need to be more widely acknowledged, understood and addressed. A design centred pedagogy, not a formula, not a framework tightly constrained by artificial assessment criteria, could liberate the confidence of the pupils and the teacher alike. A balance between the teacher-directed tasks and open ended experiences is central to developing autonomous thinkers.

This would require primary and secondary technology teachers to embrace some of the aspects of education that technology has so much to contribute towards such as citizenship, enterprise, sustainability and weave these in to the holistic purposeful scheme of work. It is well placed to contribute to the Scottish Executive National Priorities in School Education specifically ‘to equip pupils with the foundation skills, attitudes and expectations necessary to prosper in a changing society and to encourage creativity and ambition’. (SEED, 2000)

Technology Education curriculum has the potential to support team work, develop imagination, innovation and creativity, promote a range of communication and research strategies help pupils cope with uncertainty, take intellectual risks and explore values. These are the very aspects that the assessment schemes and adopted pedagogy seem to be denying. Pupils need to enjoy their learning, be motivated, get active and be permitted to be creative (Kimbell 2002) in order to gain from and find their technology education experiences worthwhile.

It must recognised that designing is thinking not writing!

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Technology learning by Theatre-playing

Thomas Langkau, University of Duisburg-Essen, Germany
Wolfgang Haupt, University of Duisburg-Essen, Germany
Jürgen Wehling, University of Duisburg-Essen, Germany

Email: thomas.langkau@uni-essen.de
Email: wolfgang.haupt@uni-essen.de
Email: juergen.wehling@uni-essen.de

Abstract

When teaching “Technology”, a number of problems should be solved, for example the problem of sustainability. Therefore at the University of Duisburg-Essen a project for sustainable technology teaching (and learning) has been installed. In this project, teacher students teach technical contents in the grades 1 to 7. Since it is known that sustainable teaching (and learning) is enhanced by teaching (and learning) in interdisciplinary projects, technological contents were integrated in such interdisciplinary projects. To achieve interdisciplinarity and to focus on the desired objectives in these projects, specifically written theatre plays to be performed by the kids, are integrated in the projects. In the theatre plays, technological contents are embedded and dealt with in their specific historical, scientific, economical a.s.o. backgrounds. In addition to that, music (singing and dancing) and arts (painting) play important roles in performing the theatre plays. Concerning these aspects, there is probably a large overlap between the technology teaching concept in Germany and the teaching concept of “Design and Technology”. A large number of theatre plays has been tested in the schools and the student activity has been evaluated, showing that important aspects of sustainable learning are achieved.

Keywords: sustainable teaching, theatre-playing, interdisciplinarity

Introduction

In the state of North Rhine-Westphalia technology is taught in all schools of the general educational system. In the Primary Schools, technology is integrated in “Sciences” (Sachunterricht) lessons, which also contain physical, chemical, biological and geographical aspects.

At the University of Duisburg-Essen we are engaged in technology teacher education for the primary, junior secondary and senior higher education level since 1973 (Haupt and Sanfleber 1976).

Now a few remarks to what we in North Rhine-Westphalia at the University of Duisburg-Essen mean when we say “technology” because this is important for the “design” of the theatre plays (Theuerkauf et al. 1996).

Technology includes technical objects, procedures and methods. In addition, when teaching technology, the interaction of technical objects and methods with society and vice versa has to be dealt with, since it is well known that technical objects and methods are influenced by the demands of society and on the other hand, society influences technological objects and methods. Take for example a car: it’s size, number of seats, position of head and rear lights a.s.o. are consequences of the demands of society. If the demands were different, cars would look different. Understanding of these interactions is necessary for the understanding of our nowadays technical world. In specific cases it can even be helpful to understand how technical objects have developed historically in interaction with society.
This is probably different from the concept of “design and technology”, but we think there is a large area of overlapping aspects, especially in the area of interaction between technology and society and in the demand for interdisciplinarity: theatre plays are especially well suited to deal with the content of exactly these overlapping areas.

**Construction and design of the theatre plays**

The idea to promote technology learning by playing theatre with the kids was born about 15 years ago. At that time we were looking out for methods for sustainable technology teaching. The problem was: how to integrate interdisciplinarity, and the interaction of technology and society in hands-on technology lessons.

These demands, we thought, might very well be fulfilled by playing theatre with the kids, the plays dealing among others (s.o.) with technological problems.

Talking with teachers strengthened our believe in the idea and so we started constructing theatre plays for this purpose. We say “constructing” because the teachers had given us a number of criteria the theatre plays had to fulfill so they could be of use for kids of age 6 to 12. These criteria are as follows:

**Content:**
- The content should be interesting to the kids.
- The content should not be “too simple” or just a short joke or something like that.
- Teachers will need many theatre plays with many topics so they can select the one he (or she) just needs for his (her) kids.
- There should be theatre plays with the same topics but for kids of different age (s. o.).

**Language:**
- The language must be simple (but not too simple), but it should not be “street language”.
- The kids should have the opportunity to enlarge their vocabulary.
- The sentences should be short (7 - 10 words).
- The text a player has to speak should not be longer than 3 sentences at a time.

**Music and dance:**
- Should be integrated in the theatre play, but its use should be flexible (short, long, very long).

**Duration:**
- 15 - 30 minutes, depending on the age of the kids. It should be flexible, for example by using or not music and dance.

**Structure:**
- The play should have a clear structure, for example: different acts should contain different aspects of the main topic.

**Number of players:**
- It should be easily possible to add or take away or combine roles.
- There should be many easily learnable roles but also a few difficult ones.

According to these criteria at first only a few plays were constructed and given to the interested teachers. Our primary teacher students had the opportunity to work in groups of 3 - 4 with the teachers in the classrooms in practicing the plays and in the performances.

**Experiences**

Right from the beginning the students made an important experience, which we had hoped they would make. While practicing the play, the kids over and over asked questions on all contents contained in the play. They wanted to know more and more details about those contents a.s.o. Thus, the students had to give additional lessons to deal with these questions and try to answer them. For example, when practicing the theatre play on the first flight in a balloon, they made experiments concerning buoyancy and even constructed balloons with the kids. And, very important, as we had hoped, the kids did not ask questions...
only to technical, but also to physical, chemical a.s.o. problems. Also the historical background and the
development of flying techniques since the first flight with a balloon were intensely discussed. So, the kids
learned technology “hands-on” and in an interdisciplinary manner.

The teachers even can try to achieve specific objectives, concerning the interaction of society and
technology, for example concerning ecological aspects (Langkau and Haupt 2001).

In addition, and as planned, the use of tools when preparing stage settings and requisites was practiced.
This is independent of the content of the plays.

Now, besides objectives concerning learning of sciences, a teacher can try to achieve a number of other
objectives by theatre playing with the kids, which are independent of the specific content of the plays too.
Those, who have played theatre with kids naturally know that.

These objectives are:
learning:
to work in a team
to act considerate to others
to take up responsibilities
to strengthen self confidence
to overcome timidness
to plan in advance
to integrate isolated kids in the class.

All those objectives can be summarized to the general objective: Support of the development of the
personality of the kids.

Now, just a few additional remarks which are obvious to those, who have experience with theatre playing
with primary level kids.

When practicing the play, the teacher should not try to achieve perfection in gesture, mimic, music
(singing) and dancing, because, according to our experience, the kids do not understand that.

This also implies to the texts the little actors have to speak. It must not be spoken literally because
experience shows, that the kids, when having understood the text, they will formulate freely.

Now, back to the beginning of the project. Already after the first semester it turned out that the theatre
plays were considered a big success by the kids, the students and the teachers (Haupt 1998; Haupt and
Lindemann 1999). So more plays were constructed. After two years a publisher got interested in the plays.
Up to now about 40 plays are published, partly as books, partly as CD-ROMs (Haupt 1993-1997; Haupt
1999-2001; Haupt 1999). The books and CD-ROMs contain not only the text for the plays but in addition
hints for teachers, for example suggestions for the stage settings, casting, suggestions for preparing
costumes, photos and videos of the play (CD-ROMs only). The teachers can make use of these hints but
naturally they also can change everything, even re-write the text with the help of the kids completely.
The tables 1 - 4 (after references) give a list of all plays which are published up to now or are planned to be
published. In the tables the theatre plays are arranged according to their main topics. Also included is
information about the technical (or physical, geographical or historical) contents they are dealing with. We
also give a list of the plays which are translated into English up to now (table 5) (After references).

Concluding Remarks
15 years of experience with theatre-playing with the kids, thereby having the choice from a wide variety
(see table 1-4) of especially designed theatre plays allows the conclusion: Theatre playing with the kids
offers the teacher a powerful (additional) method, she or he can make use of to achieve “technological
objectives”, and also, at the same time, help the kids in the development of their personalities.
This method also is a very flexible tool, since the teacher has the choice to put the emphasis on those objectives she or he thinks most important in a specific situation.

References
HAUPT, W. (1993 – 1997) Kinder spielen Theater. (A series of 18 theatre plays for kids with photos and hints for teachers.), Düsseldorf: Kamp-Schulbuchverlag Postfach 103222 D-40023 Düsseldorf E-mail: mailto:vertrieb@kamp-verlag.de
HAUPT, W. (1999 – 2001) Wir spielen Theater. (A series of 11 theatre plays for kids with photos and hints for teachers, 5 as books, 6 as CD-ROMs with videos), Villingen Schwennenig: Neckar-Verlag GmbH D-78045 Villingen-Schwenningen E-mail: mailto:service@neckar-verlag.de
<table>
<thead>
<tr>
<th>friendship / partnership</th>
<th>inventions &amp; discoveries</th>
<th>other cultures</th>
<th>respect for the natural environment</th>
<th>against violence and war</th>
<th>realisation of dreams / hope</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>The nicest thing in the world</td>
<td>The creation of men with different colour / How the moon got on the sky firing ceramics, basic astronomy Book Kamp</td>
<td>The pond fishes, basic optics IBK</td>
<td>Great imagination (A story of the little hedgehog and the little hedgehogess)</td>
<td>Birds of passage (A story of the little hedgehog and the little hedgehogess)</td>
<td>I'd like so much to be a king! (A story of the little hedgehog and the little hedgehogess)</td>
<td>The paradise / The horizon (A story of the little hedgehog and the little hedgehogess)</td>
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<tr>
<td>(A story of the little hedgehog and the little hedgehogess)</td>
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<tr>
<td>animals and birds Book NV</td>
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<tr>
<td>Shadow-jumping</td>
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<tr>
<td>(A story of the little hedgehog and the little hedgehogess)</td>
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<tr>
<td>light-rays and shadows</td>
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<tr>
<td>I am so sad! (A story of the little hedgehog and the little hedgehogess)</td>
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<td></td>
</tr>
<tr>
<td>animals and birds</td>
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<tr>
<td>Let's take a walk together</td>
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</tr>
<tr>
<td>(A story of the little hedgehog and the little hedgehogess)</td>
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<tr>
<td>animals of the forest</td>
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<tr>
<td>The happy moment</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>animals IBK</td>
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</tbody>
</table>
Table 2: Theatre plays for the 3rd and 4th grades
arranged according to the main topics of the plays

(Explanations to the abbreviations can be found in table 4)

<table>
<thead>
<tr>
<th>friendship / partnership</th>
<th>inventions &amp; discoveries</th>
<th>other cultures</th>
<th>respect for the natural environment</th>
<th>against violence and war</th>
<th>realisation of dreams / hope</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairytale world</td>
<td>Columbus discovers America</td>
<td>The Indians and the smoking ghost</td>
<td>The Indians and the fire-horse</td>
<td>The Demon</td>
<td>The knight's wife</td>
<td>Islands of horror</td>
</tr>
<tr>
<td>(A story of the little hedgehog and the little hedgehogess)</td>
<td>history of discoveries, world as a sphere</td>
<td>geography, history, steam engine</td>
<td>geography, history, steam engine</td>
<td>(A story from old times)</td>
<td>social structure at medieval times, castle (building), monastery life</td>
<td>hunger, exploitation, suppression, ships, navigation</td>
</tr>
<tr>
<td>Book Kamp, IBK</td>
<td>Book Kamp</td>
<td>Book Kamp</td>
<td>CD NV</td>
<td>Pirates and merchants (A story from hanse-times)</td>
<td>ships buoyancy, buildings (towers), social structure in the middle ages</td>
<td>IBK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A hall full of gold as ransom</td>
<td>The big bow</td>
<td>The adventure (A story of the little hedgehog and the little hedgehogess)</td>
<td>history of the discovery of Peru, Inka culture</td>
<td>humanity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>history of the discovery of Peru, Inka culture</td>
<td>ecology, basic geography, basic astronomy, temperature measurement</td>
<td>A german boy in a roman town</td>
<td>Book Kamp</td>
<td>IBK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Book Kamp</td>
<td>IBK</td>
<td>Roman technics, cities, buildings, amphitheatre, bath, a.s.o.</td>
<td>Book Kamp</td>
<td>The voyage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The long voyage of Ulf, the viking boy</td>
<td>Book Kamp</td>
<td>IBK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>life, social structure of the vikings, ships, navigation</td>
<td>Book Kamp</td>
<td>When pleasure changes to slavery</td>
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<td></td>
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<td></td>
<td></td>
<td>addiction</td>
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</tbody>
</table>


Table 3: Theatre plays for the 5th to 8th grades arranged according to the main topics of the plays

(Explanations to the abbreviations can be found in table 4)

<table>
<thead>
<tr>
<th>friendship / partnership</th>
<th>inventions &amp; discoveries</th>
<th>other cultures</th>
<th>respect for the natural environment</th>
<th>against violence and war</th>
<th>realisation of dreams / hope</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first railway in Germany steam engine and related physics and technics f.e. transmission</td>
<td>The labyrinth death of young people, love CD NV</td>
<td>The heart of sailors (First story of a pilot)</td>
<td>Under the nice surface of the ocean (Second story of a pilot)</td>
<td>The white sail (Third story of a pilot) death</td>
<td>The pearl merchant (First story of a merchant)</td>
<td>The porcelain merchant (Second story of a merchant)</td>
</tr>
<tr>
<td>The first balloon ride buoyancy, flying technics</td>
<td>The invention of printing casting metals, pressure paper-making CD NV</td>
<td>The building of a pyramid building, technics and procedures, social structure, religion</td>
<td>The building of a pyramid building, technics and procedures, social structure, religion</td>
<td>A voyage to other planetary systems basic rocket technology, basic astronomy</td>
<td>The invention of writing writing materials</td>
<td>The invention of writing writing materials</td>
</tr>
<tr>
<td>The invention of book-printing</td>
<td>The heart of sailors (First story of a pilot)</td>
<td>Under the nice surface of the ocean (Second story of a pilot)</td>
<td>The white sail (Third story of a pilot) death</td>
<td>The pearl merchant (First story of a merchant)</td>
<td>The porcelain merchant (Second story of a merchant)</td>
<td>The silk merchant (Third story of a merchant)</td>
</tr>
</tbody>
</table>
### Table 4: Other Theatre plays (not arranged to specific topics)

<table>
<thead>
<tr>
<th>Special occasions</th>
<th>Biblical stories</th>
<th>fairytale / myths</th>
<th>stories from literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recollection and hope</strong>&lt;br&gt;can be played at the end of primary school-time (4th grade)&lt;br&gt;Book NV</td>
<td>The creation of the world / The tower of Babylon&lt;br&gt;(beginning with 1st grade)&lt;br&gt;CD NV</td>
<td>Sindbad&lt;br&gt;(Thousand and one night)&lt;br&gt;(beginning with 3rd grade)&lt;br&gt;Book Kamp</td>
<td>Münchhausen’s journey to Konstantinopol&lt;br&gt;(beginning with 3rd grade)&lt;br&gt;Book Kamp</td>
</tr>
<tr>
<td><strong>The Christmas story</strong>&lt;br&gt;(1st to 4th grade)&lt;br&gt;Book NV, Book Kamp</td>
<td>Noah’s ark&lt;br&gt;(beginning with 3rd grade)</td>
<td>The flying carpet&lt;br&gt;(Thousand and one night)&lt;br&gt;(beginning with 4th grade)&lt;br&gt;Book Kamp</td>
<td>Eulenspiegel makes fun of the tailors / Eulenspiegel makes fun of the professors&lt;br&gt;(beginning with 2nd grade)&lt;br&gt;Book Kamp</td>
</tr>
<tr>
<td><strong>I am so excited!</strong>&lt;br&gt;can be played for the kids entering school for the first time&lt;br&gt;(1st to 4th grade)&lt;br&gt;CD NV</td>
<td>Four stories of creation&lt;br&gt;(beginning with 5th grade)</td>
<td>Fairytale at night&lt;br&gt;(a fairytale)&lt;br&gt;(beginning with 3th grade)&lt;br&gt;Book NV</td>
<td>The “Schildbürger” build a town hall / The “Schildbürger” buy a “mouse-dog”&lt;br&gt;(beginning with 1st grade)&lt;br&gt;Book Kamp</td>
</tr>
<tr>
<td><strong>The first day in school</strong>&lt;br&gt;(1st to 4th grade)&lt;br&gt;Book Kamp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I come from ...</strong>&lt;br&gt;different countries introduce themselves&lt;br&gt;(beginning with 3rd grade)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Explanations to the abbreviations:**

- **Book Kamp**
  Published as a book by Kamp. It contains the text of the theatre play, hints for teachers and photos.

- **IBK (Igelband Kamp)**
  Book published by Kamp with 14 theatre plays about the little hedgehog and the little hedgehogess.

- **Book NV**
  Published by Neckar-Verlag. It contains the text of the theatre play, hints for teachers and photos.

- **CD NV**
  Published as CD-ROM by Neckar-Verlag. It contains the text of the theatre play, hints for teachers, photos and a video of the play.

**Adresses:**

- **Neckar-Verlag GmbH**
  78008 Villingen-Schwenningen  
  Postfach 1820  
  Tel. 07721/8987-0

- **Kamp Schulbuchverlag GmbH & Co. KG**
  Postfach 103222  
  40023 Düsseldorf  
  Am Wehrhahn 100  
  40211 Düsseldorf  
  Tel. 0211/17711-102

More information available under [http://www.tud.uni-essen.de/theater/](http://www.tud.uni-essen.de/theater/)

All books published by Kamp can be ordered as CD-ROM including a video at: [http://www.kinderspielentheater.de](http://www.kinderspielentheater.de)
Table 5: Theatre plays in English

- How God created the World
- I am so Sad!
- Journey to the Stars
- Jumping over your Shadow
- Looking for Paradise
- The Big Bow
- The birds of passage
- The Blue Flower
- The Colourful Bird
- The Demon
- The Dream
- The First Flight with a Balloon
- The First Railway in Germany
- The Happy Moment
- The Hearts of the Sailors
- The Horizon
- The Invention of Letterpress Printing
- The Tower of Babel
- The Walk
- The White Sail
- Under the beautiful surface of the Sea
Background of Design Against Crime

Design Against Crime is an education and policy initiative funded by the Department of Trade and Industry (DTI), the Home Office and the Design Council. The initiative involves schools, Universities and professional design practice. The concept for Design Against Crime is that designers consider crime issues as they generate and develop new products, particularly the way users might adopt and adapt products and systems for criminal purposes. Pease (2001), a leading criminologist and strong supporter of Design Against Crime made the following comments about the cost of crime in the UK:

‘The design challenge is to incorporate crime reduction without sacrificing aesthetics and ease of use. Economically, the potential rewards are high. The most recent and sophisticated analysis puts the total annual cost of crime in England and Wales at £60 billion, with, on average, burglaries costing £2,300 each, vehicle thefts £4,700 and robberies £5000. (p 6)

Fitting Design against Crime into the Secondary School Curriculum

Design and Technology (D&T) teachers consulted considered the concept would be difficult for Key Stage 3 pupils(11 to 14 age phase), but that it could be introduced in the later years. As a result the project team considered how Design Against Crime could be adapted to make it more relevant to the KS3 D&T curriculum.

Scrutiny of current and proposed national education initiatives revealed that several initiatives were being implemented in schools. These included strategies for teaching literacy, numeracy and particularly the new subject of citizenship. The notion of Design Against Crime seemed to fit well into the citizenship agenda. Education for citizenship is not new. Pioneering work in several schools during the 1990s, supported by the National Curriculum Council (NCC), demonstrated its value as a valid educational experience. Nichols (1992) reported on a successful cross curricular development using material adapted from Nuffield Science and the Technology national curriculum. With the now more formal introduction into the curriculum three methods of delivering citizenship emerged. These are:

• a conferencing model with specific days for citizenship teaching and events;
• specialist teachers delivering citizenship;
• an integrated approach with several teachers making contributions guided by a co-ordinator.

Issues concerning democracy, crime, justice and particularly, being responsible for one’s behaviour and actions, all feature in study modules promoted by the Department for Education and Skills (DfES) for delivering the citizenship curriculum. Design Against Crime seeks to enable D&T teachers to make a significant contribution to this new curriculum area. Currently, following a period during which teachers have focused attention almost exclusively on delivering their own national curriculum subject, there are indications that a more integrated approach to delivering cross curricular initiatives is re-emerging.

In addition to supporting the citizenship curriculum the project team considered that Design Against Crime should also support the national numeracy and literacy strategies. Both strategies have reliance upon a cross curricular approach.

For example, details are explicit about how other subjects can contribute to numeracy. For religious education (RE), personal, social and health education (PSHE) and citizenship the following guidance is given:

‘The discussion of moral and social issues is likely to lead to the use of primary
Similarly, the following statement from Key Stage 3 National Strategy Framework for teaching English: Years 7, 8 and 9 (2001) emphasises that all teachers have responsibilities for literacy.

‘Language is the principal medium for learning in school, and every teacher needs to cultivate it as a tool for learning in their subject. Other subjects do more than simply police English across the curriculum, or nurse pupils with poor skills. Teachers have a genuine stake in strong language skills because language enables thought.’ (p 15)

In addition to providing a means of enhancing pupils’ D&T experience, by adding value to design and make projects. Design Against Crime was well placed to capitalise on these strategies

The following strategy emerged for introducing Design Against Crime into schools within the D&T curriculum:

1. Provide teaching and learning materials to introduce Design Against Crime as a component of D&T and so contribute to the emerging citizenship curriculum within schools, particularly for the 11 to 14 age phase (Key Stage 3).
2. Provide in-service education and training (INSET) for teachers using the materials developed.
3. Trial the materials in schools.
4. Evaluate the materials by collecting views of both pupils and teachers.

The Design Against Crime Teaching and Learning Model for Key Stage 3

The development for the strategy focused on:

• current, exemplar D&T activities, which with further development, could provide a vehicle for Design Against Crime project work without alienating D&T teachers;
• developing analytical and synthesis tasks which introduce crime related issues to pupils thus enabling them to gain insight into crime, particularly the way it affects others;
• developing evaluation and reflective tasks which promote discussion about both their project work and crime related issues.

The intended outcome was a series of D&T projects presented in a style which includes pupil workspaces and textbook teaching material that can be used for reference.

Developing the Model

Four innovative areas of D&T activity form the basis of the Design Against Crime initiative, electronic products, graphic products, computer aided design and manufacture (CAD/CAM) and systems and control. D&T INSET courses at Sheffield Hallam University are usually over-subscribed in these areas indicating teachers’ desire to develop these aspects of D&T in their schools. The team considered that using innovative projects in these areas, and adding value by providing new learning opportunities, would enable D&T teachers to make their contribution to the citizenship curriculum. Four projects have been developed:

- Alarm Systems: an electronic product project
- Posters: a graphic product project
- Bag Tags: a CAD/CAM project
- Crime Scene: systems and control dioramas

Developing Analytical and Synthesis Tasks

Scrutiny of the emerging citizenship curriculum and particularly information from the Department for Education and Skills (DFES) and the Qualifications and Curriculum Authority (QCA) revealed that, whilst there was some guidance, there was minimal teaching material to support citizenship teaching in schools. Guidance on web sites belonging to these organisations directed teachers to police and Home Office information sources. While these provided a wealth of material, most was in a format unsuitable for use in schools. For example, police crime statistics deal with reported crimes, arrests and convictions and do not give a true indication of the extent of crime. The Home Office web site (www.homeoffice.gov.uk) contains numerous research papers with considerable amounts of data. Aust and Simmons (2002) in their paper Rural Crime not only produce data on levels of criminal activity but also deal with issues such as the extent of fear that people have about crime.
Goddard (2001) in her paper *Evaluation of various data sources on drug use, smoking and drinking by children of secondary school age* collates several sources of information on these issues. She then focuses attention on the extent and affects of these problems, all of which are of concern to both teachers and parents. While these papers are not written for a Key Stage 3 audience the inherent data is valuable for use in schools. These publications were used as a basis for developing analytical tasks for the *Crime Scene: Systems and Control Dioramas* (2002) (p2 to 5). A particularly useful source of information is the British Crime Survey (2000), published annually by the Home Office. This provides current details of offences committed and reported. Additionally, the survey includes, and presents, information about trends in crime and the way these affect people’s lives. For the Design Against Crime projects data was carefully selected and presented in an appropriate format.

**Using data in the analytical and synthesis tasks**

The National Strategy Framework for teaching mathematics: years 7, 8 and 9 (2001) emphasises the cross-curricular aspects of data handling. The document goes on to say that year 7 pupils are able to ‘— manipulate small data sets from either simple experiments and accessible secondary sources.’ (p 18) Graphs 1 and 2 are examples from the *Posters* project (2002) (p 3). They use data from Makie A and Burrows J (1999) and show the extent of offending by boys and girls in several age groups. The pupil’s task is to study and collate the information and represent it on a single graph. To do this pupils must manipulate the data onto a common Y axis. Pupils are encouraged to use Information and Communication Technology (ICT) in the presentation of their work. This demonstrates how Design Against Crime can contribute to ICT national curriculum teaching.

**Graph 1 showing percentage of girls admitting to offences**

((Makie & Burrows 1999))

**Graph 2 showing percentage of boys admitting to offences**

((Makie & Burrows 1999))
Further analytical tasks based on this data ask pupils to consider what is meant by the term ‘Other violence’. The objective is to promote discussion about both the terminology and meaning of the data.

Similar tasks are included in each of the projects. For example, Graph 3 from the Bag Tags (2002) (p 3) project, is about recent data on burglary. Pupils consider this and are asked to give their views about why certain items are ‘popular’ with burglars.

In addition to using secondary data sources the Crime Scene: Systems and Control Dioramas (2003) (p 6 & 7) project invites pupils to generate their own data by directing them to the British Crime Survey 2000 (2001). The pupils’ task is to consider levels of crime and then produce a questionnaire to gather information from friends and relatives. Pupils then present this information in a graphical format of their choice.

The design and make tasks
Design and technology is essentially a practical experience for pupils. An innovative feature of this D&T curriculum development is the use of project workbooks which include text book style material. Text, drawings, diagrams, photographs and cartoons are used to motivate and support pupils as they develop their Design Against Crime projects. Fig 1 is a text book style illustration from Bag Tags: a CAD/CAM project (p 10) which shows pupils how they could use a sewing machine in the manufacture of their fabric bag tag.
An example of developing literacy skills within a Design Against Crime project is the use of tasks such as writing a specification. Key terms e.g. *aesthetics*, *batch produced*, *colour*, *ergonomic* etc. are provided to encourage pupils to explore how these, and others, can be used in developing their design specifications. In the *Posters* publication the word *‘alliteration’* is introduced (p 8) in the context of generating messages and slogans.

Design Against Crime is about pupils designing products to reduce crime or to illustrate, and bring to the attention of others, issues about crime. There is support for project work in preference to prescribing designing formula; each project has a different starting point and provides an opportunity for pupils to generate their own outcome. Workbooks have workspaces in the form of ‘sketch’ and ‘note’ pads which pupils can use to record and develop their ideas. Fig 2 shows examples of pupil outcomes from the *Bag Tags* project. These tags are produced by pupils using computer aided manufacturing (CAM). They are responses to designing a large tag which can be permanently fastened to their bag so easily identifying it as their property. This encourages responsibility and respect for personal belongings.

![Image of pupil outcomes from Bag Tags project](image)

**Developing Evaluation and Reflection Tasks**

The Design Against Crime curriculum model used in all the project books features a final stage of evaluation and reflection tasks. Structure and support are given to enable pupils to evaluate and reflect on both their D&T work and crime issues embedded within the project. For example, pupils may be given opportunity to evaluate and assess each others work by introducing them to assessment criteria which are they then use to make judgements. In *Crime Scene: Systems and Control Dioramas (2003)* (p 21) this is done as a paired activity. Pupils are given the following information:

> ‘To evaluate a piece of work, you need to decide what the important criteria are. Working in pairs, think about the original brief (to design and make a diorama) and the message you were trying to convey. Starting with page 8, look through your workbooks to help you identify criteria that fit both dioramas.’ (p 21)

Pupils work together to develop criteria and assess each others work.

Reflection on crime issues is the final stage in the curriculum model. To do this pupils return to issues introduced in the analytical and synthesis phase of their work. In *Bag Tags* (p 19) ripple diagrams are used, Fig 3. (Over the page)
This ripple diagram shows how breaking a window (centre of the diagram) has an impact on many different groups of people.

Pupils are then presented with the following task;

Start with yourself, and then add four groups of people to the ripple diagram below. Think about what was in your bag and write down how each group of people would be affected.

This is a teaching and learning task in which pupils engage in discussion and reach conclusions about the effects of criminal activity, particularly how other people are affected. Other similar are tasks used, including crosswords, word searches and word matching games. All contain an element of literacy. Pupils are encouraged to express their point of view, and to develop responsible attitudes towards society and in particular criminal activity.

Trialing the projects in Schools
The mechanism for developing the Design Against Crime curriculum model was to:

• develop the first project (*Alarm Systems*) in draft form
• introduce Design Against Crime via INSET courses
• trial the material in five schools
PATT 13

- use teacher and pupil interviews to collect data on their reaction to the project
- modify the Design Against Crime curriculum model and content concurrent with further project development
- present and disseminate ‘Design Against Crime’ to a wider audience
- begin research to measure potential change in pupils’ attitudes to crime and social responsibility as a result of Design Against Crime activity.

Significant in later publications is the increasing sophistication of the analytical and reflective tasks. Teachers made many helpful suggestions during the dissemination phase. The Bag Tags, Alarm Systems and Posters projects trialed in South Yorkshire schools resulted in teachers being unanimous in their view that ‘the project books are very good quality at a cost which is very reasonable’. A recurring theme during the presentations was the cost of running such projects. While teachers agreed that the cost of workbooks was reasonable, the cost of components for the Alarm Systems project was for some schools prohibitive. Some heads of department expressed concern about fitting this type of project into the timetabled carousels operated in their schools. They felt that the projects would take too long. However, teachers using the Bag Tags and Poster projects have comfortably fitted them into carousels of 7 to 9 week modules. Both these projects were developed to be undertaken in 12 to 15 hours with some of the analytical and reflective tasks completed as homework.

The usefulness of the projects is encapsulated in this teachers’ comment:

‘Aspects I particularly liked about the workbooks were the visual materials and the tasks; I think the books are visually appealing and well laid out. The tasks on crime statistics are a useful introduction to the project.’

In one school the Posters project was been adopted as a project for the full cohort of year 7 pupils Personal and Social Education (PSE) theme. Non-specialist form tutors teaching this found the tasks ‘strong in motivation’, with several pupils carrying out additional research and gathering crime statistics from the internet. This school adopted an integrated approach to delivering citizenship. A second school has decided to integrate four Design Against Crime projects into the D&T department’s scheme of work thus ensuring that all pupils engage in a Design Against Crime project. Foulger R (2002) reinforced the usefulness of Design Against Crime projects in the following:

‘At the end of each year, how often do we wish that someone would publish a Scheme of Work that can be easily slipped into the Key Stage 3 design and technology curriculum without hours of meetings? Well this might be it!’ (p 207)

Further Research

Design Against Crime projects have been implemented in many schools with over 2000 workbooks supplied to schools, many of whom are making repeat purchases. Ongoing evaluation and development of the curriculum materials has concentrated on the content and implementation of the projects. Clearly, it is necessary to examine the effectiveness of the overarching aims of Design Against Crime - “to encourage young people to be responsible citizens who grow to recognise the benefits of living with a crime free society”. The team has been successful in securing funding for further research to test the effectiveness of Design Against Crime’s contribution to the citizenship agenda. The objective is to establish whether Design Against Crime project work can produce a measurable change in pupils’ attitudes to, and understanding of, crime issues through raising awareness, discussion and active participation. Five teaching groups and six members of teaching staff in two large comprehensive schools are currently engaged in this research. The strategy being employed involves working with test groups of pupils undertaking a Design Against Crime project, and control groups who have yet to be exposed to this initiative. The main research tool used to collect data is structured group interviewing of pupils and individual interviews with teachers. At this early stage, teachers and pupils are showing a marked enthusiasm for engaging with this research.

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www.designagainstrcrime.org
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Key Words

Crime, design, citizenship, numeracy, literacy, ICT, design and technology, electronics, posters, alarms, CAD/CAM, Key Stage 3, curriculum development.
A longitudinal study of pupils’ attitudes to Design and Technology at key stages three and four in the National Curriculum.

John G. Neale
Email: jjebgrn@supanet.com

Abstract

A longitudinal attitudinal study of three parallel cohorts of secondary pupils from mixed comprehensive schools in England to National Curriculum Design and Technology at key stages three and four between 1995 and 2000. The study relates the pupils’ attitudes as measured on seven main scales to twenty two factors which indicate pupils’ preferences and responses such as enjoyment, perceived level of relative difficulty of Design and Technology to other subjects, the degree of making which pupils would prefer, whether they would wanted more freedom in the choice of projects, whether they would have chosen to study Design and Technology had they been given the option of dropping it, how their understanding of technology in general had developed over their secondary education and what the main influences were in that development. Data was collected from pupils by structured questionnaires at three points in their key stage 3 and 4 courses and GCSE and SATs results were obtained from the schools.

Introduction

The 1995 revision of the Order for National Curriculum Design and Technology made the subject much more manageable in schools yet, in many ways, there was a reversion from some of the wider holistic insights of the 1990 Order and the intentions of the original working party for National Curriculum Technology which had advocated a broad cross-curricular technology curriculum that would equip pupils with skills, knowledge, awareness of value issues, personal qualities, an awareness of constraints and an appreciation of technology in various contexts and other cultures. (Neale, J., 1996 ) How did pupils respond to the 1995 version of the curriculum? Did they accept the ostensive, process orientation with its simplified attainment targets of designing and making, or were there any indications that some pupils would prefer a wider reference and understanding of technology? There have only been a limited number of studies concerned with pupils’ response to recent educational initiatives in the technology curriculum among them are those by Hendley et al ( 1996 ) also John and Thomas (1997); both surveyed pupils’ attitudes in Wales. This study relates to those investigations. Parallel cohorts of pupils from three mixed comprehensive schools in Hertfordshire were surveyed through their key stage three and four National Curriculum Design and Technology courses from the ages of 11+ to 16+.

The study was organised in three phases. The first phase took place after the first year of the key stage three course when pupils were 12+; the second phase after the completion of the key stage three course when the pupils were 14+ and the third phase after completion of the key stage 4, General Certificate of Education (GCSE), course at the age of 16+. Survey information was collected by means of structured questionnaires with the possibility of unstructured response in phases one and two.

The research questions were similar to those of the PATT project in a number of respects. The basic research questions were:-

1 What is the concept of and the affection for ‘Design and Technology’ as a school subject, of key stage 3 and 4 pupils?
2 What is the concept of and the affection for ‘technology’ in general, of the pupils?
3 What variables bear on pupils’ attitudes to ‘Design and Technology’ and ‘technology’?
4 The longitudinal aspect of the investigation in which the pupils’ attitudes were measured at three points in their key stage 3and 4 courses gave the possibility of investigating further questions:-
5 If any significant changes in pupils’ attitudes to ‘Design and Technology’ or ‘technology’ over their key stage 3 and 4 courses?
6 If any significant changes in attitude occur, what are the main factors that relate to these changes?

The structured questionnaires utilised Likert scales ( 10 items unless otherwise stated ), on a five point response pattern of ‘strongly agree’ 5, ‘agree’ 4, ‘undecided’ 3, ‘disagree’ 2, ‘strongly disagree’ 1 or the reverse for negative statements, as follows:-
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scale

t  Pupils’ attitudes towards technology and technologists. This was a modification of one of Page’s scales used to evaluate educational initiatives among secondary school pupils in the early 80’s in the UK. (Page, R., 1978). It was chosen as a scale suitable for use in all three phases of the study.

sc  Pupils’ attitudes towards National Curriculum Design and Technology as a school subject. Design and Technology, D&T for short, was used in the modified PATT scale. This scale was used in phases one and two.

d  24 items. Pupils’ attitude to the detail of the first year of their key stage three course. This was designed by the researcher to detect the pupils’ response to the content of the course. This scale was only used in the first phase.

r  Pupils’ attitudes towards role and gender in relation to technology and D&T. This was a modified PATT scale for role. This scale was used in phases one and two.

i  Pupils’ interest in technology. This was a modified PATT interest scale and used only in phase three.

u  Pupils’ understanding of technology. This was a modified version of the scale used by John and Thomas in their attempt to detect pupils understanding of wider social implications of technology. (John, D., Thomas, G., 1997). It was used in phases two and three.

c  Pupils’ attitudes to a career in technology, (a modified PATT scale).

The aim in using scales twice, or three times in one case, was to detect any movement in attitudes through the key stage three and four D&T courses.

The research instrument questionnaires in the three phases also gathered the pupils’ identities and indicators of some twenty or so factors which included: gender, enjoyment, difficulty, preferences, and also the pupils’ combined designing and making levels in the Standard Assessment Tasks at the end of their key stage three courses at 14+ (SATS) and their examination grades at the end of their General Certificate of Secondary Education examinations at 16+ (GCSE).

The mean scores for the main scales which all had a Cronbach Alpha Reliability Coefficients of .70 or above, indicate that while pupils responded consistently, both boys and girls demonstrating an equally highly positive attitude to Design and Technology as a school subject (sc) in both phases one and two as they did also on the role/gender scale (r). There were small but significant declines in their attitudes on the ‘understanding’ scale (u), the ‘career’ scale (c) and the ‘technology and technologists’ scale (t) from phase two to phase three. In School 1 all of the career (c) responses were in the negative band for both boys and girls in phase three. These results agree with the expression of pupils’ preferences in phase 3 where some 70% of pupils did not want to continue any studies in technology and nearly 30% said that, if in retrospect they had been given the option, they would not have taken Design and Technology at key stage 4.
## PATT 13

### Phase 1 main scales questions 8 to 61, mean scores

<table>
<thead>
<tr>
<th>Pupils’ attitude to technology (t)</th>
<th>3.51*</th>
<th>3.53</th>
<th>3.46</th>
<th>3.42</th>
<th>3.45</th>
<th>3.38</th>
<th>3.55</th>
<th>3.60#</th>
<th>3.51</th>
<th>3.56</th>
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</tbody>
</table>

Pupils’ attitude to D&T (sc).  
3.62 3.67 3.57 3.40 3.46 3.31 3.81 3.85# 3.78 3.70 3.77 3.61

Pupils’ response to detail of D&T (d).  
3.75 3.76 3.74 3.69 3.71 3.67 3.78 3.82# 3.75 3.79 3.76 3.82#

Pupils’ attitude to Gender/role (r). 4.00*  
3.65 4.43 3.97* 3.67 4.39 4.07* 3.72 4.37 3.98* 3.57 4.56#

Pupils’ attitude Rating, combined 3.73*  
3.68 3.78 3.64 3.61 3.68 3.80 3.76 3.83 3.76 3.69 3.86 #

N = 419  * Indicates a significant difference between girls and boys. # Indicates highest or joint highest score in row.
### Phase 2 main scales questions 11 to 60, mean scores

<table>
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<td>boys</td>
<td>All girls</td>
<td>pupils</td>
</tr>
<tr>
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<td>3.61*</td>
<td>3.70</td>
<td>3.50</td>
<td>3.53*</td>
</tr>
<tr>
<td>Pupils’ attitude to D&amp;T (sc)</td>
<td>3.61*</td>
<td>3.64</td>
<td>3.56</td>
<td>3.54*</td>
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<tr>
<td>Pupils’ attitude to technology as a career (c)</td>
<td>3.30*</td>
<td>3.34</td>
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<tr>
<td>Pupils’ attitude to role/gender (r)</td>
<td>3.96*</td>
<td>3.63</td>
<td>4.35</td>
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<td>Pupils’ attitude to understanding technology (u)</td>
<td>3.49*</td>
<td>3.52</td>
<td>3.46</td>
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</table>

N = 216  * Indicates a significant difference between girls and boys. # Indicates highest or joint highest score in row.
### Phase 3 main scales questions 7 to 46, mean ratings

<table>
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<th>All three schools</th>
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<th>School 3</th>
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<tbody>
<tr>
<td></td>
<td>pupils boys girls</td>
<td>pupils boys girls</td>
<td>pupils boys girls</td>
<td>pupils boys girls</td>
</tr>
<tr>
<td>Pupils’ attitude to technology (t).</td>
<td>3.50* 3.42 3.38</td>
<td>3.58 3.23 3.50</td>
<td>3.69# 3.50</td>
<td>3.54* 3.58 3.48</td>
</tr>
<tr>
<td>Pupils’ attitude to technology as a career (c).</td>
<td>3.09* 3.03 2.82</td>
<td>2.90 2.73 3.20</td>
<td>3.13 3.26</td>
<td>3.21 3.34# 3.04</td>
</tr>
<tr>
<td>Pupils’ response to items on interest in technology (i).</td>
<td>3.29* 3.42 3.15</td>
<td>3.15 3.29 2.97</td>
<td>3.25 3.42 3.13</td>
<td>3.41* 3.51# 3.28</td>
</tr>
<tr>
<td>Pupils’ attitude to understanding technology (u).</td>
<td>3.35* 3.46 3.36</td>
<td>3.25 3.31 3.18</td>
<td>3.56 3.71# 3.52</td>
<td>3.39* 3.39 3.38</td>
</tr>
</tbody>
</table>

N = 269  * Indicates a significant difference between girls and boys. # Indicates highest score in row.
Enjoyment

At the beginning of the structured questionnaires in each phase of the study pupils were asked to indicate the level of enjoyment of Design and Technology lessons as a general indicator of their response to the curriculum and the way it was being taught, by ticking boxes labelled ‘never’ (1), ‘on a few occasions’ (2), ‘sometimes’ (3), ‘yes, most times’ (4), and ‘yes, always’ (5). In phase 1 the overall mean response was 3.606, that is positively skewed between ‘sometimes’ and ‘yes most times’ with boys slightly more positive than girls. This pattern was repeated in phase 3 with both boys and girls at a slightly less positively skewed level of about 3.58. In phase 2 the question was put in a different way where the pupils were asked to indicate their enjoyment, their understanding and the level of difficulty in D&T lessons relative to that they experienced in year seven in phase 1. Overall, 59% of pupils said they enjoyed lessons more than in year seven, 34% the same and 7% less than year seven. There was a higher proportion of girls in the ‘more’ category. On the point of whether they believed they undertook D&T more in year 9 the overall response was 1% saying ‘less’, 12% saying ‘same’ and 87% saying ‘more’ than in year seven. There was a higher proportion of girls than boys in the ‘more’ category. The relative difficulty figures were 39% felt D&T was less difficult than in year 7, 40% felt it was the same and 21% felt it was more difficult with a slightly higher proportion of girls in the last category.


The respondents were asked in each of the three phases to indicate their perceived difficulty level of Design and Technology in relation to other subjects by ticking a simple tick box ‘easy’ (1), ‘medium’ (2) or ‘difficult’ (3).

In phase 1, surprisingly, overall D&T (1.83), was rated second in difficulty to Maths (1.87) with Science at 1.82 next, English at 1.72 and Art at 1.67. There were significant differences between girls and boys in Maths which girls found more difficult, English which boys found more difficult and Science which girls found more difficult. There were no differences for D&T and Art.

In phase 2 D&T was lowest in perceived difficulty even below Art, which was next lowest. Maths was regarded as most difficult with girls regarding it as significantly more difficult than boys. English and Science were roughly equal with boys regarding English more difficult and girls regarding Science more difficult. Again there were no significant differences between girls and boys for D&T and Art.

In phase 3 D&T was placed second lowest in difficulty above Art. Maths was the most difficult with girls finding it significantly more difficult than boys. English was next with boys finding it more difficult and Science next with girls finding it more difficult. In this phase boys found Art more difficult than girls.

D&T was the only subject on the list in which there were no significant differences between boys and girls in all three phases.

Favourite subjects

In phase 1 pupils were asked to name their favourite subjects, overall D&T was placed sixth equal favourite subject together with Science. The top favourite was Art, then Physical Education, English, Drama and Mathematics. The top subjects for the girls were Art, English and Physical Education and the top subjects for the boys were Physical Education, Art and Design and Technology. In phase 2 Design and Technology was third favourite overall behind Art and Physical Education.

Pupils’ preferences

Pupils were asked in phase 2 to express whether they would have preferred more, the same, or less making than they experienced in their key stage three Design and Technology course; 61% expressed the preference for more making with 38% wanting the same level of making and 1% wanting less making. They were also asked whether they would prefer more, the same, or less freedom in the choice of projects for the key stage three course. 82% wanted more freedom of project choice, 16% the same level and 1% less.

Also pupils were asked if in retrospect they had the choice of whether or not they would take the key stage three course at all; 18% of pupils, that is one sixth of the pupils in this survey, said they would not have taken Design and Technology as a subject.

In phase 3 pupils were again asked in light of their GCSE key stage four courses whether they would have taken a Design and Technology course if they had the freedom not to. An astonishingly high proportion of 29.7% said they would not wish to study Design and Technology; a higher proportion of girls than boys.
The 16+ intentions of the pupils reflected these figures. 70% of pupils did not wish to continue any studies in Design and Technology; 18% were considering the possibility of Advanced Level GCSE or AS Level; 3% were considering a General National Vocational Qualification; 3% an apprenticeship involving technology and 1% would have liked the possibility of an International Baccalaureate Qualification involving technology.

In phase 1 pupils were asked if they would consider the teaching of some aspects of Design and Technology in other school subjects; the responses suggested that many would want the design element taught in Art and also some Design and Technology to be taught in Science, Geography and History.

**Pupils' wider understanding of technology**

In phase 3 pupils were asked to what degree they considered their understanding of technology had developed over the period of their secondary education, 'very little', 'a fair amount', or 'a lot'. 25% considered it had developed 'a lot', 61% 'a fair amount' and 14% 'very little'.

Also, they were asked to indicate the degree to which they considered they had been influenced in their understanding of technology by the media, Design and Technology lessons, Science lessons, parents, school clubs, leisure activities and other influences. When summing the 'some' and 'a lot' categories Design and Technology lessons were reported as the biggest influence by 93% of the pupils with the media second at 92% and Science lessons third at 80%. Parents, leisure activities, and other influences were rated at about 60%.

**SATS levels and GCSE gradings**

The SATS and GCSE results in Design and Technology for the three schools are above the National average with the mean level in SATS (range 0 – 7) at 5.93 for the girls and 5.46 for the boys. The GCSE grades (range 0 – 8) are similarly high with girls at 6.22, that is between A and B more than half a level above the boys at 5.66 that is between B and C. There were no significant correlations between GCSE and SATS results and the boys' responses to the main scales, but for the girls there were significant correlations between their results and their mean responses on the main scales.

**Phase 1: Pupils' unstructured response to the question ‘What is technology?’**

After completion of the phase one questionnaire pupils were asked to put their name on a separate piece of paper and respond to the question ‘What is technology?’. They had been prompted before completing the questionnaire to consider D&T as the school subject and ‘technology’ as referring to a wider and general use of the term. Some pupils wrote a very short answer admitting they did not really know what technology was or nothing at all, others responded with a core idea which resembled the school subject ‘design and make’ emphasis with a few ideas added; however many pupils attempted a wider description and some of these are given below.

Some of the year seven pupils’ descriptions of technology were quite revealing showing that they sensed the multi-dimensional character of technology, the impact that it has on our lives and society, the way it is involved in nearly every aspect of modern life; that they appreciated the benefits in housing, transport, medicine, the media and communications, agriculture etc; but some were also very much aware of the down side, the control technology exerted over them, the uniformity, the pollution, collectivisation, the way it revolutionises jobs and other negative aspects.

The structured section of this survey in phase 1 showed that most pupils had a positive attitude to both Design and Technology as a school subject and to technology in general. However, in many respects technology will not fit into a mould of ‘separated’ school subjects and if it treated in a wider cultural context needs a multi-disciplinary cross-curricular approach. This was the intention of the National Curriculum working party for technology as it drafted the original order for the subject and proposed the development of technological capability through skills, knowledge, the acquisition of suitable personal qualities, the teaching of value issues with increasing awareness of context, local and cultural, and also understanding of constraints. The demise of the 1990 Order is understandable in light of the inadequate teacher and management orientation and preparation, the lack of resources and the manageability problems that ensued but, the narrowing of vision in the 1995 Order with its reversion to an instrumentalist and limited practical framework with a retreat from cultural contexts and value issues would seem contrary to some of the indicators which were picked up in the first phase of this survey.

Answers to this unstructured question ‘What is technology?’ together with structured responses to other questions on the questionnaire, showed that many boys and girls would have appreciated a wider cross-curricular dimension than was being offered.

**Examples of descriptions given by year seven pupils in response to the question ‘What is technology?’**, (spellings corrected).
“It’s something that changes ways of life step by step, gradually building sources around the world. Technology is good for transport, entertainment, medicine, does things quicker; but bad for takeover, pollution, people losing jobs.” (girl).

“Technology is like the study of structures or buildings and examining how they are made; it is solving problems and also designing and making projects. Technology might ruin our lives soon and it is getting too powerful. It has control over lives of people. Soon no one will leave their home any more. The Internet and home shopping should not be allowed. Technology is also studying food fabrics and designing and making from metals and plastics. It is also computers and networks. I think things should be simpler.” (boy, pupil’s own underlining)

“Use of computers, building and constructing things and learning painting, sculpting and gluing; the use [of] logical explanations to solve your problems not just throwing away and starting again, but thinking about things, using your brain and learning about computers and machines like jigsaws or drills or hammers and nails and things like that; it’s also about cooking decorating and sewing and truthfully evaluating your work, that’s what technology is about. It is also about improving the way we live cutting down on resources and manpower making even the most difficult thing simple either by bringing in big machines to do the work or using a computer to talk to someone on the other side of the world or something like that using robots or machines to make our lives easier. Even some of the oldest inventions are the most helpful like the contact lens or the wheel, the car, the plane, the vacuum cleaner or even the bicycle are all still in constant use today. So technology has greatly improved since even ten years ago; so next time you think of technology you should think of these things and also that technology is one of the greatest things in the world.” (boy)

“1 Technology is a matter of life.
2 Technology helps us through each day.
3 Technology is sometimes fun but very serious.
4 Technology keeps us healthy and well.
5 Technology is something we would be lost without. It provides homes, clothes, food, furniture, bedding, information and lots more.
6 Technology is helpful in every way.” (girl)

“Technology is the advancement of man and machines and the world we live in and technology is what makes us able to travel into outer space and explore cures for new diseases, cures for illnesses and pain. Man tries to use technology to make the world more exciting and more comfortable for the rest of mankind. Technology has done and will gradually improve over the years to come. Unfortunately, technology can also cause illness and pollution.” (boy).

Phase 2 Unstructured response
At the end of the phase 2 questionnaire pupils (14+) were asked to respond by agreeing or disagreeing with the following quote from the Time/Life issue of 23rd March 1998 which read:

“The vast majority of products and production processes of modern society are unsustainable. We rely on dinosaur technology inefficient and voracious in its appetite for resources. Other technologies are unsustainable in what they do for our future!”

Many pupils found it difficult to respond and gave an answer similar to that from this girl who said:

“I don’t really understand the question – I don’t think my D&T courses have given me much understanding about this issues to answer it. I do agree with what its saying, but I’m not completely sure what it means. I think it is disagreeing with most technology.”

Other pupils attempted a longer reply and some were revealing, for example this boy seemed quite aggressive in his attitude;

“I disagree strongly with this statement. It implies that technology has reached its climax and is not improving at a faster and faster rate in an effort to improve our lifestyles. The quote says that technology is ‘voracious in its appetite for resources’. I can’t think of anything more false; the very focus of technology is to advance lifestyle and save labour. Therefore any use of resources by technology is thoroughly justified. I can’t see how technology can possibly be perceived as wasteful and pointless because technology is vital to improving life, possibly easing labour and stress. Someone as ill-informed as the writer of this quote should consider the
PATT 13

Consequences of their own lives without technology before being so critical. I don’t feel the D&T particularly helps me to comment upon aspects and opinions of technology in the world today because the skills we learn in ks 3 are more individual and practical rather than concerned with aspects of high technology.”

Conclusions
From the high National Curriculum Design and Technology GCSE grades and SATS levels the pupils achieved and the positive attitudes towards Design and technology as a school subject it would appear that the key stage three and four courses between 1995 and 2000 were successful, especially in relation to chaos of the preceding introductory period of the subject. However, the high proportion of 29.7% of pupils who indicated in retrospect that they would not wish to study Design and Technology if they had freedom of choice at key stage 4 and also the slight but significant declines in the means of the main scales, Understanding (u), Technology and technologists (t) and career (c) from phase two to phase three indicate that many pupils felt they had not developed a wider understanding of technology and also that they did not want to consider a career involving a technological dimension. These findings matched up with those of John and Thomas who said:

“Although a large number of pupils appear sceptical about technology’s potential value to them in their future careers, and in its relevance to the world at large, many are more positive about other aspects of the subject” (John,D.,Thomas,G.,1997,page 123).

Further investigation of the responses on the understanding scale based on that developed by John and Thomas also reveals that in many ways the pupils in this study, although competent academically, are even less positive and understanding towards technology than those in the Welsh study. They reject the statement ‘D&T helps me to understand and evaluate the purpose, processes and products of technological activity and the wider role of technology in society’ but they also agree with the negative versions of the statements:

“School D&T provides very little opportunity for pupils to study technology in the wider world and its interactions with society and the environment.”

“D&T doesn’t provide enough opportunity for pupils to bring together and apply knowledge from other school subjects”

“I feel D&T in school does not prepare young people to live creatively and effectively in a “technological world”.

There was a higher proportion of pupils opting for the ‘undecided’ option the equivalent of ‘don’t know’ in the John and Thomas study. Pupils unstructured responses in phase 2 indicate that many of them feel that they cannot comment on aspects of modern technology.

The findings of this study point to the need for a continuing discussion of the underlying rationale or framework for the technology curriculum and whether the ‘design and make’ paradigm is adequate to equip pupils for life in present day society. As Barnett (1992), has said technology by its nature does not easily fit into the school curriculum and there may need to be much more flexibility given even around a practical core. The pupils in this survey wanted more freedom in the choice of projects, they complained about the length of the coursework and the amount of (unrelated) written work. It maybe that if pupils were given a freedom element in their technology studies that some may wish to venture into the history of technology including some of the modern products which have so recently revolutionised the world like the PC or the Walkman, or into model making for films and leisure purposes, or medical technology, or military technology, or some may even surprise one by wanting to look into the sociology or the philosophy of technology before the age of sixteen demanding as this would certainly be for any school to cope with. But schools should not be asylums of the past.

References
Appendix

Main scales: Pupils' attitude to a career in technology (c).

1. I will not choose a career which involves aspects of D&T.
2. I will consider a possible career which involves D&T.
3. I feel a career involving D&T is more secure for future employment.
4. I feel a career involving D&T would be boring for me.
5. D&T would be interesting as a career.
6. I can't understand people who choose a career in D&T.
7. I would be interested in finding out about careers concerning design and technology.
8. I feel most jobs involving D&T are not interesting.
9. I think I would enjoy a profession or career which was concerned with aspects of technology.
10. A job which involves aspects of D&T would not be my cup of tea.

Phase 2 Phase 3
Cronbach Alpha .9147 .9173

Main scales: Pupils' Attitudes to technology and technologists (t).

1. I think the more technology we have the better things will be.
2. It is good we put restrictions on some of the things technologists do, because otherwise they would just wreck everything that matters in life.
3. Technology does not serve us as it should, but makes us live in ways we don’t like.
4. Technologists are very clever and responsible people.
5. Technology makes sure resources are used efficiently.
6. Technologists cause more problems than they solve.
7. Technologists are very useful people.
8. I think if we tried to live without technology we would be much happier people.
9. Technology is affecting our lives too much, we should go back to a simpler way of life.
10. If we had more technologists, it would greatly improve our way of life.

Phase 1 Phase 2 Phase 3
Cronbach Alpha .7000 .7220 .7526
(with item 2 removed)

Main scales, Pupils' wider understanding of D&T as a school subject (u).

1. I feel D&T in school does not prepare young people to live creatively and effectively in a ‘technological world’.
2. I feel that school D&T only gives a limited understanding of technology as a human enterprise that is necessary in the different countries in the world.
3. D&T provides many and varied opportunities for pupils to gain experience of the processes which are central to technological activity.
4. D&T doesn’t provide enough opportunity for pupils to bring together and apply knowledge form other school subjects.
5. D&T helps me to understand and evaluate the purpose, processes and products of technological activity and the wider role of technology in society.
6. D&T helps to develop pupils' practical capability to think and act imaginatively by allowing them to apply physical, personal and intellectual skills.
7. D&T gives some understanding of the way technology and science work together in industry and society.
8. School D&T provides very little opportunity for pupils to study technology in the wider world and its interactions with society and the environment.
9. School D&T does not prepare pupils for work and life in society.
10. D&T fosters confidence to solve problems, perseverance, enterprise, good judgement, responsible attitudes to the environment and awareness of safety.

Phase 2 Phase 3
Cronbach Alpha .7696 .7308 (with item 7 removed in phase 3).

Main scales: Pupils' attitude to gender roles in D&T and technology (r).

1. Girls are just as keen to study D&T as boys.
2. Girls are quite good at operating computers.
3. Generally, girls know as much about D&T as boys do.
4. More girls should work in technology.
5. Girls think D&T is uninteresting.
6. Boys are able to do practical things better than girls.
7. A girl should not try to become a car mechanic.
8. It is alright for a girl to have a technical job.
9. Generally, boys are more capable of doing technical things than girls.
10. D&T is equally difficult for boys and girls.

Phase 1 Phase 2
Cronbach Alpha .8691 .8463
(with item 7 removed in phase 3).
Main scales: Pupils' response to detail of D&T as a school subject (d).

1. Looking at other products and taking them to pieces doesn't help me in the design of my own projects in D&T.
2. Designing and making projects in D&T to a high standard gives me a feeling of satisfaction.
3. Learning to work together with other pupils isn't important in D&T lessons.
4. I rarely use skills and knowledge from science, art and maths in my work in D&T projects.
5. It is important to use the skills I have learnt in D&T to shape and form materials accurately.
6. It isn't necessary to learn how different products are manufactured in industry in our D&T lessons.
7. Designing and making products in food and textiles is an interesting part of our D&T course.
8. The research I do for a project doesn't help me with my own designing or making in D&T.
9. When designing and making a product it is good to think, not only about the materials and how to make it but, also about its use maintenance and disposal.
10. The safe and accurate use of tools and machines doesn’t matter very much in D&T projects.
11. I am making good progress in D&T.
12. Trying different methods and problem solving isn’t really necessary in D&T.
13. Modern electronic components are so useful, I would like to use some in the future.
14. 'Brainstorming' in class to get ideas for projects in D&T helps me in the design of my projects.
15. Organising and planning out my practical work helps me in my D&T projects.
16. I enjoy doing a lot of sketches and notes of my own ideas when designing a product in D&T.
17. It isn’t really necessary to know about the properties of materials to use them correctly and creatively in D&T.
18. I am prepared to change my designs if I find I encounter Problems when making projects in D&T.
19. It takes too long to use computers and IT to get information for my projects in D&T.
20. Making products in different materials in D&T is enjoyable.
21. I don’t want to learn about theory in D&T in topics like Mechanisms, structures, energy and materials.
22. I find it exciting to work out and develop new ideas for my projects in D&T.
23. I don’t find joining and gluing components together interesting in D&T.
24. I do not learn much from commenting on or evaluating my own work in D&T projects.

Phase 1

Cronbach Alpha .8254

Main scales, Pupils' interest in technology in general (i).

1. I enjoy learning about new discoveries involving technology.
2. I am not interested in technology.
3. If there were a school technology club, I would join it.
4. A hobby which involves technology is boring.
5. I feel reading books and magazines about technology is profitable.
6. There should be less media coverage of technology on TV, radio and in magazines.
7. To visit factories and other places and see technology in action would be interesting.
8. I am not interested in industrial, commercial or other applications of technology.
9. The history of technology is fascinating.
10. I do not really want to know about the development of present day technology.

Phase 3

Cronbach Alpha .8570
The paper compares the Design and technology (D&T) curricula of Scotland and the state of South Australia and it takes a particular focus on how values have been addressed in each. It presents:

- information (demographic and educational) on the context and development of the two curricula
- description of how Design and Technology is organised in each jurisdiction
- information on how values are articulated through each curriculum
- issues concerning implementation

The paper discusses the comparative strengths and weaknesses of each curriculum in its attempts to articulate values through D&T. In conclusion, key pointers for consideration for those engaged in D&T curriculum development are presented.

Keywords: design and technology, curriculum, values, Scotland, South Australia

Introduction
This paper compares Design and Technology (D&T) curriculum developments in two educational jurisdictions over the last decade. In particular it explores the capacities of the two curricula to embrace values as an integral part of D&T practice. The commentary and reflections presented here are the professional considerations of the authors – who have had involvement in the respective developments, have written on values in technology education (McLaren,1997; 1999, Keirl, 2000; 2001) and are D&T teacher pre-service and in-service educators.

Demography
While both jurisdictions serve Western-style free-market economies and enjoy degrees of cultural linkage through the English language, trade and settlement, there are notable demographic differences between the two. However, these differences do not impinge greatly on the commonalities of approach to education.

Australia is a vast continent with a history of British colonial expansion dating from 1788, yet preceded by over 50,000 years of Aboriginal and Torres Strait Islander coexistence with the land. The population is approaching twenty million and, as Indigenous people constitute about 2% of the whole, the majority are from multiple immigrant sources. The country is now a century-old Federation comprising six states and two territories. Of these, the state of South Australia has an area of 984,372sq. km and constitutes 12.8% of Australia’s landmass. Often described as ‘the driest state in the driest continent’ it has only one major river. It has a population of about 1.5 million (7.8% of Australia’s total) of whom about one million live in the capital city of Adelaide. South Australia is a key producer in wine, wheat, barley, mining and aquaculture.

Scotland, while a constituent country of the United Kingdom, maintains its own distinctive cultural, financial, educational and political identity. Its population of about five million constitutes 8.6% of the UK total with the majority living in the central belt between the firths of Clyde and Forth. The country’s landmass is 78,749sq km (32% of UK) and it has no shortage of water or rivers. The major industries of Scotland are oil, gas, electronics, whisky, forestry and fishing but it is tourism that pays the wages of more people than those industries combined and contributes a £4 billion a year to the Scottish economy.

Scottish education
The education system in Scotland has always been autonomous. The Scottish Executive Education Department (SEED) has overall responsibility for the curriculum, examination system and quality assurance in education. There are 32 local governments each with responsibilities for education within their particular council area.
**PATT 13**

Learning and Teaching Scotland (LT Scotland) is a national public body, sponsored by SEED, which aims to enhance the quality of educational experiences with a view to improving attainment. It provides advice, support, resources and staff development. Its remit covers all matters relating to the curriculum in the pre-school, primary and secondary education sectors.

LT Scotland have successively produced *5-14 National Guidelines for Scotland* for the identified curriculum areas including Technology (SCCC, 1993; LTS, 2000a). These are not statutory but provide the recommended and advised curriculum structure and learning. Her Majesty’s Inspectorate for Education (HMIE) Scotland review the effectiveness of schools and provide feedback in terms of the 5-14 curriculum and related policies. The 5-14 rationale provides an entitlement for all state educated youngsters from arriving at primary school to completing their second year of secondary school (i.e. from 5 to 14 years old) when option courses begin. These courses are offered by the Scottish Qualification Authority (SQA) which is also responsible to SEED.

**South Australian education**

Constitutionally, education in Australia is the prerogative of the states and territories. However, national collaboration in the 1980s saw the establishment of ten Common and Agreed goals for schooling in Australia with, a decade later, the updating of the federal agreement with state and territory education ministers declaring the National goals for schooling in the twenty-first century (MCEETYA, 1999).

In South Australia, a single government body, the Department of Education and Children's Affairs (DECS – formerly DETE - Education, Training and Employment) is responsible for the development, implementation and monitoring of curriculum in the state-owned early childhood centres and schools. About one third of all schools are managed by the Catholic Education Office (CEO) or are independent schools.

In 2001 DETE and the CEO published a new curriculum framework - the South Australian Curriculum, Standards and Accountability (SACSA) Framework. As the name suggests, and with some affinity with the Scottish developments, the framework is not a prescriptive policy but a common structure for the guidance of each centre/school and its carers/teachers to develop curriculum appropriate to local circumstances.

**D&T in each jurisdiction**

**Scotland**

The 5-14 National Guidelines for Environmental Studies (ES), Technology component (SCCC,1993) comprised two key features: developing knowledge and understanding of technology in society and developing knowledge and understanding in using the design process and a section on developing informed attitudes.

Technology Education in Scottish Schools (SCCC, 1996) was published to clarify and develop the rationale and value of Technology Education. It described the purposes, values and learning outcomes of an effective technology education which focused on developing technological capability. It recognised that: ‘Technology is a distinct form of creative activity….It is an intrinsic part of all cultures, and both reflects and shapes the values and beliefs of those cultures.’ (SCCC, 1996:3). It also recognised that Technological Capability is about providing opportunities for young people to explore and develop moral thinking and social responsibility, as specialist technologists or thinking and acting consumers, users or citizens in addition to taking practical action and being creative.

Technological Capability comprises mutually supportive and interconnected aspects of technological sensitivity, confidence, perspective and creativity. For example, technological sensitivity endeavours to develop learners with ‘a caring and responsible disposition, a habit of mind which asks and reflects about social, moral, aesthetic and environmental, as well as technical and economic aspects of technological activity undertaken by oneself and others in a variety of contexts.’ (SCCC, 1996:9). Technological perspective involves bringing an inquisitive mind to bear on the made world and appreciate the complexity of decisions which may involve resolution of tensions between aesthetic, cultural economic, ethical and functional aspects. The learners explore ‘how the made world has come to be as it is and indicate ways in which it might have been different.’ (SCCC, 1996:8).

The rationale of ES remains the same in the resultant revised guidelines for 5-14 ES: Society, Science and Technology (LTS, 2000a). Through a common framework it aims to enhance critical thinking, problem solving and develop informed attitudes and ideas about sustainable development, responsible citizenship and moral and ethical considerations and consequences of students’ own actions as well as those of others. Technology is described a single attainment outcome: ‘technological capability’. (The underlying concept of technological capability is also embedded in a range of post-14 certificate courses, introduced in 1999.)
Additionally the permeating framework for ‘developing informed attitudes’ within ES develops the dispositions embedded in the Scottish Curriculum (LTS, 2000b)

- *a commitment to learning* (technological confidence);
- ‘Enjoyment of practical work and of it being worth doing well.’ and ‘Working alone, together and with experts and how each can help achieve solution to problems’ (LTS, 2000a:76)
- *respect and care for self and others* (technological sensitivity);
- ‘The importance of other people’s views, feelings and situations when developing criteria and whilst engaging in designing and making.’ and ‘The notion that ideas and solutions, which although satisfying some, might be unacceptable to others.’ (LTS 2000a:76)
- *social and environmental responsibility* (technological perspective);
- ‘The way products come into existence, are bought, sold, used and discarded and the effects upon social systems and environmental quality’ and ‘The interplay between meeting people’s needs through the use of materials, money and time conserving and improving the quality of the natural environment through minimising the harmful effects of action.’ (LTS 2000a:76)

**South Australia**

The SACSA concept entails one coherent birth-to-year-12 (age 18) document. In line with the national agreement (MCEETYA, 1999), there continue to be eight ‘learning areas’ (these are not subjects but give the framework for developing them) one of which is D&T. SACSA also interweaves five Essential Learnings: Identity; Thinking; Interdependence; Futures; and, Communication. These are ‘…understandings, capabilities and dispositions that are developed (as) personal and intellectual qualities, not bodies of knowledge, and …are developed throughout an individual’s life and not arrived at in school.’ (DETE, 2001). There are also cross-curricular equity perspectives including Aboriginal and Torres Strait Islander culture, multi-culturalism, gender, vocational education, and education of students with disabilities. The framework is a revision and refinement of prior technology curriculum guidance for birth to age 5 (DECS, 1995) and for ages 5-18 (AEC, 1994a&b).

SACSA D&T (DETE, 2001) is grounded in a three dimensioned (the three are to be integrated and neither isolated nor sequenced) understanding of technological literacy. The dimensions are the operational (learning to use and do), the cultural (learning through technology), and the critical (learning about being with technology). These are articulated through three strands: critiquing, designing, and making – which are never intended as a lockstep sequence. (Their predecessors of design, make, and appraise - DMA - had become a pedagogical mantra.) The D&T learning area offers eight aims, five of which are ‘…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
- capacities of responsible management and duty of care towards themselves and others when designing, making and using.’ (DETE, 2001:Middle Years Band:37)

Examples of two outcomes (standards) for critiquing and designing at year 10 (age 15-16) are:

**Critiquing:** The student examines critically the competing values embodied in designed products, processes and systems, clarifies relationships amongst people, products and quality of life and presents ethical analyses of various possible technological futures.

**Designing:** The student independently generates and manages design strategies to create ethically defensible products, processes and systems.

A fuller report of the SACSA D&T development is available elsewhere (Keirl, 2002)

**Values in these two curricular frameworks**

To talk of ‘values in curriculum’ is almost to imply that curriculum can be, or has been until now, values-free. This notion is clearly indefensible. We would suggest that the promotion in recent years of ‘values in (Design and) Technology Education’ reflects, at very least, some sense of dissatisfaction with the status quo or, alternatively, recognition of a shortfall of articulation of a fuller spectrum of values or, quite probably, both. Whatever the perception, we acknowledge that values of some sort are ever-present in curriculum. We subscribe to the view that the range of values traditionally present in this field of education has been limited – notably
towards economic imperatives, instrumentalism and technicist approaches both in the aims of technology (technical?) education (training?) as well as in its pedagogy.

It is clear that the two curricula under review share visions far beyond the technicist and the instrumental. Both express themselves with much richer terminology and higher expectations than has traditionally been the case – although they do this in their different ways. The Scottish inclusion of technology under an environmental umbrella gives it far greater meaning than as skilling and know-how alone. The South Australian re-naming of the learning area from ‘Technology’ to ‘Design and Technology’ was itself a reflection of the values-rich and purposive-intentional activity of design compared with the object- and use-only connotations of technology.

Each curriculum makes its holistic and socially inclusive purposes of technology education explicit through the respective concepts of technological capability and technological literacy. If students are to develop ‘technological sensitivity, confidence, perspective and creativity’ (Scotland) or ‘ethical, critical, enterprising and futures dispositions’ (South Australia) then they will inevitably be exposed to a spectrum of (often competing) values. Both curricula are explicit in their expectations of technology education being a vehicle for student engagement with, inter alia, social, cultural, moral, environmental, ethical, and aesthetic values. Not only are such values beyond, and deeper than, the simply instrumental, but their explicit articulation exposes the until-now invisibility of any values in technology curriculum.

Significantly, both curricula highlight the central importance of designing as the enabler of technology values education. In both jurisdictions it is design activity that engages students’ thinking with a full spectrum of competing values and questions. Perversely, it is also perhaps the design issue that has been partially responsible for the tardy development of a values dimension to technology education.…. 

Issues of implementation
We recognise that any new curriculum is only part of an evolutionary process and, in ways, reflects ideology at a particular point in time (Apple, 1979; 2001). However, some aspects of implementation, though probably unsurprising, need reporting.

Despite both curricula being attempts at rationalisation and simplification, implementation has been patchy. In Scotland, Harlen, Holroyd and Byrne (1995) and HMI reports (HMI, 1996; 1997; 1999; 2002) document issues of teacher confidence and poor implementation. The shift in emphasis from a skills-based crafting of predetermined items towards holistic technological capability has largely been ignored. ‘In technology, in only a minority of schools (up to 15%) were pupils skilful in designing and making and had a good understanding of the impact of technology on society.’ (HMI, 2002:10)

For South Australia, there is a lack of documentary evidence of implementation. No detailed research is available and there is no system of formal inspection in place. However, a pattern similar to that in Scotland can be reported. In the primary sector, values-based interrogation of designs and technologies takes place in two ways - through growth in quality D&T work per se but also through D&T’s invaluable role as integrator of the general curriculum.

In the secondary sector there is far less evidence of values-rich (D&T) activity. The bracketing of (D&T) in the last sentence indicates a key problem. There is clear evidence from both jurisdictions that values cannot flourish without a design pedagogy that is quite different from that of (the still-dominant) traditional technology teaching. In Scotland the approach is ‘demonstration and do’. There is little opportunity for pupils to engage in design activities in which they decide upon, justify and have ownership of their own design decisions. Generally, resources, processes, size, outcomes continue to be teacher-directed and determined. Value judgements, attitudes and opinions are not incorporated as a vehicle for learning as the curriculum guidance encourages. There seems to be very little discussion about technology or technology in society. In South Australia it is significant that, where secondary teachers declined to adopt design and design pedagogy with the 1994 innovations (AEC, 1994a&b), curriculum adoption has now become even more difficult for them with the recent iteration.

There are two broad aspects to the issue of take-up. Firstly, the very adoption of design-based values-rich curriculum and pedagogy requires or assumes a parallel philosophical and pedagogical alignment by the practising teacher. This hearts-and-minds issue is far from trivial and it is probable that nowhere else in curriculum has there been such a high expectation of change by the profession. However, this cannot be an absolute reason for rejection of curriculum innovation as curriculum-in-general continues to move and develop in all jurisdictions.
Indeed, the positioning of Technology under ES umbrellas to convey commonality and connections in learning and dispositions (Scotland) and the grouping of technology subjects within Learning Areas and interwoven with essential learnings (South Australia) are perceived by some as potential erosions of the integrity of D&T education. There is currently speculation in three Australian states that constructs such as essential learnings will become the principal organisers of the next wave of curriculum development.

The second aspect concerning implementation concerns quality professional development (PD). In both jurisdictions this, too, has been patchy, even non-existent. If teacher confidence, knowledge and competence are to be enhanced then they will not just ‘happen’. In both jurisdictions, limited funding means that D&T must compete with other worthy claims for support. In the meantime, the flow-through from teacher education will take time to bring benefits to schools.

**Considerations for D&T curriculum development**

We conclude with these considerations for those involved in values-rich D&T curriculum development:

- Unifying concepts such as technological capability or technological literacy (whether deemed philosophical or political in nature) usefully serve to articulate curriculum vision and intention. In doing so they can facilitate values-rich constructs of technology (although each can be constructed in the narrowest of ways too).
- Designing is central to the facilitation of a values-rich D&T curriculum. With it comes the need for particular pedagogical strategies.
- Thus, initial teacher preparation and support for practising professionals may need to address teacher confidence and/or facilitate personal values- and philosophy-shifts. Well-designed PD requires quality resources – financial, temporal and human.
- Finally we identify, in three ways, a significant debate over maintaining the integrity and viability of D&T as a curriculum identity. First, how helpful are instrumental and ‘values-narrow’ associations with applied science, ICT, and vocational education? Second, is being part of an umbrella arrangement of curriculum (ES in Scotland) an enhancement or an erosion of D&T integrity? Third, is there a danger of dilution into constructs such as key objectives and essential learnings? Thus, the broadening of D&T’s values base, whilst defensible, must also keep D&T’s integrity afloat in strong and rapid curriculum currents.

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Pr. Joël LEBEAUME, UMR Sciences Techniques Éducation Formation, France
Email: lebeaume@stef.ens-cachan.fr

Abstract

The paper focuses on the main issue to define Technology Education for the middle school. From the French example, it shows the necessity to propose internal purposes and external missions in order to consider its inclusion in the middle-school curriculum. The analysis of teachers’ and parents’ ideas indicates the human and social constraints and the conditions of its acceptability.

KEY-WORDS : Curriculum, purposes, missions, politic, contents, teachers’ ideas.

INTRODUCTION

In France, the question about the purposes of Technology Education within middle school is a permanent question. Why is it a compulsory school subject? How to build it as a general education, i.e., unvocational education? For more than thirty years ago, technology education has been defined with several aims: to enable pupils to discover the technical world, to better know careers, to prepare them to work in firms, to develop their capabilities, to allow them to produce, and so on. The contents of Technology Education curriculum depend on these purposes: handwork, applied science, information of customers, technical knowledge, for example.

Currently, the ministry discusses new orientations for Technology Education. The minister and the administrators prefer to define it as a way of pre-vocational training and to guide pupils toward vocational high schools.

From the French example, this paper indicates the different levels where Technology Education has to be defined and the main issues to value its features, i.e., to avoid to distort it.

THREE LEVELS FOR DECISION ABOUT TECHNOLOGY EDUCATION

The French curriculum of the middle school (age 11-15) is subject-centred. The pupils’ time schedule reveals the different school-subjects: French, mathematics, sports, history-geography, biology-geology, physics-chemistry, English, arts, etc. These school subjects are included within the curriculum for a long past time. Technology Education is the youngest one; it has been only generalised in 1985. Its existence within the curriculum and its purposes are discussed.

But to discuss about it, it is important to distinguish the political level, the pedagogical level and the implementation level.

Political level

The existence of each school subject depends on not only of its purposes for education. The choice of curriculum’s components is a political decision related with the economical, social and ideological context. Introducing Technology Education is different according to the economical development, the labour market, the social issues for example young people’s violence.

At this level, the issue is not really the choice of contents but the one of the role and the function of each school subject. Martinand (2003) specifies that the question is about the role, the missions and the stakes of Technology Education. In others terms, what happens if it would be not within compulsory curriculum? In France, these missions have been discussed with the administrators and the existence of Technology Education is linked with four main missions:

• To help to school and careers guidance: this first point is fundamental for school and society in particular in order to give an overview of the different careers and ways offered by schools.
To approach the technical world: it is important that pupils have to get familiar with artefacts, process, etc. and that they have any knowledge about technique.

To use computers: everybody has to know how to use these current devices to exchange and communicate across the world. But it is essential that this learning enables pupils to understand the principles of data processing, sharing, etc. and that enables future citizens to know legal using of files and data.

To help pupils with concrete activities: it is indispensable in order to respond at the different styles of learning but also to enable pupils to have experiences about team work, personal engagement, project process, learning by doing, etc.

These social stakes may be attempted with different solutions. They may be included within several school subjects, for example in science education, in history-geography or in others identified school subjects such as Information Technology. In France, the political decision has been to create a new school subject with the label “technologie”. For twenty years ago, this school subject is not yet understood and its missions always have to be repeated.

Didactic and pedagogical level
This level concerns the construction of the school subject in a more internal point of view. Several aspects or decisions are fundamental about what pupils have to do during teaching-learning: to produce, to analyse devices, to draw, to make, to use computers or others machines, etc. Every option is possible but only some one are pertinent in regards of the missions.

We have shown the coherence of the school subject when there are relationships between the pupils’ tasks, their purposes and their references with social and technical practices (Lebeaume, 2000). This model enables to examine the different choices and to propose the best one. In France, the new technology education curriculum is divided into two parts: productions guided by projects and information technology (cf. Lebeaume & Martinand, 2002). The first part focuses on production by projects referred to current technical practices in order to offer genuine technical experiences. These school activities contribute to the four missions of teaching-learning because their technical nature enables pupils to compare school technical project and real technical project in according to its three components: the artefacts and devices, the rational technical thinking and the labour specialisation. The second part (less important in the planning) is centred on exercises with computers in order to get familiar with the different rational using and to learn how to use.

The designing of technology education curriculum has not been done from the best choice of purposes but from the selection of the coherence between tasks, aims and references. This choice also is the defining of the structure of the curriculum. The main principles in order to build this structure contribute to give it progressiveness and flexibility (Lebeaume, 2000).

In order to build a progressive teaching, it is necessary to define the beginning and the different tasks during the four years of schooling. Then, the curriculum is divided in three stages. Each one defines specific tasks and a few basic competencies useful to continue.

The flexibility is necessary to permit the implementation in different contexts and with different teachers. The current Technology Education programs keep teachers choosing technical projects, their references and the pedagogical organisation according to equipment, pupils and technical environment.

Implementation level
But Technology Education depends on its real teaching and this level concerns specific equipment and teachers education (pre and in-service). In France equipment is paid by local administrations from an “equipment guide” which list the whole of machines (for a new school, the cost is about 100 000 euros). The whole of junior high schools doesn’t have the same equipment but each year new machines are bought.

Several recent studies enable to question the implementation by teachers and the contents of teachers education. One about their teaching practices in the part of productions by projects (Lebeaume, 2001) indicates that each technology teacher has its own idea about the best purposes. It reveals three major conceptions of Technology Education

• developing elementary skills or knowledge to be able to do, to know how to do, to know project process;
• developing individual and social capacities about team work, acting and thinking, psychological development;
• developing critique abilities concerning technological environment (reasoning about technical world).
The productions then don’t have the same meaning: to know how to do, to become a person, to discover the world. The teaching-learning also is organised differently because it is oriented by systematic exercises, activities with pleasure or projects. The analysis of their interviews reveals that their different ideas are guided by the constraints: available equipment, money, time and status of their school subject. With a sociological point of view, these attitudes toward technology may be interpreted in according to the three logics (Dubet, 1998): each teacher is a member of a professional group with his strategic comportment and his individual motives.

From these attitudes, it is possible to design contents to teachers training which take account of their conceptions. It is necessary to enable teachers to decide about the curriculum with their sensibility and their responsibility. To be able to identify the missions and the structure of curriculum and to be able to locate his own conception is the best way and a didactic competency to understand the conditions of its implementation.

The Technology Education implementation also depends of the way the subject is assessed. In France, there are not any standards to assess the national programs and its implementation. Between prescribed Technology Education and realised Technology Education, i.e. between the official texts and the teacher’s actions, the regulation alone is carried out by inspectors. They have to assess the subject and the teachers and to organise the examination to recruit the new teachers. In the French administration, the inspection is organised with general inspectors (industrial techniques and economics techniques) and regional inspectors in each region. Each of them has sometimes his own idea about and for Technology Education. But there is not any research about this administration level and the different orientations of teaching learning along the French regions.

CONFUSIONS ABOUT TECHNOLOGY EDUCATION
But teachers have to implement Technology Education in a difficult context because their school subject is not really known. A research by questionnaires about parents’ ideas (Lebeaume & Trocmé, 2002) reveals that among several purposes, parents consider that the careers information and the knowledge about enterprises are the less important. They prefer practical experiences, teamwork, and information technology. Also, the others teachers have an unclear picture of Technology Education (Lebeaume & Valtat, 2003; Daugherty & Wicklein, 1993). Science teachers and mathematics teachers only say that there are activities of production and with computers but are unable to more specify their ideas. They consider that it is more useful for any pupils and vocational guidance.

One of the main issues in France is this ignorance of Technology Education, its features, it nature, its structure, its purposes and its missions. The administrators, the parents, the teachers project their own idea in order to define it. Only the Technology Education Community has an enough clear idea of it, but with some variations about its structure and its mission.

CONCLUSION
The question about purposes for Technology Education is an internal question asked in order to define teaching-learning and standards. But these choices depend on the first level. It is the political decision about missions of this school subject. A global coherence between internal and external points of view and between the missions, the structure and the implementation is necessary.

But it seems that the real question and the fundamental issue are the mean to manage this school subject. With purposes and aims or objectives, the standards organise Technology Education with a serial of exercises or with several school activities guided by pupils’ development. If we consider that Technology Education has to enable pupils to meet the current technique, then the genuine technical experiences are essential. The technical project with its technical nature – which is different of a serial of problem solving – is essential. In fact, there are two ways of thinking Technology Education: from what pupils have to learn and from what pupils have to do. The coherence of this curriculum and this school subject depends on the relationship between these two ways of thinking this education.

REFERENCES


Teacher’s Interpretation of Sustainable Development

Leo Elshof, University of Ottawa, Canada
Email: lelshof@mountaincable.net

Abstract

This paper will describe an exploratory research conducted with technological studies teachers in Ontario concerning their understanding of sustainable development.

keywords: sustainability, critical thinking

Introduction

The concept of sustainability is one which has infiltrated our daily language and consciousness. Sustainability itself is a normative ethical principle, not a scientific concept as such, and since it has both necessary and desirable characteristics, there is no single model of a sustainable society (Robinson, 1996). As a complex concept, sustainability spills over disciplinary borders, employing metaphors and insights from a number of relatively new scientific disciplines including systems and ecological sciences, it resists simple definition. Sustainable development can be considered as a: “process of conscious collective evolution” and not a matter of a few quick fixes and business as usual or pursuit of a single social value; it is continuous principled vigilance”(Harrison, 2000:118). Although some argue that ‘sustainable development’ is vague, even an oxymoron, the strength of concept lie in its ‘constructive ambiguity’ and its ability to keep people who would not normally talk to one another ‘at the table’ (Dale, 2001:34).

The failure to address the crucial issues of sustainable production and consumption processes, life cycle analysis (LCA) and Design for Environment (DfE) principles within design and technology curricula are symptomatic examples of a benign neglect to address wider environmental concerns from within design and technology education. This is unfortunate because technological education has the potential to help students envision, transform, design and construct a more sustainable built world, one, which is, understood more in a “relational totality” (O’Sullivan, 1999) rather than as a collection of isolated components. In the Ontario curriculum, environmental and social issues related to technology are relegated to a curriculum strand called ‘impact and consequences’. In the enacted curriculum in the classroom, the strands ‘theory and foundations’ and ‘skills and processes’ predominate. The impact and consequences strand is supposed to expose students to the broader ‘implications of technology’, in it’s enacted form many teachers interpret this narrowly in terms of safety-related issues and career opportunities.

Technological education for active and responsible citizenship in a rapidly changing world depends not so much on the exact replication of industrial techniques and processes— as is the case in many technological classrooms, but rather on developing the skills necessary to explore the: “full human and environmental context of any project and to reflect critically on its purpose and outcome”(Conway, 2002:260). Changing social and cultural practices or ‘lifestyles’ as well as expectations as they relate to material consumption and energy use are much easier conceptualized than enacted. Moving ‘sustainable development’ beyond the realm of empty political rhetoric entails substantive change to the way in which products are designed, used and reintegrated into the material stream. The crux of the sustainability conundrum involves transforming the nature of the relationship between our technosphere and the capabilities of the biosphere to regenerate and sustain the life support systems upon which we all depend.

RESEARCH QUESTION

This exploratory study set out to identify which facets of sustainable development teachers deem to be the most significant, from a personal, collegial and student interest perspective.

METHODS

Forty five technological studies teachers from southwestern Ontario including ten in a pre-service teacher program completed questionnaires which explored their thinking and worldview’s concerning sustainability in the summer and fall of 2002. In Ontario technological studies programs include: manufacturing , construction, transportation, design, transportation, communication, and personal services courses. A purposive sampling strategy was used to select technological studies teachers for this study. Purposive sampling involves selecting participants because they are most likely to provide relevant and valuable information (Maxwell & Loomis, 2003). The teachers also completed an exercise involving the interpretive analysis of images and cartoons related to various dimensions of sustainability.
Ten teachers also agreed to participate in semi-structured interviews to elicit their perspectives on the concept of sustainability and its relationship to the teaching of design and technology. A web forum was also created to allow teachers to discuss the issues in greater depth. The collected data consisted of in-depth interviews which were transcribed and coded using ‘HyperResearch’ software. Statistical analysis was performed on the questionnaire data.

**DATA SOURCES AND ANALYSIS**

Space limitations allow for presentation and discussion of only one section of the research instrument.

Cartoon interpretation is an effective methodology to elicit teachers’ thinking concerning sustainability and worldview issues (Elshof, 2001). As cultural texts editorial cartoons are an excellent medium for exploring personal and cultural values and beliefs from a non-threatening perspective. Cartoons also provide an opportunity to provoke a synthesis of other fragments of ideas or issues which teachers may have on sustainability. Teachers were asked to review 130 editorial cartoons and answer questions found in table 1. At least two cartoons were provided for each major category in table one. (Table 1)

<table>
<thead>
<tr>
<th>Table 1. Cartoon Interpretation Task (N=45)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category of Cartoon</strong></td>
</tr>
<tr>
<td><strong>Social Justice &amp; Equity</strong></td>
</tr>
<tr>
<td>Technology and the developing world</td>
</tr>
<tr>
<td>Connections to international trade</td>
</tr>
<tr>
<td>Exploitative labour and environmental practices e.g. sweatshops</td>
</tr>
<tr>
<td>Equity-human rights</td>
</tr>
<tr>
<td>Technology &amp; cultural hegemony</td>
</tr>
<tr>
<td><strong>Economic</strong></td>
</tr>
<tr>
<td>Implications of short term ‘economic’ thinking</td>
</tr>
<tr>
<td>Growing wealth-gap</td>
</tr>
<tr>
<td>Consumption and consumerism</td>
</tr>
<tr>
<td>Unintended ‘revenge’ costs of technology</td>
</tr>
<tr>
<td>‘Perverse’ economic subsidies</td>
</tr>
</tbody>
</table>
### Ecological Mean Std Dev | Mean Std Dev | Mean Std Dev | Mean Std Dev | Mean Std Dev
--- | --- | --- | --- | ---
**Global warming** | 5.7 0.9 | 5.1 1.3 | 4.4 2.5 | 4.9 3.2
**Pollution** | 7.4 0.8 | 7.7 1.6 | 7.5 1.5 | 6.8 2.8
**Biodiversity** | 3.3 1.1 | 4.1 1.7 | 4.3 2.3 | 4.1 3.6
**Impacts of consumption** | 5.6 1.9 | 6.8 2.7 | 5.6 3.1 | 5.3 1.3
**Environmental justice** | 4.3 2.1 | 5.3 3.6 | 5.2 4.3 | 4.2 2.2
**Domination and control of the natural world** | 4.9 1.5 | 5.2 2.0 | 4.1 1.7 | 3.5 3.1
**Population growth** | 8.6 3.1 | 7.4 2.6 | 6.6 3.1 | 5.5 2.1

Teachers were asked to rank several items related to which groups should be the focus of change in moving toward sustainability and to their preferences for learning more about sustainability as it relates to technological education. A few examples from these responses are shown below.

**Question:** If we as a society need to change our thinking and behaviours to become more sustainable, where is change most important? (1 = least important to 10 = Most important).

<table>
<thead>
<tr>
<th>Ranking in descending order of importance: (n=45)</th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political leadership</td>
<td>7.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Individual citizen action</td>
<td>6.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Citizen awareness - Education</td>
<td>6.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Community participation</td>
<td>5.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Business and industry practices</td>
<td>4.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Equity-International (developed-underdeveloped nations)</td>
<td>3.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Changing consumption patterns</td>
<td>3.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Equity-Intergenerational</td>
<td>2.6</td>
<td>5.1</td>
</tr>
<tr>
<td>Our Worldviews</td>
<td>2.1</td>
<td>3.3</td>
</tr>
</tbody>
</table>

**Question:** What type of professional development opportunities would enable you to better understand and develop curriculum which incorporate sustainability concepts?

<table>
<thead>
<tr>
<th>Ranking in descending order of importance: (n=45)</th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working with business and industry practitioners</td>
<td>8.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Workshops</td>
<td>7.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Web-based instruction</td>
<td>5.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Work with non-governmental organizations (NGO’s) or other community groups</td>
<td>4.2</td>
<td>5.2</td>
</tr>
<tr>
<td>Lectures</td>
<td>4.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Computer simulations</td>
<td>3.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Self-directed study</td>
<td>2.3</td>
<td>4.5</td>
</tr>
</tbody>
</table>
Interview Data

Space permits only a small sample of the descriptive data to be presented.

In individual interviews a number of the teachers expressed strong concerns with cartoons which were critical of the automotive industry and the promotion of ‘car-culture’:

“In the school board I’m at, with their very pro-business connections and the Ontario Youth Apprenticeship program which is closely ties to business, these kind of questions have no place. I really believe that teachers need to ask these kinds of questions regarding cars and SUV’s (sport-utility-vehicles). But, thinking in terms of how they might perceive it, people in more power than me would certainly have some real difficulties with these issues.” [Larry-manufacturing]

This is understandable given the fact that the automobile manufacturing sector is a major sector of the Ontario economy and the industry yields significant influence in shaping technological education within the province. Nancy a communications teacher, reflects a similar concern:

Coming from communications it seems right across the [school] board, for the video component of the course students make a 30 second commercial about something, anything that will sell something. It’s promoting consumerism, there’s no critical dimension. It’s about making something that you think is cool, like here’s a giant SUV truck that I love, we don’t ask the questions whether it something people need because if you’re advertising you’re convincing people that they have a need for it.

Tom, a student teacher expressed a concern regarding the lack of critical thinking in the technological classrooms he’s worked in:

“I haven’t seen any evidence, there’s little to no critical thinking being encouraged in the classrooms I’ve been in. For my associate teacher it’s all about using the tools, not the implications about what you’ve made. He’s got the students making up ads to sell products, it doesn’t matter what the products are, he doesn’t ask the students to think about what they’re selling at all. It’s all back to the curriculum and it being consumer based, it’s sell, sell, sell. It’s not about thinking about the real environmental cost of products.” [Tom-Communications teacher]

“I’ve never really thought about the term ‘sustainable development’, but now that I reflect about it, my technological area is one of the biggest contributors to some of the problems in terms of air, water and soil pollution.” [Denise-Technological Design]

As Table 1 (Table 1 at end of paper) indicates teachers consistently estimated their colleagues level of interest in sustainability issues lower than their own levels of personal interest. This may reflect in part the dearth of professional development opportunities to dialogue both within technological education departments and wider professional circles concerning sustainability issues and their relationship to technological education. Sustainability issues related to social justice and equity were also considered less important. On a personal level, population growth, human rights, international trade and pollution were all seen as the most significant components of sustainable development. On a personal level teachers found the least important components to be biodiversity, international trade, perverse economic subsidies and global warming. Perhaps most disconcerting are the low scores representing teachers perceptions of student interest in sustainability issues. The perception that students in technological education are relatively disinterested in the connection between technology and sustainability issues is one that requires further investigation.

Discussion

The World Summit on Sustainable Development held in Johannesburg last year and was one of the largest gatherings of any type concerned with the issues.

Despite widespread media coverage, less than ten percent of the teachers who participated in this study were aware that this conference even took place.

The task for technological teacher educators is to move pre-service teachers away from the uninterested, doubting and denying quadrants of figure 1. (Figure 1, next page)
Despite the fact that this study indicates a very low level of trust in the popular media to accurately report on environmental issues (78%), and that most believe that these reports exaggerate the seriousness of environmental problems (71%), the popular media remains the most popular learning medium for learning about sustainability. Only two teachers in this study indicated that they have undertaken a formal course in environmental science. Clearly a need exists for classroom resources which teachers find trustworthy and which facilitate the inclusion of sustainability linkages to the technological studies curriculum.

Professional development opportunities designed for technological teachers to learn more about the environmental sustainability or sociocultural implications and dimensions of technological practice are virtually nonexistent in Ontario. PD for technological teachers has historically focused instead on incorporating new software and hardware into the classroom. The participation rate in this study was much higher among those technological teachers possessing a university degree than those with a college diploma or a trades certificate. Possible reasons for this discrepancy is that these individuals were unfamiliar with research and/or viewed this as unimportant and disconnected from their classroom practices. The willingness to critically reflect upon the nature of one’s premises and worldview is a crucial dimension of effective teaching practice. Individuals who have had some formal educational experience exploring the nature of critical thinking and the research process may in theory be more receptive to it than those whose background consists of solely of vocational training. Unfortunately many technological teachers continue to choose “rejection rather than engagement” (Petrina, 2003:137), when it comes to confronting the broader social and environmental questions related to their discipline. Education about sustainability goes hand-in-hand with ‘critical technological literacy’ (Petrina, 2000) which entails in part, a process of politically engaging with technological practices which sustain and drive consumption, exacerbate the gap between rich and poor and treat the natural world as little more than an ‘undeveloped’ economic resource.
Breaking Open Disciplinary Silos

There is little evidence that technological educators are moving are becoming more receptive to STSE connections or themes, in fact there is some evidence that technological education is moving in the opposite direction. Petrina(2003) in a case study involving technological teachers in British Columbia points out that technological studies teachers as a group can be ‘invulnerable’ to curriculum reform, particularly when the reform requires them to critically engage with the sociocultural dimensions of technology and their worldviews.

The language and metaphors of environmental sustainability are largely drawn from the disciplines of ecology and systems science. They include concepts such as: metabolism, energy flow, symbiosis, entropy, embodied material energy, webs of relationships, interdependencies, system dynamics, stocks and flows, feedback systems, negotiation, symbiosis, non-linear dynamics, unpredictability, precautionary principles, and intergenerational effects (Ford, 1999). These All are noticeably absent from most technology curricula and the working vocabulary of technology teachers. Technology curricula implicitly construe a worldview by virtue of the degree and manner in which they engage students in a cultural critique of technology and by whether they help students articulate a critical worldview. The reconstruction of technology curricula to incorporate these metaphors and the insights they embody cannot occur through a prescriptive ‘top-down’ driven process of curriculum change. Sustainable reconstructive insights concerning the nature of technology and its relationship to the biosphere are best developed by teachers who have critically reflected on the metaphors of sustainability and who then incorporate them, at least in part, into their worldviews and classroom practices.

Disciplinary ‘silos’ continue to exist within pre-service teacher education programs, few opportunities exist for dialogue and collaborative curriculum development with other groups of teachers like those for example in science and geography. This isolation works against the development of a broader eco-literacy in students and a more embodied understanding of how consumption-driven lifestyles are an integral part of the sustainability problem. These conditions contribute to the fact that the deeply embedded ‘unsustainable meta-narratives’ (Jucker, 2002) which constitute our economic, production and consumption systems are rarely discussed or systematically explored in the technological education community. All disciplines as Plumwood points out, are riddled with blind spots:

Dominant forms of reason –economic, political, scientific and ethical/prudential – are failing us because they are subject to a systemic pattern of distortions and illusions in which they are historically embedded and which they are unable to see or reflect upon (Plumwood, 2002:16).

Creating New Discursive Spaces

Encouraging teachers to adopt a critical epistemology of technology involves helping them undergo a perceptual shift away from: “perceiving technology as a set of value-free activities or outcomes to understanding it in terms of social relationships embedded in cultural norms” (Hansen, 1997:57). This can be a daunting task for individuals who have not examined technology in a critical way and whose socialization in industry has never encouraged them to engage in what Kincheloe at al. (1999) term ‘postformal thinking’ with regard to technology. Historically, professional development opportunities for technological teachers in Ontario have focused on technical skills and not on how to develop STSE connections within the curriculum. If students are to be engaged as active participants and citizens in improving the sustainability of urban ecosystems (Hollweg, 2003), they will require knowledge and skills in applying both simple and advanced technologies as well as knowledge of how technology impacts sustainability both positively and negatively.

Hansen’s phenomenological approach focuses on understanding the constitutive nature of technology as non-neutral and acknowledging that existing technologies pre-determine to a point both our worldview and our culture (Hansen, 1997:57). The Government of Canada’s publication ‘A Framework for Environmental Learning and Sustainability in Canada’(Government of Canada, 2002:6) emphasizes the importance of establishing ‘safe and respectful places’ for ongoing dialogue concerning sustainability, where the values and ethical dimensions of these issues can be discussed. Establishing participatory and transformative learning experiences for young people that allow them to draw their own conclusions about issues are crucial for this process. But, before teachers can organize these ‘safe and respectful places’ for discussing sustainability, they themselves must have the opportunity to engage in a critical, collaborative and constructive dialogue which helps them situate sustainable development relative to their own practices. As Jickling & Wals, (2002:224) emphasize:
To educate for sustainability is not necessarily educational when sustainability is fixed, pre-and expert determined (i.e. academics) and to be reproduced by novices (i.e. students).

Technological teachers need ‘safe and respectful places’ for critically reflecting upon and discussing their interpretations of sustainability, these opportunities hold out the best hope that teachers will situate sustainability within their own professional teaching practices and the curriculum.

References


A Theory for solving inventive tasks: is it another rationale for technology education?

Dr Margarita Pavlova, Centre for Technology Education Research, Griffith University, Australia
Email: m.pavlova@griffith.edu.au

Abstract

Different rationales for technology education depend highly on the social context in which the subject was developed. In Russia it is claimed that the development of students’ creativity is one among four aims of technology education. This paper analyses the meaning of the concept as it is presented in educational documents, within the context of Russian educational reforms that emphasise mastery of content as an important aim of education.

This paper examines TRIZ (a theory for solving inventive tasks, with the acronym TRIZ derived from the Russian title for the theory) that has been developed as a framework for invention in engineering and compares it to the design-based approach to technology education. The paper argues, on the basis of existing research that the philosophy of TRIZ and its methods can be used as a rationale for technology education in particular contexts. However, it is argued further that TRIZ tools such as inventive principles as well as ‘psychological operators’ aiming to reduce psychological inertia can be used effectively in the development of student’s creativity in any context.

Key words: students’ creativity; TRIZ (theory for solving inventive tasks); rationale for technology education; social context

Introduction

A design-based approach (DBA) to technology education, and TRIZ (the theory for solving inventive tasks, known by the English translation of the original Russian acronym) (Altshuller, 1973), were competitors for reforming Labour Training in Russia. At the beginning of the 1990s when the DBA was brought from the West and was considered as an important approach that helps to develop problem-solving capabilities in students, many educators questioned this, asking why TRIZ has not been used as a rationale for technology education? TRIZ was specifically designed initially, to teach engineers, and then students, to find innovative solutions for technological problems. Currently, design-based approaches appear to have won the battle due to the enthusiasm of the people involved. However, the question remains: can TRIZ be used as the rationale for technology education? Would it present a better rationale for particular contexts?

There are historical parallels to the DBA versus TRIZ question. One such story relates to the construction of the Britannia Bridge. The construction of the tubular bridge by the English engineers was a very challenging task in the 1830s. The knowledge from preliminary experiments was clearly insufficient. Hodgkinson’s empirical work provided the basic source of knowledge on the buckling of thin-walled structures (Rosenberg & Vincenti, 1978). The theory for shearing loads in beams had just been worked out by Jourawski in Russia and was not yet known in Western Europe. “Thus no theoretical basis was available for analyzing the catastrophic buckling of the sides that appeared in the second test of the model” (Rosenberg & Vincenti, 1978, p.28). The bridge was designed by means of experimental investigations and the design was heavier than it needed to be. Jourawski later made an extensive critique of the bridge design based on his theoretical understanding of shearing loads (Rosenberg & Vincenti, 1978).

This story provides an example of two different approaches to problem-solving. Trial and error approach can bring results, but not necessarily the optimum ones. Theory, however, can provide knowledge that will optimise the solution. Thus, both DBA and TRIZ associated with these two approaches can be used as rationales for technology education aimed at the development of students’ creativity in problem-solving. Is one better than the other?

Creativity as mastery of the content
Technical creativity has always been a feature of the Russian educational system. In Labour Training it was mainly achieved through the extra-curricula activities in which students were involved after classes at school and
at the Palaces of Young Pioneers where they engaged in searching for technical solutions for problems. Currently, the development of creativity is one of the four aims of technology education which include:

• to develop students *politechnically*, to acquaint them with modern and prospective technologies of processing materials, energy and information via the application of knowledge in the areas of economics, ecology and enterprise; develop general working skills;
• to stimulate the creative and aesthetic development of students;
• to acquire life-needed skills and practices, including the culture of appropriate behaviour and non-conflict communication in the process of work;
• to provide students with the possibilities of self-learning and studying the world of professions, the acquisition of work experience which could be the basis for career orientation. (Lednev, Nikandrov, Lazutova, 1998, p.248)

These aims are part of the overall *Strategy of modernisation* (2001) of Russian education. The main emphasis in the modernisation of school content is on the development of the ‘cultural’ person who would potentially be able to solve problems in different fields. Thus, a potential ability to solve problems is considered as a major goal of education that can be achieved by mastering the content of education, structured on the basis of different spheres of human activities that constitute the culture. These comprise: cognitive, civic-social, socio-working, household and culture-leisure spheres:

• Competencies in the sphere of cognitive activities (based on methods of mastering strategies for acquiring knowledge from different sources of information)
• Competencies in the sphere of civil-social activities (roles of the citizen, voter, consumer)
• Competencies in the sphere of socio-working activities (including the ability to analyse the situation in the labour market, evaluate personal professional abilities, orientation to the norms and ethics of labour relationship, etc.)
• Competencies in the household sphere (including aspects of health, family well-being, etc.)
• Competencies in the area of culture-leisure activities (including choice of the ways of using non-work time that culturally and spiritually enriches the person).

This represents a significant change from previous beliefs. Twenty years ago the aim of the school was to provide systematic knowledge and skills. Now education is the process of pedagogically organised socialisation aimed at the interests of person and society’ (BSE: 1999, p. 62 in Lebedev, 2001. The person should be socialised into the Russian *culture*. Before, there were two equally important aims of education: to educate and to upbring/socialise were separated. Now the current educational modernisation policy argues for socialisation via education. Socialisation, according to Lebedev (2001) is understood as ‘mastering the culture of society, which provides the possibility for a person to be the subject of activity, to carry out different social roles’ (p. 11). Mastering culture is viewed as a basis for developing the capability of a person to act.

Lebedev (2001) claims that ‘the main result of school education should be the readiness and ability of young people, school graduates, to take responsibility for personal well-being as well as for the well-being of society’ (p. 6). This potential character of results correlates with the cognitive approach to competency construction (Norris,1991) where competence is about potential but performance is about actual situated behaviour. For example, competence is the knowledge and rules that are necessary for a linguistic performance (Chomsky as stated by Norris, 1991). Thus, the mastery that Russian students should achieve in different areas of activities can be described as having a potential nature, it should give them the ability to solve problems creatively when they need to.

Russian key competencies are different compared to western competencies where they are employment-related. While viewing the competency approach to education as a world practice they perceive it as suitable to the Russian educational tradition, viewed as an orientation on the scientific vision of the world, on spirituality, and activity as a member of society (Russian Ministry of Education, National Fund of Development of Human Resources, 2001, pp. 4- 5).

The development of students’ creativity is based on mastering the culture- structured content, and thus, TRIZ appears to be a more appropriate strategy for achieving this purpose in this particular context, as it provides an approach to master problem-solving process in technology education.

**TRIZ**  
The theory for solving inventive tasks, was developed in Russia in the nineteen-sixties and used initially as a framework for creating original and easy to implement solutions in engineering. More recently, it has been
applied as a general framework for improving inventive thinking within secondary schools in Russia. Altshuller began developing TRIZ as a pure engineering science, based on the statistical research of patents and other sources of technical information. The goal of this research was to reveal the ‘patterns of innovation’ so that they could be exploited for the purpose of advancing technological systems. Altshuller (1973) established the following procedures to develop this methodology for creative problem solving:

- Accumulate a data bank of numerous creative solutions (inventions, for the technological arena);
- Identify different levels of creative solutions, then select the high-level solutions from the data bank;
- Reveal typical patterns by which creative solutions of different levels are obtained (innovation principles, patterns of evolution, etc.);
- Develop algorithms for obtaining these solutions.

This analysis has been used to argue that there are a number of objective rules in the development of any technological system. This part of the argument is in accord with the views of some philosophers of technology such as Elull (1987/1990) who postulate that technical development is “as much the result of human choice as it is of technical determination. The technical universe also makes determinations that are not dependent on us and that dictate a certain use” (p. 37). Technique has “its own weight, its own determinations, its own laws. As a system it evolves by imposing its own logic” (p. 150). The essence of TRIZ is seen as recognition that technical systems evolve towards increasing functionality (‘ideality’) by overcoming contradictions, mostly with minimum introduction of new resources. Thus, for inventive problem-solving, TRIZ provides “a dialectic way of thinking, i.e., to understand the problem as a system, to image the ideal solution first, and to solve contradictions” (Nakagawa, 2001, p.1). Thus, TRIZ has a different starting point compared to invention heuristics developed within psychology.

At its very highest level, TRIZ may be seen as the systematic study of excellence. There is no one definitive version of a TRIZ process.

For example, Mann (2002) presents TRIZ as a hierarchy.

The five key philosophical elements of TRIZ are: Ideality - and the concept of systems evolving to increasing good, decreasing bad; Resources - and the concept of minimizing resources; Space/Time - and the importance of viewing systems in terms of their space and time context; Functionality - and the over-riding importance of function when thinking about systems; and Contradictions - and the concept of contradiction elimination as a primary evolution driver (Altshuller, 1973). Some of these are unique to TRIZ; some have parallels within other similar studies of creativity.
At the bottom of the TRIZ hierarchy, there are a wide-ranging and comprehensive series of tools and techniques for solving different technological problem that may be encountered. For example, 40 inventive principles provide guidelines for finding a solution for particular problems. Three principles illustrate the point.

Principle 1. Segmentation
- Divide an object into independent parts (Replace mainframe computer by personal computers; Replace a large truck by a truck and trailer; Use a work breakdown structure for a large project)
- Make an object easy to disassemble (Modular furniture; Quick disconnect joints in plumbing)
- Increase the degree of fragmentation or segmentation (Replace solid shades with Venetian blinds; Use powdered welding metal instead of foil or rod to get better penetration of the joint).

Principle 2. Taking out
- Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object (Locate a noisy compressor outside the building where compressed air is used; Use fiber optics or a light pipe to separate the hot light source from the location where light is needed; Use the sound of a barking dog, without the dog, as a burglar alarm).

Principle 32. Color changes
- Change the color of an object or its external environment (Use safe lights in a photographic darkroom).
- Change the transparency of an object or its external environment (Use photolithography to change transparent material to a solid mask for semiconductor processing. Similarly, change mask material from transparent to opaque for silk screen processing).

At the middle level there are a number of methods that string the tools together in a way that is appropriate for a particular user. The algorithm of solving inventive tasks (in Russian the abbreviation is ARIZ) is the central analytical tool of TRIZ. Its basis is a sequence of logical procedures for analysis of a vaguely or ill-defined initial problem/situation and transforming it into what is described as a distinct System Conflict. Consideration of the System conflict leads to the formulation of what is described as a Physical Contradiction which is eliminated by providing maximal utilization of the resources of the subject system. ARIZ puts together in a system most of the fundamental concepts and methods of TRIZ such as Ideal Technological System (Ideal System), System Conflict, Physical Contradictions, Substance-Field Analysis, Standards and the Laws of Technological System Evolution.

Altshuller also developed the strategy he called the Lifetime Strategy for a creative individual. This consisted of what Altshuller regarded as effective actions for an individual to develop and implement high-level creative goals. The following qualities are those defined as necessary to become a lifetime creator:
- A significant personal goal
- The ability to create and carry out an action plan
- Being a hard working individual
- Being experienced in the use of creative problem-solving techniques
- Being persistent
- The ability to achieve intermediate useful results (i.e, to ascertain that you are ‘on the right track’)

This multi-dimensional, multi-level theory for solving inventive tasks provides a potentially rich ground that can be used to develop students’ creativity during technology education classes.

**TRIZ or DBA as rationale for technology education?**
What can be seen as the major differences between TRIZ and DBA?

The major differences between traditional TRIZ and design-based approach to technology education are as follows:
- TRIZ is aiming to overcome identified conflict whereas DBA aims to find an optimum balance between confronting elements. The TRIZ theory identifies a number of different types of technological solutions. The first type is described as a design solution, where the key feature of the process is the search for a compromise. The second type is defined as an inventive solution, where the key feature involves overcoming contradictions. The concept of increasing ideality is regarded as the over-riding trend of technology evolution. The ultimate limit of ‘ideality’ is the Ideal Final Result (IFR). The IFR is a simple and yet profound concept which says that systems will evolve to deliver all desired benefits, without any costs or harm.
• TRIZ is oriented to the problem, not to the client. TRIZ puts a special emphasis on the technical side of a solution – function and materials, comparing to DBA that put a special emphasis on aesthetics that is regarded as an extremely important feature in contemporary Western society (Pavlova, 2002).

• TRIZ is a very complex tool that cannot be learnt very quickly whereas DBA required less time to understand. Practitioners who are teaching TRIZ argue that mastering ARIZ is the most time-consuming and difficult task (Mann, 2002; Domb, 1997). Thus several simplified form of ARIZ have been proposed (Nakagawa, 2000) to help students get started, and gain some of the benefits of TRIZ. This boosts their confidence, as well as their knowledge, so that they will be willing to spend the time that mastery requires (Domb, 1997).

• It is generally necessary to master TRIZ to a very high level of competence to achieve successful result. DBA can be used successfully at different levels.

• TRIZ and DBA have been developed on the basis of two very different traditions - engineering for TRIZ and humanistic (or consumerism as the worst version) for DBA.

• Learning patterns are different. In TRIZ students learn theory first with a lot of examples to illustrate the particular principle or particular approach. In DBA students can learn using both ways, the path from practice to theory is considered as extremely useful.

• TRIZ is more effective in producing innovative ‘guaranteed’ results in a systematic manner. World-wide distribution and further development of ideas are reflected in the establishment of several centres in the USA, including the Altshuller Institute, conferences on TRIZ in Europe and the USA and active research undertaken by several institutions in Japan and Israel. Research (Helfman, 1992; Clausing, 2001; Manor, 2002) has provided findings that suggest that TRIZ improves students’ inventive thinking abilities.

In the context of an orientation to developing students’ creativity through the process of mastering TRIZ, TRIZ can be regarded as a possible rationale for technology education within a particular context. Elements of TRIZ such as tools (40 inventive principles, etc) or ‘psychological operators’ that facilitate the creative process such as course in Creative Imagination Enhancement (CIE) that is aimed at reducing psychological inertia (including Smart Little Creatures Modeling and Dimension-Time-Cost operators) can be used in the classroom to enhance students creativity. In this case they can be compared with heuristics and psychological methods of development of students’ creativity.

Conclusion
To conclude, this paper has described the features of a theory for solving inventive tasks that is little known in western countries in the context of technology education. The theory is known as TRIZ, and it is compared with design-based approaches currently being employed as rationale for technology education in western countries. There appears to be sufficient evidence of the viability of TRIZ in developing the creative thinking abilities of students. TRIZ appears to provide strategies additional/alternative to those used in DBA approaches and has received sufficient attention and research since becoming available in the West to warrant consideration as both an additional rationale for technology education in a particular context and as a set of tools (principles and strategies) for developing or improving students creative thinking abilities in any context.

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Capturing the Minds of a Lost and Lonely Generation.

Dr Frida Tungaraza, Department of Educational Psychology, University of Dar es Salaam, Tanzania.
Margaret Sutherland, Department of Educational Studies, University of Glasgow, Scotland
Email: ftungaraza@yahoo.com Email: M.Sutherland@educ.gla.ac.uk

Abstract

UNICEF states that in 88 countries studied ‘more than 13 million children currently under the age of 15 have lost both parents to Aids, most of them in sub-Saharan Africa’ (UNICEF, 2002). The impact of this Aids pandemic cannot be underestimated. Indeed the long-term impact of such statistics is scarcely imaginable and has not been experienced in the world to date.

This paper will consider this impact in relation to Tanzania and will outline:

• The impact of the Aids pandemic on children under 15
• The difficulties in engaging marginalised youth in education
• How through sustainable technology marginalised youth may once again be involved in the education process education; social context

Key words: sustainable, technology, disengagement

The rise of the AIDS pandemic in Sub Saharan Africa is well documented. UNICEF state that in 88 of the countries they studied more than 13 million children currently under the age of 15 have lost their mother or both parents to AIDS (UNICEF, 2002). The impact of this on society, and on children in particular, is perhaps less well documented, in part due to the fact that the effects are only now being felt and acknowledged.

Tanzania lies on the east coast of Africa. The current population is 35.1 million (UNICEF, 2002). Tanzania appears on UNICEF’s list of ‘least developed countries’. It is estimated that 50% of Tanzanian’s live on less than $1 a day. The average life expectancy is 48 and 46% of the population are children.

Following the 1990 World Conference on Education for All in Jomtien (UNESCO, 1990) many countries adopted the new vision of education for all by providing schooling for every child. In spite of this the Tanzanian Development Research Group (TADREG, 1993) discovered that rural parents were still refusing to send their children to school. Attendance at school is an on going issue for the Tanzanian government. Only 51% of boys and 55% of girls were in net primary school attendance between 1995 and 2000 (UNICEF, 2002). Only 38% of children attending are likely to complete their 7 years of compulsory education (primary) and only 6% of boys and 5% of girls (UNICEF, 1995-1997 (gross)) will go on to enrol at secondary school. It is clear from these statistics that a significant number of children are disengaged with the education process.

Tanzania has also witnessed a new phenomenon since the 1990s namely an increase in the number of children living on the streets. Reliable statistics for this are hard to come by but a report in January 2001 suggested that in Dodoma, the Tanzanian administrative capital, there were approximately 3000 children living in the streets while available statistics indicate that in 1994 there were only 1000 street children (African Church Information Service, 2001). There are many and varied reasons why children end up on the streets. Rapid urbanisation has led to the myth that life will be better in urban areas. Many children leave their rural communities in search of a better life. Some children are lured by the promise of employment. Baraka, a street boy takes up the story

“we were brought to Dar by a man called Juma. He promised us he would employ us in his drinking water vending business. When we reached here he disappeared and we could not trace his whereabouts. Since then we have been living on the streets” (Cidosa, 2001, page 1).

Domestic violence and abuse can leave many children feeling vulnerable and with little protection, leaving home is often deemed to be a better option. According to the Mkombozi Review (2000) 22% of children came to the streets after being excluded from school. Perhaps one of the most concerning figures is the rise in the number of
children who find themselves on the streets as a result of losing parents to AIDS. This is now the leading killer in sub-Saharan Africa (UNICEF, 1999). It is estimated that in 1998 200,000 lives were lost in Africa as a result of conflict and war. By comparison, in the same year, 2.2 million people died from AIDS. UNICEF suggests that this crisis is unique for children for the following reasons:

1. the huge scale of the problem
2. an AIDS-weakened infrastructure
3. the vulnerability of orphans
4. grief before death and the tragedy of losing both parents
5. the AIDS stigma (UNICEF, 1999, page 3)

It is perhaps little wonder that many of these children become disengaged from the learning process. A study in urban Zambia ascertained that 32% of orphaned children were not enrolled in school compared to 25% of non-orphaned children (UNICEF, 1999, page 5). In rural areas the Zambian study revealed an even higher non-enrolment rate with 68% of orphans and 48% of non-orphans. (UNICEF, 1999, page 17). The number of orphans has been rising steadily in Tanzania. In Kagera region it is estimated that 40 percent of the 1,515,100 Kagera population is below 18 years of age, this means that 167,130 (28 percent) out of 606,040 children are orphans. (Mushi et al, 2002, page 27).

What then, is the role of education among children so traumatised and devoid of hope? Whatever the reasons that can be speculated, the curriculum on offer in schools appears to be failing to meet the needs of the people and the country (TADREG, 1993). Parents, and the community in general, are questioning school as an institution, since, according to them, many children left school illiterate and unfit for rural life (Mosha, 1988, page 18). Conventional schooling still conditions students to think in terms of white-collar employment rather than self employment (Cooksey and Reidmiller, 1997, page 132).

This disengagement in the learning process is not unique to developing countries. The Alliance for Excellent Education, based in the United States of America, cite findings from the America Youth Policy Forum workshop where it was stated that today’s students feel as though high school is irrelevant, that classes are boring, and that they are just passing time until something important […] comes to pass (America Youth Policy, 2000, pg.4)

Scales (1996) discovered that 40% of high school pupils and nearly 50% of middle school pupils reported feeling disengaged from the education process. In England, Hampshire County Youth Service have as one of their targets in their strategic development plan 2000-2003 each district to establish projects which will benefit young people who have become disengaged from education and/or their local community (Hampshire County, 2000).

A common theme emerging from the literature would seem to be the relevance of the education experience for young people. Where education is relevant then participation is greater. It would appear that in certain circumstances sustainable technology can make a qualitative contribution to the lives of marginalised youth but in order to do so has to be embedded in practice which takes other important educational principles into consideration.

Sustainable technology, for the confines of this paper, is taken to mean ways of using technology that promote a sustainable future whilst simultaneously considering the impact on society, the environment and, most importantly, the development of the individuals involved in the activities. It is questionable whether anything can be sustainable in such a fast changing world. The word sustain derives from the Latin sustinere (sus, from below and tenere to hold). The notion of sustainability is thus inextricably linked to the idea of sustainable development. Sustainable development arose from the conservation and environmental movements in the 1970s. UNESCO suggests that the term sustainability links the concepts of society, environment, economy and development (UNESCO). It considers education to have a pivotal role in sustainable development stating that creating such links (as described above) demands a deeper, more ambitious way of thinking about education, one that retains a commitment to critical analysis while fostering creativity and innovation (UNESCO).

Crewe and Harrison (1999) suggest that Bush (1983) is correct when he defines technology as the organisation of tools and techniques for the performance of tasks (page 15). Hitherto technology has often been bound by traditional ideas of what technology is. A widening of definitions would allow for a broader range of activities to be considered as ‘technology’. In addition, there is debate surrounding the use of indigenous technology. This is, in many ways, a double-edged sword. Whilst recognising that indigenous knowledge is important and is to be celebrated (Brokensha et al, 1980; Hobart, 1993; Richards, 1985; Warren at al, 1995) Crewe and Harrison (1999) suggest that local people and the knowledge they hold are still looked upon as ‘them’ with Western
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technology presumed to be superior to that already in place. There is considerable debate surrounding what
constitutes technology and there is a need to consider the impact a sustainable technological approach to learning
and teaching might have on the lives of street children.

In September 2000 the Pan African News Agency described a project that has emerged in Korogocho, Nairobi,
Kenya. Korogocho (meaning hopeless in Kukuya) is a slum area of Nairobi and was home to a number of street
boys. Residents in the area viewed these boys with great suspicion and regarded them as potential muggers and
criminals. Otipa, head of the Wikyo Akala project reported that when arrested by the mob, the slum children
would be lynched using burning tyres. It is a common sight in Kenyan slums to see outlaws being necklaced
using old car tyres by an irate mob before they are set ablaze in a lynching (Pan African News Agency, 2000).

Meyer, one of the founders of the project, states that at the start of the project .... the wish was to radically
transform the way people live in that shantytown. We’re still a long way from our goal. However Otipa claims
that the project is targeting several issues:

1. engaging the street children in worthwhile activities;
2. clearing the slum area of old tyres;
3. reducing the crime rate within the slum area; and
4. contributing in positive way towards the environment.

Projects such as the one described above offer tangible evidence as to the possibilities of sustainable technology
playing a crucial role in improving the life skills and chances of young people. Testimonies from the young
people involved suggest that this training and subsequent income allows them to become self reliant the money I
earn buys me and my family food and clothing (Pan African News Agency, 2000). It is postulated here that ‘self
reliance’ is key to the success of any sustainable technology programme as it offers young people the
opportunity to be independent.

Sustainable technology connected to a trade based approach has a vital role to play in the education process.
Considering them to be of equal status with an academic approach may help to raise the standing of the skills
acquired by the young people through sustainable technology. ActionAid’s ACCESS programme in Ethiopia
offers non formal education to children out of school. Keen to ensure that non formal education did not become
a parallel education system that may destabilise government education, ActionAid’s programme is integrated
into the state system. Initial concern about the standard of education was put to rest when it transpired that
ACCESS students did far better than state school pupils due to its learner centred methods and flexible

Many of the children living on the streets are doing so because extended family members could no longer
support them once their parents had died of HIV/AIDS. If sustainable technology projects can work together
with young people and governments offering opportunities to learn life skills and earn an income which will
contribute to the extended family unit, then the exclusion of street children from family and society may be
lessened. It is acknowledged that for some young people relationships with family have broken down to such an
extent that this link is not possible. However, projects would do well to strive towards re-establishing family
connections thus supporting a vital thread in the fabric of Tanzanian society. The ACCESS programme saw
community leaders report improved results in literacy and numeracy. This improvement allowed the young
people to take a full part in family and village life.

Perhaps the most powerful argument for reengaging street children in education, through whatever means, comes
from the children themselves. Farida, a 10 year old girl involved in an Oxfam funded project in Singida says
“I like being educated and doing the garden. Here we are comfortable. I can sleep well and I feel safe.”

Peter, a 17 year old involved in the project at Kititimo says “Coming to Kititimo and getting an education was the
turning point in my life.”

Discussion about the role of sustainable technology, by necessity, has to take place against a backdrop of cultural
and structural dynamics. The interrelated concepts of sustainable development and sustainable technology have
as much to do with values, beliefs, equity and ethics, as they have to do with technology per se. To explore the
notion of sustainable technology as a tool for re-engaging children in education without considering how this
might challenge the concept of formal education would be to support the notion of the monolithic power of
formal education.

A change of emphasis is required if sustainable technology is to fulfil its role by offering young people
opportunities to acquire life skills relevant for today and tomorrow. Learning, in all its guises – formal and non-
formal - need to merge in order to ensure that an inclusive approach is adopted and that life chances for individuals are enhanced. This in turn will impact on the country, the environment and ultimately the well being and development of our planet. A tall order? Yes. But capturing the minds of a lost and lonely generation will go some way to achieve it.

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Values in an industrial context: a lesson for education?

Marion Rutland, University of Surrey, Roehampton, UK
Email: m.rutland@roehampton.ac.uk

Abstract

The paper focuses on one aspect of an ongoing research project investigating the concept of ‘creativity’ in the context of teaching and learning in design and technology in lower secondary curriculum. The need for industry to have a ‘creative’ culture in their workforce was discussed during one of the interviews, with particular reference made to a programme ‘One small step’ developed by the company Rolls-Royce.

The paper explores the development, implementation and outcomes of the programme and other initiatives in Rolls-Royce. It outlines the set of values; reliability, innovation and integrity and ‘behaviours’ that grew out of the programme and their impact on the company. The paper is based on an interview with the Director - Human Resources and follow-up interviews with the Director of Learning and Development and Head of Career Development: Engineering. The paper concludes by considering the relevance of these initiatives in an educational setting and lessons that can be learnt for teaching and learning in D&T.

Key words: values, industry, education, D&T, initiatives, creativity,

Introduction

Design and technology (D&T) is concerned with the realisation and application of appropriate needs to human problems, with value judgements being made throughout the designing and making process. There is no value free, neutral judgement (Riggs, 1991). A number of writers have identified values that are relevant for consideration in the teaching of D&T (Layton 1992, Barlex 1993, Prime 1993, Martin 1996). They have included economic, technical, aesthetic, moral and ethical, social, cultural, environmental and political. Considering values is an essential aspect of teaching D&T. Each specialist field provides a range of interesting contexts in which to discuss and explore key issues. For example when designing and making in:

- **woods, plastics and metals**: a knuckle-duster, mouse trap, pipe rack or ashtray might all seem to be technically sound products, but are they acceptable in society today? Should we be using materials that are non-renewable or non-biodegradable?
- **electronic and communication technologies (ECT)**: improve mass communications but there are potential dangers including health risks from using mobile phones, consequences for the environment from disposable batteries and the inappropriate use by children of computers and the Internet.
- **Textiles**: - fabrics, design from a range of cultures and the production of clothing in developing countries all have a rich potential for addressing aesthetic, social and ethical considerations.
- **Food**: - enables discussion on chemically and genetically modified (GM) foods, religious and cultural beliefs, health and the effects of a diet of highly processed foods.

It can be argued that considering values is a strategy for making pupils, as future citizens, sensitive to the social, cultural, economic and environmental implications of the products they are designing and making (Rutland, 2002a).

Context

This paper focuses on one element of an ongoing research project looking at creativity within D&T in the lower secondary school curriculum. A research model for creativity was developed out of the literature review. It was used to analyse data from interviews with four professional designers (Rutland, 2002b), a school-based case study exploring current practice and interviews with expert teachers to identify the techniques and strategies that can be used by the teacher to enhance and develop their pupils’ creativity.

The need for industry to develop an innovative or creative workforce was discussed during one of the interviews with a managing director of an electronics company. Particular reference was made to a programme developed by the company Rolls-Royce to help develop a ‘creative’ culture in their workforce and it was suggested that this industry-based strategy should be explored further. The focus of this paper is to outline and discuss the development, implementation and outcomes of the programme and other initiatives of Rolls-Royce. It is based
Findings from the interviews
Details from the interviews can be found in Appendix A.

Rolls-Royce operates in world markets at an international level and requires highest quality people in the management structure and throughout its labour force to compete successfully. Rolls-Royce considers that expertise, qualifications and knowledge are essential to design and make components and assemble them into jet engines with the highest safety standards. The company sees a clear correlation between business success, the quality of the people, their innovation and the ability to compete with other companies. The ability to compete is dependent on willingness by the company to take commercial risks through investing in new ranges of engines on the cutting edge of technology, without taking risk with safety and design.

It can be argued that ‘integrity’ for many businesses in the 1980s had not been a key issue. However, in the 1990s it was realised that honesty with customers and employees was expected as it gained people’s support and gave a greater depth to those relationships. In the 1990s Rolls-Royce was a traditional, hierarchical company where people used to be told what to do, and where the higher authority was always very strong. There was a culture of people looking up to the Board to make all the key decisions and the decision making process was slow.

It was considered essential to create a workforce that was able and willing to innovate and be creative. Innovation is considered an essential ingredient for Rolls-Royce as their products are at the leading edge of technology and they are often pushing the boundaries of engineering. Creativity, in the Company, is recognised as a key phase of the design process.

Rolls-Royce’s response to these issues in the late 1990s was to instigate a number of ‘change management’ initiatives, beginning with the programme ‘One small step’. This was borrowed from a saying of the first man who landed on the moon ‘One small step but a giant step for mankind’. The aim of the programme was to involve as many people in the company as possible in understanding key business factors and how each employee could make their contribution. The strategy was to set in place a series of workshops where all 18,000 employees from the aerospace business were invited to 800 workshops of about 20-25 people. Trained volunteer managers and supervisors led the workshops. They were provided with materials based around questions such as; what type of business are we in? what are the issues that we face?; and what are we asking of people to help us succeed in the market place against competitors? The workshops were voluntary as it was decided that agreeing to attend was the first part of the ‘change process’.

In total over 11,500 people attended the programme and it ran for over four months. It is considered that it had a major impact in the company. Employees still refer back to it as the first big programme that made an impression in that it communicated to them that the company’s business position mattered and it contextualised how everybody could play a part. The whole idea of ‘values and behaviour’ evolved from those workshops. Employees came along and talked about their work and how they saw it develop. Employees regarded it as first big step forward towards changing the culture of the company to encourage a greater willingness to be inventive amongst themselves, to question their individual managers in their attitudes and gaining a better understanding of their role in the company and the organisation.

The set of company values and qualities for Rolls-Royce that grew out of the workshops are:
1.  Integrity: we seek to earn trust in all that we do
2.  Reliability: to be right every time, on time. Our commitment goes beyond expectations
3.  Innovation: is a way of life for us, an attitude and a state of mind. It relies on open minds, problem sharing and trying to see everything from our customer’s point of view.

A series of thirteen ‘behaviours’ were built to match the set of company values. They are a reflection on the way in which all employees are encouraged to act in order for the company’s vision, goals and values to be achieved. They are:
1.  be customer focused
2.  receive and encourage new ideas
3.  implement identified change fast
4.  have the will to take rational risks
5. operate with integrity
6. take pride in every job done well
7. promote responsibility, delegated authority
8. reward performance
9. communicate simply and openly
10. share information and make it work
11. have concern for the environment and community
12. promote equal opportunities
13. develop, attract and retain high quality employees

It is these values and behaviours, which ensure that the vision and goals of the company are achieved.

The **Vision** is to make Rolls-Royce the first choice for power solutions across the whole spectrum of civil aerospace, defence, marine and energy through employees, customers, partners, investors, suppliers, technology and engineering, business performance and reputation.

The **Goal** for every Rolls-Royce employee is:

- **To be trusted**: ‘something that is never assumed - it must be earned. It comes because we act with integrity and treat our customers as our partners’
- **To deliver**: ‘that we are responsible professionals who act, listen, respond, act and go that extra mile for our customer; what we say - we do’
- **Excellence means** ‘a way of life and a way of thinking. It relies on innovation, which comes through collaboration and co-operation in the belief that, through teamwork, good can always be bettered. It is this that will keep us ahead.

The vision, goal, values and behaviours together ensure that Rolls-Royce is ‘Trusted to deliver excellence’ (Rolls-Royce, 1999, www.rolls-royce.com).

Later in 1999 another programme, ‘Taking the Lead’, was run for about 5,000 managers, i.e. the senior managers, foremen and team leaders in the engineering areas. The company includes about 45,000 people and 5,000 people are in roles supervising others. The framework of that programme was to take further forward the leadership understanding of the business and their role as supervisors and managers. Its aim was to develop better communication and more openness and a 360-degree appraisal system, involving a number of people in the process, was launched with the programme.

In addition, Rolls-Royce has a set of prestigious annual awards called The Chairman’s Awards for Technical Innovation to encourage and reward creativity. These awards include:
1. Team and individual awards for the application of innovation and creativity which has led to savings and benefits for the company
2. Awards for engineers who have successfully obtained patents for the company
3. Awards for young engineers who have demonstrated outstanding technical achievement.

Other initiatives to promote innovation and excellence by Rolls-Royce include the development of a ‘Creativity Website’ on their intranet to introduce techniques to aid and improve the generation of ideas and highlights some of the hurdles that have to be overcome in order to realise creative and innovative potential. The methodology ‘Theory of Inventive Problem Solving’ (TRIZ), is a specific tool-set to help designers enhance their creativity and problem solving. It is used widely in industry and has been adopted by Rolls-Royce. Designers in UK, Germany and the US have been trained in the techniques. It is a philosophy, a method and a collection of specific tools and strategies for solving technical problems. A partnership has been formed with the Institute of Work Psychology at Sheffield University to research factors that stimulate creativity and enable innovation. The selection criteria for graduate designers has been the subject of significant research.

The company has a career structure based on professional growth operating from graduate level through the management structure and into senior levels. Progression is based on the personal contribution of the engineer and not on the number of people reporting to the engineer or the size of the budget. The criteria for promotion include innovation and creativity. All graduate recruits participate in ‘real life’ business group projects. The group projects are assessed for design and engineering skills, team effectiveness, contribution to business and the application of innovation and creativity.

Rolls-Royce considers it is important to pay and reward people in a reasonable manner, provide a career pathway and appropriate training. An essential factor is to create an atmosphere where people can think of, and implement, different and better ways of doing things without fear of recrimination if they make a mistake. A
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successful organisation needs intelligent employees who can take risks and make their own decisions. It is human nature to be wary of change and risk but people can be motivated towards better understanding and then change, if the intentions are clearly explained to them.

The belief at Rolls-Royce is that it is the standard of service offered to the customer that really matters, whether it is a public or private company. Reputation in the community is also a key issue. If reputations are high, an organisation will attract good employees. The success of an enterprise clearly depends upon the whole team. It is possible to transform any organisation by teamwork across the organisation in support of customers. A successful enterprise needs high calibre people across its organisation and teamwork.

It can be argued that there is no reason why this concept can not be applied to the world of education. Schools are there to service the community and if a school is to be successful it needs to attract good teachers who will have a direct influence on the education of the pupils. Schools require teachers with a clear career pathway, who are rewarded fairly, are able to work as a team, who feel that they are valued for their contribution and are confident, and able, to make professional judgements for the well being of their pupils.

Conclusions and recommendations

The paper has explored the range of initiatives Rolls-Royce has developed and the clear rationale that has evolved for their company practices and employees. Their goal is to ‘be trusted to deliver excellence’. When considering the relevance of their thinking and initiatives to education, and specifically D&T, it would appear a similar strategy would benefit and enhance the teaching of D&T in our schools. A set of values aimed at developing an ethos of quality and excellence in D&T in schools might be.

- Design, technical and aesthetic expertise
- Innovation and creativity
- Quality outcomes
- Consistency and reliability
- Appropriate technologies
- Environmental and ‘real world’ awareness.

A set of behaviours to ensure these values might be:

- Be creative problem solvers
- Make decisions
- Take risks
- Work as team
- Communicate clearly
- Have an open-mind
- Take into account safety issues
- Understand and make links with the world outside school

These values and behaviours would need to be developed in schools through working with D&T subject leaders, heads of departments and teachers to develop a vision with common and achievable goals. The world of business and industry requires creative, resourceful, skilled and articulate people and pupils need to see the relevance of school and their lessons to the world outside school. D&T presents an ideal opportunity to address these two requirements through interesting, motivating activities that fully develop the potential of each individual child.

Ways of doing this might be through:

- developing educational links with industry ie encourage schools to provide experiences through contextualised projects, the structured use of industrial mentors in school on projects to strengthening continuity between school and the world of work
- encouraging educationalists and industry to develop educational programmes and teaching resources for schools.

These initiatives should be throughout the compulsory stages of education (5-16). The aims of quality and excellence for D&T pupils will enable them to move into a range of career pathways, including employment with companies such as Rolls-Royce. When the D&T National Curriculum in England and Wales was introduced in 1990, there was a range of organisations working with schools to achieve these aims. Today, there are projects such as ‘Young Foresight’ www.youngforesight.com that encourages Year 9 students to look into the future and design tomorrow’s products and services. SETNET, the Science Engineering Technology Mathematics Network www.setnet.org.uk is an outcome of a UK Government initiative - Action for Engineering, which aims to ensure there is flow of well motivated, high quality people from schools. ‘SETPOINTS’ have been established across the UK as a focus for teachers, business and industry to obtain information about resources, schemes and initiatives. It is important that these types of activities are built in a
systemic manner into the D&T curriculum with a common vision and goals (aims) and a set of values and behaviours (objectives). The curriculum should be taught with an appropriate, creative and co-operative pedagogy to ensure that it is a relevant and prepares all pupils for the world outside school.

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Appendix A
Mapping of the interviews with:
John Rivers, Director - Human Resources (2001); Margaret Gildea, Director of Learning and Development (2003) and Ken Fulton, Head of Career Development - Engineering (2003) Rolls-Royce against the three-feature research model.

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<td>Rolls-Royce created a ‘set of values’ reliability, innovation and integrity. We described what sort of company Rolls-Royce was and the sort values that our people would recognise as appropriate. The majority of employees responded positively to a set of values; they thought a good company should have values.</td>
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<tr>
<td>Supporting these values is a set of behaviours.</td>
<td></td>
</tr>
<tr>
<td>Concern for quality</td>
<td></td>
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<tr>
<td>Concern for a customer focus</td>
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</tr>
<tr>
<td>A desire to reward good performance</td>
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<tr>
<td>A desire for employment policy based on equal opportunity</td>
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</tr>
<tr>
<td>A desire to have open and straightforward communication between the company and its employees, in two ways</td>
<td></td>
</tr>
<tr>
<td>A desire to develop and maintain the best people</td>
<td></td>
</tr>
<tr>
<td>Innovation should be a value for Rolls Royce; all the products that we make are at the leading edge of technology and we are often pushing the boundaries of engineering. The value of ‘reliability’ is embedded in our commitment to safety; we have in our hands the lives of thousands of people. In one sense innovation and reliability are quite difficult values to match because with innovation comes risk. So in our business our values set us a challenge</td>
<td></td>
</tr>
<tr>
<td>In engineering we see creativity as the intellectual exercise of coming up with solutions that could satisfy a stated requirement. Innovation encompasses creativity but also covers the actual realisation of the (hopefully) best possible solution</td>
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</tr>
<tr>
<td>In my personal view, for many businesses in the 1980s, integrity did not matter. In the 1990s the realisation has come that having honest relationships with your customers and employees is expected and it adds a greater depth to those relationships. With that level of integrity you can achieve a great deal in an organisation because you have established belief in what that you are doing and will gain peoples' support.</td>
<td></td>
</tr>
<tr>
<td>A company like ours operates in world markets and needs the best. Our only serious competitors are American companies such as General Electric and Pratt &amp; Whitney. They are very much bigger than we are and they have huge financial resources. There is a clear correlation between business success, the quality of the people, their innovation and the ability of the company to compete with other companies.</td>
<td></td>
</tr>
</tbody>
</table>
• Our business is **qualifications and knowledge driven**. You can't make components and assemble them into an engine without expertise and knowledge in an industry like ours with the highest safety standards.

• Rolls-Royce is very good in that respect in **offering good development in the early years through training schemes**.

• In terms of risk, we took huge **commercial risks** in the last ten years. We invested 8 billion pounds in a new product. We could have made a lot more money as a company by not doing that and taking the profit in the short term. We decided to invest heavily in new range of civil engines and now we have the widest product range of all three companies and consequently we have grown our market share. That was a huge business risk for us to take. So the risks in this business are difficult to measure. **You can not take risks in safety and design but you take big risks in investing and pushing the limits of the design to give yourself a competitive edge.**

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• **How do you 'galvanise' people in an organisation to innovate?** Rolls-Royce was a traditional company and hierarchical. It was an organisation where people used to be told what to do, and where the higher authority was always very strong. People looked up to the Board to make all the key decisions. The decision making process was slow ten years ago and certainly when I first went there I was struck by the desire of the organisation and the people to force every decision up to about 12 people at the top of the organisation. Organisations can not succeed like that.

• **'Change management’ through a programme called “One small step’** a concept borrowed from a saying of the first man who landed on the moon ‘One small step but a giant step for mankind’. The idea was to involve as many people in the company as possible in understanding what the business issues were and how those individuals might contribute to their requirements

• **Our approach in ‘One Small Step’** We set in place a series of workshops and we invited all 18,000 employees from the aerospace business to 800 workshops of about 20-25 people. Volunteer managers and supervisors were given several days training on how to run workshops and were provided with materials to lead workshops. The materials were based around questions such as:

  What type of business are we in?

  What are the issues that we face?

  What are we asking of people to help us succeed in the market place against competitors?

• We made it **voluntary**. Some people found that a bit difficult and wanted us to decide whether they would come. We said 'it is up to you really' as that is the
first part of the change process. It is sufficiently important for us to set a side a
day and you need to decide if you agree.

- Overall 15,000 people came and we ran the programme for over four months. I
  think the record shows that it had a major impact in the company. People
  still refer back to it as the first big programme that made an impression; it did
  get across to a lot of people that it mattered to them what the companies’
business position’ was and how everybody in company could actually help.

- The whole idea of 'values and behaviour' was really started in those
  workshops and took root. People regarded it as first big step forward towards
  changing the culture of the company to encourage a greater willingness to be
  inventive and honest themselves, to question their individual managers in their
  attitudes and understanding better their role in the company and the
  organisation.

- Later in 1998 we ran another programme for about 5,000
  managers i.e. the senior managers, foremen and team leaders in the
  engineering areas. We are a big company of about 45,000 people
  and 5,000 people are in roles supervising others, whether it is 700
  or half a dozen. The framework of that programme was again to
  take further forward their understanding of the business and
  their role as supervisors and managers. Develop better
  communication and more openness. We used it as a way of
  launching 360-degree appraisal.

- We have a set of prestigious annual awards called The
  Chairman’s Awards for Technical Innovation. These awards
  include: -
  1. Team and individual awards for the application of innovation
     and creativity which has led to savings/benefits for the
     company
  2. Awards for engineers who have successfully obtained patents
     for the company
  3. Awards for young engineers who have demonstrated
     outstanding technical achievement
- The selection criteria for graduate design

Social/environmental features
macro/micro, social, cultural,
(Amabile, 1983, 1996; Boden, 2001,
Csikszentmihalyi, 1990, 1996, Dacey
& Lennon, 1998, Sternberg & Lubart
1995)

- A successful organisation will get as many people as possible
  thinking of different, better ways of doing things. You have to
  create an atmosphere for people to do that without fear of
  recrimination if they get it wrong.

- Conditions for their work? You have to pay and reward people in a reasonable
  manner. You don’t have to pay them the highest, but you have to pitch it at a
  level where people see it as proper reward for what they do. Recognition does
  not have to be monetary. Simply saying to people that the time they have done a
  good job goes a long way.

- People will ask at interview what part will I have in this
organisation, what kind of role will I play, what position might I hold, where might I hold it and what training could I expect?

- The whole concept of encouraging people to **take risks, make their own decisions** and not wait for others means that you have to accept that occasionally they might not do what you think is right.

- If you live in an organisation where **highly intelligent people simply refer everything to someone else**, and they are very good at it, you will not compete. You will only be second best.

- Talk about **risk and change** and everyone will grow wary. It is not something confined to the British. It is everywhere you go - it is human nature.

- People do **want to understand better and can change**, if you take the trouble to explain what you are trying to do.

- The success of the enterprise rests on everybody's efforts; it depends upon the whole team.

- We are all concerned about our **reputation in the community**. It does not matter what the private view of the teacher is, what really matters is the reputation of that school in the eyes of the community. That is true of any organisation i.e. a technical college or a tertiary college.

- If the reputation of the organisation is high it will almost certainly attract good teachers. Good teachers have an **influence on pupils both good and bad** and that works its way through the community. The community is the customer base for a school.

- What really matters is what is the **standard of service** that is offered to the customer. You can take pride in that whether your company is public or private sector. I think you can transform any organisation by thinking in that way i.e. the idea of teamwork right across the organisation in support of customers. We have done a lot to encourage teamwork between our businesses. A successful enterprise needs **high calibre people right across its organisation and teamwork**.

- We have developed a “**Creativity Website**” on our intranet – it introduces techniques to aid and improve the generation of ideas and highlights some of the hurdles that have to be overcome in order to realise creative and innovative potential.

- The importance of creativity and innovation in the design process led us to form a partnership with the Institute of Work Psychology at Sheffield University to **research factors that stimulate creativity and enable innovation**.

- We have identified **TRIZ as a specific tool-set to help designers enhance their creativity and problem solving**: - TRIZ is the Russian acronym for “**Theory of Inventive Problem Solving**”

  The methodology is widely used in industry and has been around in Rolls-Royce for over three years

  We designers trained in UK, Germany and the US

  It is a philosophy, a method and a collection of specific tools and strategies for solving technical problems.
How do we show in design and technology that we value creativity?

Marion Rutland, University of Surrey, Roehampton, UK
Email: m.rutland@roehampton.ac.uk

Abstract
The paper reviews the concept of creativity in general terms and in the context of education. This is followed by consideration of whether, and how, teachers of design and technology (D&T) show that creativity is valued in their pupil’s work. These issues are investigated through the findings of the UK joint Nuffield Design and Technology Project and Qualifications and Curriculum (QCA) research project ‘Creativity in Art and Design and Technology’. The paper concludes by considering what lessons there to be learnt for teachers of D&T to enhance and value their pupils’ creativity.

Key words: creativity, D&T, A&D, curriculum, QCA, Nuffield

Introduction
Defining creativity in general terms is not a simple process. At a simple level it has been defined as the ability to produce new knowledge (Dacey, Lennon 1998), or a more complex view is that creativity is a puzzle, a paradox a mystery but essentially it is as a novel combination of ideas and should include value (Boden, 1994). Some see creativity as a messy and confusing subject, bringing something to life that was not there before (de Bono, 1992). There are levels of creativity. Big creativity is when something of enduring value is contributed to an existing field of knowledge, which transforms it. Small creativity is more humble, though perhaps equally valuable, activity giving a fresh and lively interpretation to any endeavour (Feldman, Csikszentmihaly, Gardner, 1994). Boden (2001) sees a three-form view of creativity including ‘combinational’ creativity producing novel, or unfamiliar or improbable combinations of familiar ideas. More complex forms include ‘exploratory’ creativity when a person, without breaking any rules, comes up with something not radically different and ‘transformational’ creativity when a person alters the rules and creates something radically new in the field of knowledge, domain or ‘conceptual space’.

Traditionally creativity was viewed through the person and studies have attempted to identify the key characteristics of a creative person. Gardner (1993) was concerned with the cognitive characteristics of the creative person who solves problems, makes products or asks new questions within a domain that are initially considered to be unusual but becomes acceptable within at least one cultural group.

Other writers view creativity as a process or system, when new information is used with old structures, patterns, concepts and perceptions (de Bono, 1992). It is the achievement of something remarkable and new, something that transforms and changes a field of endeavour in a significant way. Other writers emphasis the product and see creativity as characteristics reserved for products that are seen as novel within a domain, but are ultimately recognised and judged by experts as acceptable within an appropriate community (Gardner, 1993). A similar stance describes a product as creative when it is a) novel and b) appropriate (Sternberg, Lubbart 1995). Sternberg & Lubart (1999) combines process with product and define creativity as the ability to produce work that is both novel eg original, unexpected and appropriate, that is useful and adaptive taking into account task constraints. Amabile (1983, 1996) highlights the impact of specific social factors and intrinsic motivation on creativity.

Until recently research into creativity focused on one or other of the elements outlined above. More recent studies on creativity hypothesise that multiple components must converge for creativity to occur (Amabile, 1983, 1996; Csikszebtmihalyi 1990, 1996; Feldman et al, 1994; Gardner 1993; Gruber 1989; Sternberg and Lubart 1995, 1999). They argue that there are four essential elements of creativity, the person, the product, the domain and the situation, environment and context. A three-feature model for creativity in an educational setting could consists of domain relevant features - a set of practices associated with an area of knowledge; creativity-relevant features- influencing, controlling the direction and progress of the process; and social, environmental features - macro/micro environmental, social and cultural issues. The element of person is central to the model as it reflects the influences of the three features on the creativity of the child (Rutland, 2002).
Creativity, defined in educational reports in the UK, incorporates the views of many of the above writers. It is seen as ‘imaginative activities fashioned so as to produce outcomes that are original and of value’, and in more recently writing ‘imaginative processes with outcomes that are original and of value’ (Robinson, 1999:29, 2001:118). Cropley (2001) sees a common core of three elements in education and learning. There are novelty - a unfamiliar creative product, course of action or idea; effectiveness - it works, achieves some end which may be aesthetic, artistic, spiritual or materialistic such as winning or making a profit; and ethical - the term creative is not usually used to describe selfish, destructive behaviours. He argues that appropriate learning conditions can promote at least some element of creativity in many if not all children. The goal is not to produce acclaimed creative geniuses but individuals who can get ideas, try something new, take a risk in classroom or at home.

Background to the research
This paper will explore through the findings of the UK joint Nuffield Design and Technology Project and QCA project ‘Creativity in Art and Design and Design and Technology’ whether, and how, teachers of D&T show that creativity is valued in their pupil’s work. The aim of the research project was to develop a better understanding of the contribution that teaching A&D and D&T make to the development of creativity. The research was underpinned by three questions:
1. What does creative activity look like in A&D and D&T?
2. What strategies and activities enable pupils to act creatively?
3. What factors affect the teacher’s ability to develop creative activities?

Methodology
In 1999 twenty A&D and D&T UK teachers for pupils aged 5-16 were invited to a meeting by QCA and the Nuffield Curriculum Centre. They discussed and presented examples of their work with in both A&D and D&T. Four features were identified that had to be in place for pupils to act creatively in either subject:
• the activity had to be presented in a context to which the pupils could relate;
• the activity had to be supported by a significant stimulus which was often, but not exclusively, intensely visual;
• focused teaching was necessary to provide knowledge, understanding and skills;
• An attitude of continuous reflection needed to be encouraged.

In Autumn 2000 six A&D and four D&T teachers planned, taught, documented and assessed a unit of work for their children across the age range of 5-16 years. They were asked to use the planning framework in QCA schemes of work for A&D and D&T (1998, 2001). A planning framework was given as guidance for the teachers and it included outcomes, pupil behaviour and strategies, teaching strategies and the learning environment.

During November and December 2000 half day visits were made to three primary and three secondary schools for A&D and two primary and two secondary schools for D&T to explore
• The context of each of the schools
• Their perceptions of the place and role of the subject
• The project teacher’s approach to the subject
• The specific work being done on creativity

Details of the visits to the ten schools can be found in Appendix A.

Findings from the visits
Ethos
The interviews with eight of the ten headteachers highlighted the importance of support from senior staff, the ethos of the school and relationships between the subject, teacher, headteacher, school and the local environment. In all the primary and secondary schools, except one, a relationship was noted between the support inside and outside the school and the quality and creativity of children’s work. External links with the local community, including local advisers, museums, art colleges and attendance on courses was a common factor in these schools. A supportive school environment and good resources appear to be a major contributing factors for creative work with the pupils in both A&D and D&T.

Vision of the departments
Again, there were common factors for both A&D and D&T departments. Talented and committed A&D and D&T teachers were found in both the primary and secondary schools and the most creative work appeared to be happening where teachers had a clear idea of the elements of their subject that were needed to develop creative outcomes in their pupils’ work. The primary A&D and D&T curriculum had a wider focus and a cross curricular
emphasis including links with other subjects, language development and national initiatives such as literacy and numeracy.

**Activities**

The entire primary and secondary A&D projects were based on an open theme, around the style of an artist, architecture, a play, the seaside or historical events and people. This was not the situation for the D&T as projects in both phases were ‘closed’ and ‘product’ based for example a pizza, a musical instrument, a novelty notebook or a toy. The children were not encouraged to look at, investigate a context, explore design ideas and consider a range of common, but different outcomes. The use of restricted, focused design briefs restricted the pupil’s opportunities to generate and develop their own ideas. In one secondary school the D&T design brief was ‘closed’ with little opportunity for design decisions for the pupils, except for decoration. Designing activities consisted of drawing or sketching ideas.

Secondary and primary A&D teachers began projects with visual stimuli and required the pupils to carryout individual research to develop their thinking. These activities included making connections by exploring shapes and observing buildings and natural objects. The use of interesting and varied starting points and a wide range of stimuli, including visual, for D&T did not appear to be key issues.

Primary A&D and D&T teachers were more likely to allow the children to experiment and work as a whole class or in groups. The range of types of activities was wide and varied; they included discussion, school visits, visiting speakers, field trips, displays, school performances for parents. D&T teachers in primary schools were more open in this approach and willing to allow the pupils to explore and investigate to generate individual ideas at the same time as developing the necessary skills, knowledge and techniques.

Secondary and primary A&D and D&T teachers were more clear about the need to develop technical and aesthetic knowledge about colour, shape and form, and the techniques of shading, observational drawing and making 3D models. They encouraged children to making decisions and have ‘thinking’ time. Two commented on the time that was needed for ‘construction’ activities. In one secondary school it was noted that when an A&D teacher taught a D&T project that the work was visually better but that there was less quality in the finished technical and constructional aspects.

Lower secondary D&T tended to focus on ‘constructional’ creativity, that is the skills and knowledge required to ‘make’ something for a specific purpose. Finished quality and functionality were key issues rather than developing design ideas, learning about a range of materials and techniques and making design decisions. One teacher had adapted her approach to include a ‘see it is works’ as well as experimenting with colour and materials. She commented that this approach took longer but that the work was ‘far more imaginative and creative than in previous years’.

**Teacher support**

In both A&D and D&T there were children who were naturally more able to develop ideas and others who needed support and guidance from teachers. Some children could see different ways of doing things for themselves; others need guidance and the opportunity to try things out. The role of the teacher was crucial in creating a supportive atmosphere, where children developed knowledge, understanding and skills in materials and techniques and then made informed choices. Originality and creativity appears to come from confident, well motivated children who have developed capability in specific areas and are working in such a supportive environment. Time to reflect and think about their ideas was considered important by the A&D teachers but was not mentioned by D&T teachers.

**Constraints**

These were common for A&D and D&T. They included concerns over lack of time, the impact of the National Curriculum and school inspections, large classes, addressing the needs of all of the children, costs for resources and examination board requirements. One A&D teacher commented that his children needed both aesthetic and creative abilities and that ‘realistic’ designs required ‘construction’ skills if they were to be really creative.

**Main findings**
In February 2001 the teachers attended a meeting in London at QCA to present and discuss examples of some of the children’s work done in their schools. This overview made it possible to identify four features that had to be in place for the pupils to be creative in either subject:

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

However, it was thought that the deciding factor is the way in which these features are managed. It must in such a way that individual pupils can handle uncertainty and feel confident in taking risks in exploring and developing ‘originality’ in their outcomes (Barlex, 2003).

Conclusions
The findings from the visits indicate that a supportive school ethos and local environment and teachers who plan and teach to encourage creativity are common factors for A&D and D&T. The development of constructional, and to some extent technical, creativity are generally the main focus for D&T teachers, especially in the lower secondary school. Choice and decision making and being creative are not the key issues. A&D teachers appear to place more importance on allowing children to make their own decisions and have time for thinking through their ideas.

A key factor for the lack of emphasis and value put upon creative in D&T is the type of design brief frequently set in D&T. They are restrictive and close down creative thinking from the beginning of the ‘project’. Children are going the design and make a ‘………….’ Particularly in the lower secondary, the context and the use of interesting and visual stimuli are not of high important and children are not required to be motivated to explore, observe, consider, and discover different but relevant outcomes. A range of practical design activities are not deliberately planned to both develop knowledge, skills and understanding, give opportunities for design decisions and choice resulting in variation and originality. Teachers do not always see their role as creating an environment where children are confident and able to take risks in their designing and making.

Creativity must be valued for its impact on, and enhancement, of the learning experience in D&T and the development of transferable skills associated with creative problem solving. In lower secondary D&T there is a need for a better balance between technical, aesthetic and constructional creativity. Value should be placed on the ‘novel’ and unusual outcomes with credit given in assessment procedures to children for taking risks. Contexts and starting points should be more ‘open’ with stimuli that interest and motivate and more use made of a range of teaching strategies, including whole class, group and individual activities.

References
Rutland, M (2002) ‘What can we learn about creativity from the practice of professional designers to inform design and technology classroom practice?’, DATA Research International Conference, Coventry, July 2nd -3rd 2002, pp 153 - 159


Appendix A Mapping of schools visited against ethos, vision, activity, teacher support for pupils to be creative and constraints

<table>
<thead>
<tr>
<th>School</th>
<th>Ethos</th>
<th>Vision</th>
<th>Activity/s</th>
<th>Teacher support for pupils to be creative</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary A</td>
<td>• Small, rural school</td>
<td>• The importance of skills such as colour, mixing, observational drawing, shading</td>
<td>• Year 1 - Seaside project (textiles, multi-material)</td>
<td>• Context – e.g. local church, ‘Elmer’ the elephant</td>
<td>• Recent decreased flexibility in the curriculum</td>
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<td></td>
<td>• Supportive head</td>
<td>• A valued response from the children</td>
<td>• Short tasks to develop skills e.g. colour mixing, observational drawing, shading</td>
<td>• Providing children with skills, knowledge and understanding that they could use in the project</td>
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<tr>
<td></td>
<td>• Associate Art Adviser/teacher</td>
<td>• Links with other subjects (language, science)</td>
<td>• Being a 'fly on the wall ie supporting and standing back where possible</td>
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<tr>
<td></td>
<td>• School history of an interest in creativity</td>
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<tr>
<td>Primary B</td>
<td>• Rural primary</td>
<td>• Art and design taught in an integrated style</td>
<td>• Year 6 Macbeth</td>
<td>• One week residential visit to Northumberland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• School has a unit for learning difficulties</td>
<td>• Links across the curriculum with history and geography</td>
<td>• Began with class discussion and class asked to write down their thoughts</td>
<td>• Range of activities – observational drawing, 3D shapes based on aspects of the story, multi-material collages, drawing and paintings based on the opening act of Macbeth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Whole school approach to Robinson Report</td>
<td>• 'Imagination' work and 3D shapes - sculpture</td>
<td>• Emphasised developing skills, stimuli, collecting evidence, observational</td>
<td>• Gave children time to think</td>
<td>• Concern for what could be done within the existing, established curriculum in primary schools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Language</td>
<td>• Taught skills to give choice</td>
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Pupils Attitudes Towards Technology   Annual Conference   June 2003
### Primary C
- City primary school
- School focus for arts and creativity
- Local A&D curriculum document
- Use of local advisers, courses, galleries, cultural sites

### Secondary A
- Mixed, city comprehensive
- Strong art tradition in area
- Support from

<table>
<thead>
<tr>
<th>Primary C</th>
<th>development – technical words-</th>
<th>drawing &amp; talking skills.</th>
<th>Secondary A</th>
</tr>
</thead>
<tbody>
<tr>
<td>• City primary school</td>
<td>• Excellent art displays around the school.</td>
<td>• Year Viking cross-curricular project</td>
<td>• Mixed, city comprehensive</td>
</tr>
<tr>
<td>• School focus for arts and creativity</td>
<td>• Art and design used as focus for children’s projects</td>
<td>• Children designed and made Viking costumes in groups (5)</td>
<td>• Strong art tradition in area</td>
</tr>
<tr>
<td>• Local A&amp;D curriculum document</td>
<td>• Links with D&amp;T</td>
<td>• Brief to use paper and surface design</td>
<td>• Support from</td>
</tr>
<tr>
<td>• Use of local advisers, courses, galleries, cultural sites</td>
<td>• Had dedicated area for children to work on their projects</td>
<td>• Used classrooms and specialist art area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>•</td>
<td>• Costumes worn for a performance for parents</td>
<td>• Starting point – Sagrada Familiar by Antoni Gaudi – links between building and natural objects</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Allows most talented/creative pupils develop own ideas</td>
</tr>
</tbody>
</table>

- Space in the school
- Confusion in Ofsted Inspection between A&D and D&T.
- Lack of curriculum time for foundations subjects (other than English, maths, science)
- Having realistic designs for costumes
- Having the 'construction' skills to be creative
<table>
<thead>
<tr>
<th>Secondary B</th>
<th>Secondary C</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Head</td>
<td>• Involved in CAPE UK – Creative Partnerships in Education –</td>
</tr>
<tr>
<td>• Good support from local Adviser</td>
<td>• Year 9 Looking at architecture and environmental</td>
</tr>
<tr>
<td>• Links with local Art College.</td>
<td>• Pupils are encouraged to develop and use a range of techniques i.e. digital camera</td>
</tr>
<tr>
<td>• ‘talented’ pupils not in art had built this up</td>
<td>• Pupils expected to make connections by exploring shapes and symbols in the paintings of Miro</td>
</tr>
<tr>
<td>• Now wide ranges of pupils of all abilities take art.</td>
<td>• Introduced to surrealistic movement e.g. dreams</td>
</tr>
<tr>
<td>• Observational drawings, chalk drawings of shells, model of theatre in clay/wire, ICT virtual reality</td>
<td>• Widened pupils’ thinking through other artists e.g. Dali</td>
</tr>
<tr>
<td>• Shows techniques they can choose to use</td>
<td>• Asked them to interpretate lines and shapes in the paintings</td>
</tr>
<tr>
<td>• Stands back, allows time for their thinking</td>
<td>• Encouraged pupils to be reflective</td>
</tr>
<tr>
<td>• Gives regular feedback, does not mark every week.</td>
<td>• Influences of group dynamics in some groups – produced very different outcomes</td>
</tr>
<tr>
<td>• Has 2-3 activities going at one time</td>
<td>• Time for making e.g. craft skills for making the bowl took a long time</td>
</tr>
<tr>
<td>• Encouraging creativity means pupils need more individual attention and guidance</td>
<td>• Large year group with wide interest and ability range</td>
</tr>
<tr>
<td>• Large mixed, city school with 6th Form</td>
<td>• Individual needs in a large class</td>
</tr>
<tr>
<td>• Strong church tradition</td>
<td>• Strong links with the community</td>
</tr>
<tr>
<td>• Strong links with the community</td>
<td>• Creative arts strength</td>
</tr>
<tr>
<td>• Creative arts strength</td>
<td>• Runs art conferences and takes part in local events</td>
</tr>
<tr>
<td>• Runs art conferences and takes part in local events</td>
<td>• Very experienced teacher/adviser</td>
</tr>
<tr>
<td></td>
<td>• Teachers of A&amp;D and D&amp;T work together</td>
</tr>
<tr>
<td></td>
<td>• Shared A Level teaching</td>
</tr>
<tr>
<td></td>
<td>• Wide range of visual creative art displays</td>
</tr>
<tr>
<td></td>
<td>• Emphasise surface design, colour and texture</td>
</tr>
<tr>
<td></td>
<td>• Textiles has strong A&amp;D tradition</td>
</tr>
<tr>
<td>Secondary C</td>
<td>Secondary C</td>
</tr>
<tr>
<td>• Urban mixed comprehensive</td>
<td>• Year 9 Miro/Surrealistic Dream Bowls</td>
</tr>
<tr>
<td>• Newly</td>
<td>• Based on characteristics of the artist Miro, incorporated into their designs</td>
</tr>
<tr>
<td></td>
<td>• Pupils design and paint their own symbols/logos from everyday objects</td>
</tr>
<tr>
<td></td>
<td>• Made 3D individualised paper mache bowls/vessels</td>
</tr>
</tbody>
</table>

Pupils Attitudes Towards Technology Annual Conference June 2003
<table>
<thead>
<tr>
<th>School</th>
<th>Arts College granted status – new head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim</td>
<td>'Creativity' part of school plan</td>
</tr>
<tr>
<td></td>
<td>Aim to look at more innovative, creative approaches to learning</td>
</tr>
<tr>
<td>based</td>
<td>on CAPE in Chicago</td>
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<tr>
<td></td>
<td>Aims to explore relationship between creativity and learning</td>
</tr>
<tr>
<td></td>
<td>Part of local arts in schools scheme.</td>
</tr>
<tr>
<td></td>
<td>Young, strong department</td>
</tr>
<tr>
<td></td>
<td>Different teachers interpretative in slightly different ways</td>
</tr>
<tr>
<td>Design</td>
<td>Pupils move from 2D to 3D and back to 2D.</td>
</tr>
<tr>
<td></td>
<td>Explored 2D photographs of dwellings, did 2D drawings and 3D wooden and other material block models.</td>
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<tr>
<td></td>
<td>Painted corrugated card relief model buildings based on their sculptures.</td>
</tr>
<tr>
<td></td>
<td>Final model used to develop a lino print</td>
</tr>
<tr>
<td>Visual stimulus at the beginning</td>
<td>Support and guidance for pupils</td>
</tr>
<tr>
<td>Sketching is popular but some pupils prefer other strategies</td>
<td></td>
</tr>
<tr>
<td>Sometimes work in groups, sometimes as individuals</td>
<td></td>
</tr>
<tr>
<td>'Dwelling' design was deliberately left open</td>
<td></td>
</tr>
<tr>
<td>Taught concepts of perspective drawing and asymmetry</td>
<td></td>
</tr>
<tr>
<td>Concept of present and future building developed</td>
<td></td>
</tr>
<tr>
<td>Creativity</td>
<td>Need to fully involve pupils of all interests and abilities</td>
</tr>
<tr>
<td>Work done mainly at school (little homework)</td>
<td></td>
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<tr>
<td>Importance of retaining practical aspects</td>
<td></td>
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</table>
| Need for verbal evaluation for some pupils (time)
## Design and Technology

<table>
<thead>
<tr>
<th>School</th>
<th>Ethos</th>
<th>Vision</th>
<th>Activity/s</th>
<th>Teacher support for pupils to be creative</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary A</strong></td>
<td>• Inner city, multi-cultural, infants school in 'Education Action Zone'</td>
<td>• Enthusiastic teacher completed 10 day D&amp;T co-ordinators course</td>
<td>• Year 2 Food technology, Pizza</td>
<td>• Starting points - visit to Pizza Express</td>
<td>• Number of children doing the project</td>
</tr>
<tr>
<td></td>
<td>• Emphasis on the development of language</td>
<td>• To cover QCA schemes of work</td>
<td>• Develop links with industry</td>
<td>• Share ideas, discussion</td>
<td>• Cost i.e. ingredients, transport for visit</td>
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<tr>
<td></td>
<td>• Strong headteacher support</td>
<td>• Address literacy &amp; numeracy</td>
<td>• Series of focused practical tasks e.g. product analysis, tasking cheeses, fillings</td>
<td>• Built on children's ideas and people's needs</td>
<td>• Curriculum time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Development of language through D&amp;T</td>
<td>• Children design and make their own pizza</td>
<td>• Focused task taught knowledge and skills</td>
<td>• Packaging took longer than expected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Widen children's experiences</td>
<td>• Design packaging</td>
<td>• Allowed children to make design decisions e.g. filling, base</td>
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<td></td>
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<td></td>
<td></td>
<td>• Giving regular feedback to children</td>
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<tr>
<td><strong>Primary B</strong></td>
<td>• Suburban, church one class intake school</td>
<td>• Teacher recently completed 10 day D&amp;T course for co-ordinators</td>
<td>• Year 5 Musical Instruments from QCA schemes of work</td>
<td>• Introduction - through investigating a range of musical instruments</td>
<td>• A new project</td>
</tr>
<tr>
<td></td>
<td>• Very supportive head, released teacher for 2 years to support and</td>
<td>• Teaching on local ITE programme and ran INSET for teachers</td>
<td>• New project</td>
<td>• Children tried the instruments</td>
<td>• Teacher did not know all the children</td>
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<tr>
<td></td>
<td></td>
<td>• Had clear plan to develop and implement D&amp;T</td>
<td>• Teacher taught alongside class teacher</td>
<td>• Visitor showed children how to make violins</td>
<td>• Children found difficulty understanding differences between instruments they explored and</td>
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<td></td>
<td></td>
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<td></td>
<td>• Allowed children to experiment with wide range of materials to find the one suitable for their design</td>
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</table>
### Secondary A
- Mixed rural, community comprehensive
- Strong support from head teacher and senior staff
- School has technology status
- Runs 1 week cross-curricular technology project
- Technology has a high profile in school
- Teacher is an Advanced Skills teacher
- Has built a strong teaching team
- Year 7 Novelty Notebooks project.
- Used design strategy – 'look at it and try'
- Changes introduced produced ‘far more imaginative and creative notebooks than in previous years’ eg shape, materials, colours
- Changed shape of notebook
- Tasks to teach techniques – transfer, surface design, ‘neated’ a seam
- Developed a prototype – modelled ideas in paper
- Used a wider range of materials and fabrics
- Introduced a wider range of teaching styles - more 'needs' driven
- Considered that the pupils were creative because they were of high academic ability
- Criteria given - mass

### Secondary B
- County, selective girls’ school
- Examination focus
- Department included D&T and A&D
- Food technology still had a home
- Year 9 Toys on Wheels
- 6 week ‘taster’ for options in Year 10
- 3 weeks
- Considered that the pupils were creative because they were of high academic ability
- Criteria given - mass

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</table>
### Traditional D&T approach in past
- Evidence of gender bias in fields of D&T in the past

### Economics approach i.e.
- Learning how to cook family meals
- Strong A Level group
- Modelling done in graphics

### Designing e.g.
- Sketching and developing ideas and 3 weeks making
- Design activities – sketching own ideas and developing them
- Visual creativity - expression on the face
- A&D teacher produced visually better work with less quality in the finish/technical aspects

### Production
- Demonstrated skills - use of drill.
- Pupils who had done the graphics course first did better quality graphic design work
- Introduced a wider range of good materials/resources for choice
- Pupils encouraged to produce 10-12 expressions
- Expected pupils to self-evaluate
- Felt constraints made pupils think wider and more creatively

### Priorities for resources and staff
- Few links with advisers, other schools and teachers
- Loss of textiles, teacher leaving and not being replaced
The Nature of Technological Knowledge: Philosophical Reflections and Educational Consequences

Dr. Marc J. de Vries, Eindhoven University of Technology, Netherlands
Email: m.j.d.vries@tm.tue.nl

Abstract

Technological knowledge has a normative component that scientific knowledge does not have. When we have knowledge of a computer, that often comprises normative judgements: it functions well or it does not function well. In knowledge of technical norms, rules and standards as another type of technological knowledge we also find a normative component. This characteristic has consequences for our assessment of knowledge. For scientific knowledge truth is the ultimate condition. For knowledge of norms, rules and standards as a type of technological knowledge this the condition is problematic. They refer to things that do not exist yet, but are still to be designed or made. Nor truth, but effectiveness is the condition here. For technology education the normative component is important. Pupils must learn to make judgements about effectiveness, as this is a prominent characteristic of technological knowledge, that makes it distinct from scientific knowledge. Pupils must also learn to deal with ethical and other values when doing technological project work.

Keywords: technological knowledge, philosophy of technology, technology education

Introduction: What philosophy of technology can mean for technology education

One of the goals of technology education is the formation of a good concept of technology in pupils’ minds (Vries 2000i). That is why pupils’ concepts of technology from the very start have been an important element in PATT (Pupils’ Attitude Towards Technology) studies. But the actual concept of technology that pupils appear to hold is only one of three issues in the development of technology education. The other issues are: what is a correct concept of technology, and what educational settings need to be created in order to cause the pupils’ actual concept of technology to shift towards a concept of technology that the experts see as a correct one? The third issue is dealt with in what can be called PCK (Pedagogical Content Knowledge; see Gess-Newsome and Lederman 1999). The remaining issue is a problematic one for technology education in particular. Contrary to many other school subjects, there is no clear academic equivalent of technology education, from which a good conceptual basis can be derived (Vries 2002ii). Of course there are engineering disciplines, but those are all specific for certain engineering fields and do not necessarily help us to get an overall picture of what technology is.

There is, though, another academic field that can help us in developing a conceptual basis for technology education: the philosophy of technology (Vries and Tamir 1997). There are two kinds of this philosophy: one that has conceptualisation as its main goal, and one that has critical analysis of the role of technology in culture and society as its main goal. The first one is often indicated as: analytical philosophy. The second one can be indicated by the term: cultural philosophy. In particular the last-mentioned is known through the work of authors such as Ellul, Heidegger, Mumford, and others (Mitcham 1994). The first-mentioned often does not reach a wide audience. Yet, for those involved in developing a conceptual framework for technology, this type of philosophy of technology is highly relevant. The main characteristic of analytical philosophy is that it always asks the question: “what do you exactly mean when you say/write . . . ?.” This is the same question that technology educators should ask themselves when talking and writing about technology, technological processes, technological knowledge, technological objects, etcetera. It is precisely this sort of conceptualisation that we want to accomplish in our pupils’ minds. The reflections that the analytical philosophy of technology offers can be very useful to take into account when considering a conceptual basis for technology education. This holds not in the least for the concept of technological knowledge. What do we mean by that. What makes it different from other types of knowledge that pupils learn at school? Does it make a difference in teaching whether we deal with technological knowledge or
with other types of knowledge? If yes, how? Those are the kinds of questions that I would like to deal with in this paper.

What is knowledge in general?
One of the sub-domains in philosophy is epistemology. In this sub-domain the core question is: what do we mean by the term ‘knowledge’? In other words, what does it mean when we say: “a person P knows that x”, whereby x is a proposition, a statement about a state of affairs? In traditional epistemology this question is answered by listing three conditions for knowledge.

a. the person P must believe that x,
b. the person P must have found some sort of justification for believing that x,
c. x must be true.

All three at first sight seem relevant conditions. How can we say that someone knows something if he does not even believe it himself or herself? But also it seems fair to require that in order to change a mere belief in knowledge that person has sought and found a justification for that belief. That justification can be manifold: it can be someone’s own observation, it can be a testimony by a trustworthy other person, it can be a sound reasoning from other facts that have been justified already, and it can be drawn from one’s memory. Finally we require the believed statement x to be true. If someone claims to know that iron floats on water, we deny this to be knowledge.

There are however complications with respect to this simple definition of technology. In the mainstream epistemology debates a well known problem is what is called the Gettier problem (Audi 1988, p. 245). In an extremely short, but now famous article, E.L. Gettier mentioned some examples in which the person P believed that x, had found justification for that, and also x was true, but yet we would not like to say that P knew that x. This happens for example when the justification that P found and the fact that x is true are a mere coincidence. Suppose that P reads his/her watch and than says: I know that it is four o’clock now. P believes this, has found justification for it (a personal observation) and x is true, because indeed it is four o’clock at that moment. But this is a coincidence, because P’s watch does not run and by accident the reading of the watch happens at the two single moments per day that the static watch indicates the right time. All conditions for knowledge are fulfilled, yet we would not like to ascribe knowledge of the correct time to the person P.

Various ways to ‘repair’ the Gettier problem and yet keep most of the original definition of knowledge have been suggested. Most of them add conditions to the existing set of three to exclude cases of coincidence of the justification and the truth of the proposition x. Others completely redefine the concept. For example, A. Plantinga changes the internalist and deontological perspective of the original definition (knowledge is determined by factors within a person, e.g. his/her belief, and obligation to seek justification) into an externalist perspective, whereby the criteria for knowledge are external (the proper functioning of the person’s faculty of cognition, i.e. according to its design plan). The debate about this is still ongoing.

Technological knowledge: normative components
But perhaps more important for technology educators is the objection that comes from the side of philosophers of technology. Considering what we would like to call ‘knowledge’ in technology, they have come up with two issues. In the first place not all knowledge in technology can be expressed in propositions. “When we say: the pupil should know how to use a hammer”, we do not mean that the pupil believes propositions about how to use a hammer. That would be ‘knowing that’ and what we really mean is ‘knowing how’ (these terms have been distinguished by G. Ryle; see also Cross 1982). A second objection against the classical definition of knowledge is that in technology there are types of propositional knowledge that can not adequately be associated with truth, because they do not refer to an actual state of affairs. Based on the distinction between the functional nature of a technological artefact (what it is supposed to do or be) and its physical nature (geometry, materials) (see Kroes and Meijers 2000), we can at least distinguish the following four types of propositional knowledge in technology (Vries 2003, forthcoming):
a) X knows that carrying out action Ac with artifact A will result in a change in state of affairs $\phi_i \rightarrow \phi_{i+1}$. This is what I call functional nature knowledge. The artifact may not exist yet (that is the case when the designer works on the functional list of requirements for the artifact that is yet to be designed). An example of this knowledge type is: X knows that a cork can be extracted from a bottleneck by getting grip on the cork and pulling it out (and a corkscrew is a device by which this can be done).

b) X knows that artifact A has physical property p. This is what I call physical nature knowledge. This knowledge can be knowledge about the material of which A has been made and about its shape. An example is: X knows that a corkscrew has a helix with a sharp point.

c) X knows that the fact that A has physical property p (or a combination of properties p_i) makes it suitable for carrying out with the artifact the action Ac that results in the change in state of affairs $\phi_i \rightarrow \phi_{i+1}$. This is what I call knowledge of the relationship between physical and functional nature. An example is: X knows that the sharp helix of a corkscrew makes it suitable for getting grip on a cork (so that it can be extracted from a bottleneck).

d) X knows that the (intended) total change in state of affairs $\phi_1 \rightarrow \phi_2$ can be realized through a series of $\phi_i$. This is what was I call process knowledge. An example is: X knows that a cork can be removed from a bottleneck by first turning a corkscrew helix into a cork and then pulling at the corkscrew handle.

Type c is akin to knowledge in natural sciences. But the other types are different from scientific knowledge. They have a normative component that scientific knowledge does not have. When we have knowledge of an electron, we can not say it is good or bad. It just behaves according to given natural laws. But technological knowledge of the types a, b and d comprise normative judgments. For type a knowledge we can say that a function is well or badly fulfilled. Note that there are serious problems here in defining the truth criterion. When I know that this is a broken car, how can I establish the truth of that proposition? The proposition entails a function ascription that in this case is even impossible to verify. Yet we feel that it should be acceptable as being knowledge to say that I know that this is a broken car. In the knowledge types b and d there can be normative elements too. The sequence of actions may be a technical norm for doing something (e.g. for the design process there are lots of prescriptive action sequences in literature). Even if it were possible to establish ‘truth’ here, still it would probably not be our main interest. We would rather be interested in effectiveness of such prescriptions than in their ‘truth’ (whatever that might be). This normativity can have many expressions: as technical norms and standards, as rules of thumb, as ‘good practice’, etcetera. But whatever these may be, they make the definition of knowledge as ‘justified true belief’ inadequate for technological knowledge in general.

**Teaching technological knowledge**

What does all this mean for teaching and learning technology? The main conclusion from the philosophical reflection that have been described above, is that teaching technological knowledge should include the normative components of that knowledge, otherwise we would not do justice to the particular nature of technological knowledge. There are at least two ways to do that. In the first place we must throughout our technology education curriculum teach pupils to make judgments with respect to the function and functioning of technological artifacts. It is not enough to describe functions of artifacts. Such descriptive knowledge is only part of technological knowledge, and not even the most characteristic. In the second place pupils must learn that norms, standards, rules of thumb, and whatever other normatively determined types of technological knowledge form an important part of what technologists need to know. The term ‘norm’ should not immediately make us think of ethical norms, because a lot of norms in technology are not directly ethical in nature (e.g. industrial norms for the size of screws). Many norms, however, directly or indirectly are related to ethical norms. Therefore pupils should be made aware of the ethical aspects of technology. Sometimes curriculum developers shy away from doing that because they are afraid to indoctrinate pupils. This need, however, not be the case. It is important to help pupils to acquire analytical tools, with which they can recognize when a value dilemma shows up and how to deal with it through proper reasoning. Each individual teacher/school can then decide whether or not to add specific ethical content to that. The extent to which this can be realized, of course depends on the level of education.
References

An Analysis of the Debate: Has the Study of Technology a Vocational or Academic Purpose?

Dr. Ann Marie Hill, Professor and Coordinator, Technological Education, Queen’s University, Kingston, Ontario.
Email: hilla@educ.queensu.ca

Abstract

This paper titled, An Analysis of the Debate: Has the Study of Technology a Vocational or Academic Purpose? is directed towards the conference theme, The Place of Design and Technology in the Curriculum, under the category, Vocational Craft Skills or Academic Thinking? What is Design and Technology? The paper examines the apparent divide in interpretation and philosophical understanding of the role of the study of technology in school curriculum. Is it vocational craft skills or academic thinking? The paper, in part, addresses the affect of this divide on the views of non-technology educators and educational administrators about the study of technology. A brief historical perspective is used to shed light on this question, as does an examination of what is accomplished in and by the study of technology in schools from the standpoint of research. This elaboration is used to return to the question, “What is Design and Technology?” and to examine design within the framework of design and technology. The term technology education is used throughout the paper rather than design and technology because the former is perhaps more commonly used internationally.

A Few Reflections on History and Technology

To begin, a quotation from Wiener (1993, p. 4) is well worth inclusion in its entirety as it clarifies the debate regarding technology itself from an historical perspective:

“I have been much impressed by the history of invention and discovery as a battlefield of a most intense conflict between two notions of history. In one of these notions, which has been the favorite point of departure of most historians down till the end of the last century, history is largely a theater in which kings and statesman and generals and great names play the leading parts. On the other hand, from Marx and Engels on, we have been taught to regard history as essentially an interplay of economic and great social forces, in which the individual means little more than a somewhat accidental embodiment of these forces. The actors are secondary to the Greek chorus.”

Let us for a moment examine this change in development of technological invention from an historical point of view. Up until the end of the 19th century, Wiener (1993) describes the history of invention as theatre with individuals playing leading roles or parts. The focus is on the individual, typically working alone. In the world of technology and invention, this means that one craftsman builds the entire artefact, from beginning to end. This represents a craft perspective. Wiener then moves into more modern history, from Marx and Engel on. He describes the history of invention from this point on as interplay of economic and social forces. The individual is secondary to these forces. In the world of technology and invention, this means that there is a collective of individuals working together, each contributing their bit to the whole. It also represents the notion of assembly and the line worker, and an industrial perspective. He sees the former as Western ideology and the latter as Soviet ideology. He posits that Soviet ideology has spread to the West today in both practice and theory, and that many Westerners have not considered that they share ideology with Marx and Engel. He states that the “trend towards large-scale investigations involving divided and even community responsibility turns out to be the same in the two countries [Russia and the UK].” (p. 5) Wiener’s discussion of this progression of change unfolds using his four stages of invention

Pacey (1992), writing about idealistic trends in western technology from the Middle Ages to the present, states that “[o]ne problem with the history of technology is that there is no single theoretical perspective or ‘paradigm’ in this field, and no integrated view of the whole.” (p. viii) He describes various roles of
technology in history, and its varied interpretations and misinterpretations in its relationships to science, mathematics, and the arts, particularly in the Renaissance period when science and technology moved closer together. Historical examples are provided to exemplify “blind spots” (p. 94) in the science and technology relationship, conventionally interpreted as science first technology second, and examples are used to correct this conventional interpretation. Additional examples from the 16th and 17th centuries are used to present Pacey’s suggestion that in this time period, there were three distinct movements that represented attitudes towards technology: first, a mathematical and engineering interest; second, enterprise and industrial interests; and third, an artisan, craftworker, miner, and peasant interest, “who claimed direct access to knowledge through practical experience.” (p. 129) He discusses numerous influences on technological change, progress, and interpretation from the Middle Ages to present day, particularly (1) social ideals (notably, favoured religions at different periods and their influence on movements, attitudes, and interpretations of technology), (2) the state, (3) the industrial revolution, (4) conflicting ideals in engineering in America and Britain, (5) the institutionalising of technical ideas, and (6) the idealist trends in more modern technological thinking. So here again we find historical reporting about technology represented as a non-linear path, and the mosaic of the debate about whether technology is vocational craft skills or academic thinking.

Copp and Zanella (1993) discuss the relationship between science, engineering, and technology in an historical analysis of discovery and innovation over the past two centuries. Their writing expands that of Pacey’s (1992) with regard to this more recent time period. Copp and Zanella posit a distinction between modern science and the profession of engineering. They state that “[m]odern science gradually separated from its ancestral field of natural philosophy but retained the understanding of nature as its overriding goal. Scientists seek general patterns in nature that can be summarized in models and theories.” (p. 5) and that “[t]he profession of engineering, on the other hand traces its major roots back to craftsmanship and works toward increasing our control over nature for human benefit.” (p. 5) They indicate that modern technology developed from an engineering model, but that in a larger historical perspective, technology used other approaches. For example, the trial-and-error approach to technology used prior to the Industrial Revolution in the development of items that the textile, metal, pottery, and medical sectors used. They document that “[t]he technology of the First Industrial revolution developed from the practical experiences of the craftsmen than from sound theoretical foundations.” (p. 6) and that “[t]he trial-and-error method of developing technology gradually gave way to more systematic approaches such that a Second Industrial Revolution was under way by the last quarter of the nineteenth century. Practitioners in the emerging profession of engineering began paying careful attention to the methods and knowledge being by scientists at an increasingly rapid rate.”(p. 7)

Interestingly, Ferguson (1993) discusses the value of nonvisual nonverbal knowledge, and its lack of respect as the profession of engineering emerged and the Industrial Revolution took hold. He states that the visual work of the engineer could not be realised without the “sensual knowledge” used by skilled workers in the shop and field. “Their work involves the laying on of knowing hands.” (p. 58) He gives credit to the value of these craftworkers by acknowledging their contribution to technological advances that put Britain in the forefront during the Industrial Revolution, but that went mostly unrecognised by historians because the contributions were made by skilled craftworkers.

“The tacit knowledge and the skills of workers may not have been the determining factors in Britain’s leading role in the Industrial Revolution, but they were essential components of it. Today, similarly, the knowledge and skills of workers – sensual nonverbal knowledge and subtle acts of judgment – are crucial to successful industrial production. Yet the engineering profession makes little effort to give credit to skilled and knowledgeable workers and to learn from them.

Few design engineers are expert machinists or welders or millwrights or riggers, but young engineers can learn important lessons about latent possibilities and limits of craft knowledge and skills if they will but watch experienced workers in their expert, unselfconscious performances. And ask them questions. A designer who spends time intelligently observing field and shop work can expect to learn how to improve the construction of a project and to
Is this division prevalent as well in our present dialogue about whether the study of technology is vocational, craft, or academic thinking? Perhaps the debate is political, with the notion that one idea must win over other ideas instead of embracing a notion that technology is mosaic in nature, where pieces form a full picture. Perhaps the debate has to do with cultural status. The few insights of historical perspectives presented here reveal that the role and status of technology have changed over time, and that divisions have existed throughout history. Remnants of each stage overlap with each other and co-exists with the next stage of development leaving as Pacey said, “no single theoretical perspective or ‘paradigm’ in this field, and no integrated view of the whole.” (p. viii) What is clear is that the apparent divide in interpretation and philosophical understanding of the role and status of technology in western society, and the study of technology in school curriculum, is not new. To fully engage in the present day discussion in a productive manner, we must understand the past and use this understanding to articulate the mosaic nature of technology.

Outside Looking In

So what is the impact of the apparent debate on non-technology educators’ and educational administrators’ perceptions of the study of technology? How do they see technology from the outside in? It is clear that technology educators’ engagement in the debate over the nature of technology and technology education is important; it is needed or it would not exist. But why is the debate needed? Debate always exists, and it is healthy and advances knowledge. But this debate seems to take on an either or flavour. Do technology educators feel that their discipline may disappear at the primary and secondary school levels? Do they feel that it is marginalised within the school system and as such want to change its very essence to counter marginalisation? Is pride and understanding of technology’s contribution to knowledge, its ways of knowing, and its intelligence (as Ferguson, 1993, describes it: nonvisual nonverbal knowledge, sensual knowledge, knowledge built on knowing hands, tacit knowledge and skills, and subtle acts of judgment) being lost, or thrown out? The danger with being engaged in debate for the sake of debate, is that it can become nonproductive. It can lose sight of an end goal, the importance of history, and a larger picture.

Using Canada as an example, for the most part, while technology educators conduct debate to try to clarify in their minds the nature of technology and technology education, there is the lack of expression that enables them to explain their discipline to non-technology educators, educational administrators, and the public at large. This leaves non-technology educators a bit confused about what technology and technology education are or could be. How can individuals outside of the technology education profession understand and articulate about the nature of technology education when the professionals in the discipline are not capable of doing this themselves? A dangerous gap exists here that can be filled by individuals other than technology education professionals. Typically, non-technology educators and educational administrators fall back on old paradigms that continue to be used by school guidance counselors for explanation, paradigms that slots the study of technology solely for students who are at risk or who are not university bound. They and Ministry of Education officials become impatient and uneasy with a profession riddled with debate, and the danger here is that it can be seen as a field or subject area unpleasant to attend to. Not only can the debate destabilize attitudes towards technology and technology education, a lack of articulation about the nature of the field by its own practicing professionals can open the doors for the public at large to define the discipline. Examples of this are the Media’s portrayal of technology as computers, which is readily accepted by the public at large, and the paradigm used by school guidance counselors.

Using History and Research to Help Bring Definition to Technology Education

In the very least, history can give technology educators comfort in knowing that the role and status of technology have changed over time, and that divisions and debate have existed throughout history. However, as proposed earlier, we can also look at history and learn from it, use it to help explicate to others technology’s purpose and value, and its mosaic nature. Understanding that technology is not one field, but a discipline with many different fields that have evolved over time, each using different skills, knowledge, materials, tools and equipment, and methods is a starting point. At the same time, the identification of commonalities helps to establish a common framework that ties the different technologies together, all the
while allowing for existing differences. For example, commonalities can be that technology begins with a human need, uses a technological method for problem posing and problem solving, and that problem posing and problem solving manifest themselves in different ways, “including experimentation, design, invention, and troubleshooting” (Lewis, Petrina, & Hill, 1998, p. 22) depending on the technology at hand. These are only two possible commonalities, of which both are historically documented. Science has a structure that is more or less internationally accepted, with general science used to introduce commonalities and the practice and theory of the individual fields within the discipline, for example, biology, chemistry, physics. Not to simplify the matter, of course debate exists in science over such things as inquiry methods, philosophical issues, and proven theories, to name a few, but the discipline has nevertheless managed to find a way to define itself, and the public at large does have a general understanding of the word “science”. I am not convinced that the same can be said of technology.

In addition to history, recent research can also assist in giving purpose and value to the study of technology in schools and to the nature of technology education. Hill and Smith (1998), in what they have come to call The Theory of Authentic Learning, document how technology education classrooms provide opportunities for student learning that resemble everyday life. The theory celebrates the study of technology by documenting how technology classrooms, traditionally grounded in a hands-on approach to problem solving (a commonality), address many paths that students follow in their meaning making. In another paper in these proceedings (Many Paths to Meaning: Research Support for the Study of Technology), Hill and Smith (2003) bring definition to the study of technology “by expanding the dialogue beyond dropouts or non-university student paths.” (p. 6). Their present research documents paths to meaning in authentic learning environments. Their preliminary analysis can be used to expand the debate about the study of technology beyond the present divisive dialogue of whether it is vocational, craft, or academic thinking. It shifts the discussion into a more encompassing view where the nature of technology is dependent on student purpose for taking the technology course or program, and how the student uses these studies in her or his career pursuits. Key then, is that courses or programs use curricular planning and instructional strategies that allow for different student purposes and pathways, be it work or academic related, in their development as young adults. This point is further discussed in concluding remarks. The next two sections return to the discussion related to what is technology and what is design within a technology framework.

What is Technology?
Technology is a form of knowledge steeped in the tradition of problem-based contextualised learning. In earlier times, technical problems primarily were practical in nature and were investigated by craftspeople and artisans whose unique knowledge base was acquired through exploration and experimentation. This process led to an enormous body of knowledge in a variety of technical areas; for example the 13th century cathedral builders or masons knew exactly where to place buttresses and the required height of their counter pressures. Their investigations were guided by technical knowledge about the shape of a building and knowledge aided by geometrical rules (Pacey, 1992). Technological innovation builds on existing technology and further experimentation, as in the cases of prestressed concrete, the battery, and electrical power plants. Technology differs from science in that while there is an array of knowledge and abstract concepts, independent of science, that serve as a framework within which technical problems can be analysed, this endeavour is framed within practical work. As Pacey states, “Technology is more than just applied science because it depends on awareness gained during practical work, not only abstract knowledge” (1992, p. 128). This is an important point to make because in some countries (in Ontario, Canada, the study of technology in primary schools is now housed within a policy document titled, The Ontario Curriculum, Grades 1-8. Science and Technology (Ontario Ministry of Education, 1998) the distinction is becoming blurred and public perception is that technology is either science, applied science, or computers.

Technology is a form of knowledge in its own right, but there is a close relationship between technology and science. It is helpful to examine this relationship to understand each as a separate discipline. This relationship can be examined from different perspectives. (1) Both need to concern themselves with their impact on humans and the environment, and the balance between these issues and political and economical concerns. Pacey (1992) links technology with artefacts and thinking but warns about doing so without a sense of critique. Petroski (1992) and Papanek (1991) link technology and culture to a sense of critique. (2) Basic scientific research can be a stimulus to technological innovation. However, existing scientific
knowledge alone does not always provide solutions. The Wright brothers’ technical problem of the flying machine is one such case where basic scientific theories had existed for more than one century (Newton, Euler, Bernoulli), but were inadequate to design the details of the flying machine (Pacey, 1992). The solutions were found through technological exploration and experimentation, and importantly, careful documentation of the investigation. Naughton (1993, p. 7) gives a modern example of this in car design where he posits that scientific knowledge such as, “the theory of mechanics and fluids helps engineers to design combustion chambers in which fuel is burned”; and “suspension elements such as shock absorbers”, but other features such as the feel and look of the car, “have to look at other sources of knowledge such as experience, design and craft knowledge and to their own feeling of configurations”. (3) Technological innovation can proceed and influence scientific research, as in the steam engine, thermodynamics, and the water pump. “In the seventeenth century, experience with water pumps stimulated ‘scientific’ work on the vacuum and on barometers….The practical arts could also influence ‘scientific method’. The experimental approach in science owed a great deal to people’s growing experience of machines and industrial processes” (Pacey, 1992, p. 94). Both scientific and technological advancements have benefited from collaboration and the sharing of knowledge, but the forms of knowledge have originated from different philosophies, histories, and methods.

What is Design within Technology?

The purpose of this section is to very briefly highlight a position taken earlier in this paper, that the study of technology uses a technological method for problem posing and problem solving, and that problem posing and problem solving manifest themselves in different ways, “including experimentation, design, invention, and troubleshooting” (Lewis, Petrina, & Hill, 1998, p. 22) depending on the technology at hand. With this interpretation, design is one of many ways to approach the study of technology.

An analysis of a design approach to the study of technology shows variance even within this one approach. Hill and Anning (2001a, 2001b) document that design in four different design workplaces (apparel designer in Quebec, graphic designer in Ontario, mechanical engineer in England, and architect in England) all used different design processes. In addition, designers in these four design areas each described different skills and knowledge needed in their design field and each described different ways in which they learned their skills and knowledge. In this same studies, Hill and Anning also examined designerly thinking and behaviours of four different age groups of students and their teachers. Not surprisingly, students within and across age groups approached design differently. The research brought into question the utility of a generic design model in primary schools without translation into a context of age and task. This example of design within a technology framework reinforces the interpretation that technology is mosaic in nature, even within a single technology field.

Concluding Remarks

All of this may leave the head spinning for technology educators determined for one interpretation of technology education to come out as ‘king of the hill’. However, in a larger picture, technology is many different things. History documents this, and the world outside of school shows us this. The divide examined in our discussion for this conference theme (The Place of Design and Technology in the Curriculum) and category (Vocational Craft Skills or Academic Thinking? What is Design and Technology?) is essentially bureaucratic in nature; bureaucratic in order to manage entry and exit qualifications, curriculum policy, curriculum structure, and instructional strategy. Unfortunately, language used to discuss this divide perpetuates a class system, and not surprisingly, status within it.

To put aside a divide couched in language of either/or, and recognition that technology education is more than just one or the other, would work to the benefit and advancement of technology education. Furthermore, this divide exists when the focus is bureaucratic, catering more to school’s role in social engineering, and occurs when there is a void with regard to a focus on students, one of the key stakeholders of the school system.

I am suggesting that the focus in the discussion of the nature of technology education and its place in the curriculum be on the student, and on how technology education enriches the lives and education of students, and the school system itself (Hill & Smith, 1998; current issue). Education’s responsibility is to address the needs of all school age students. If the study of technology offers an array of possibilities and
students learn with both head and hand as part of the full understanding of any one technology, then the question, Is it vocational (typically associated with hand) or academic (typically associated with head)? becomes a mute point. What the student chooses to do with their study of technology becomes the actual deciding factor as to whether their study of technology is vocational, craft, or academic.

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What contribution to the value of design & technology can be made by science?

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

Abstract

The paper summarises briefly the findings of the Interaction Report into the relationship between science and design & technology in secondary schools. It then describes five different attempts to relate science and design & technology in secondary schools. The initial work attempted by Loughborough University is described. Then the work being carried out at two schools in which science and design & technology teachers are working with teacher trainers from Sheffield Hallam University in a collaboration to explore the contribution that can be made to each other’s subject is described. In one school the work centres on the design and manufacture of climbing equipment. In the other school the aim is to develop a common conceptual framework for staff and pupils through exploring common issues such as units of measurement and terminology. Key interests include interaction of staff and tools of communication. Then the work being carried out as part of technology college curriculum innovation and assigned a best practice research scholarship is described. Finally the aims of an industry led initiative to enhance the interaction between science and design & technology is described. The discussion considers the barriers to developing interaction between science and design & technology and identifies some of the features necessary for success.

Key words
cross curricular, design & technology, interaction, science

The Findings and Recommendations of the Interaction Report

The Interaction Report (Barlex and Pitt 2000) clarified the difference between the nature of science and technology. In the Report science is seen as being concerned with exploring the physical and biological worlds and providing explanation of their behaviour. It is concerned with understanding what is. Technology is seen as being concerned with changing the made world in order to provide improvement. It is concerned with what might be. The relationship between science and design & technology in the secondary school curriculum in England was revealed as being almost non-existent as opposed to the relationship between science and technology in world outside school where there were a variety of mutual interactions. In developing a relationship between science and design & technology the Report supported co-operation and collaboration but considered integration completely inappropriate given the quite different purposes of science and technology. The Interaction Report can be obtained as a PDF from the Engineering Council UK website at http://www.engc.org/

The Work of Loughborough University

A meeting was held at Loughborough University at the invitation of the PGCE tutor for science in the summer term of 2001 with representatives from science and design & technology departments from two large secondary schools. Using the recommendations of the Interaction Report for guidance the meeting identified the four areas of co-operation and collaboration.

1. Develop procedural competence in science and design & technology by concentrating on evaluation using design & technology expertise in peer group reviewing and developing a common approach. This would involve the following:
   • science investigations carried out by pupils (linked to possibility of using an investigation chooser chart),
   • science investigations carried out by others,
   • designing and making procedures of pupils,
2. Using exploration of contemporary technology (smart materials, innovative products) to lift science, modernise design & technology and provide literacy development.

This would involve an overlapping/complimentary approach to these explorations so that different focus of explorations is apparent to pupils with the exploration of single-use cameras and electric kettles being seen as good starting points.

3. Science for design decisions
This would involve the following:
- Mechanics needed for designing and making a weighing machine
- Understanding energy for designing and making a moving toy e.g. a boat
- Understanding food (nutrition and composition) for designing and making a food product

4. Mental Modelling

This would involve looking in depth at teacher explanations of common areas e.g. metals, plastics, and electric circuits, through teachers observing each other’s explanatory lessons.

Overlaid on this was the possibility of Science/D&T PGCE students working with teachers to develop the materials required for this new curriculum.

But for all these ‘good’ intentions nothing happened despite follow up phone calls, emails and letters. The reasons given were two fold – lack of time and lack of an immediate and obvious benefit in terms of current and pressing requirements, maintaining and improving KS3 assessment and GCSE examination grades.

The Work of Sheffield Hallam University
Staff from the Design & Technology Department in the School of Cultural Studies at Sheffield Hallam University have worked closely with two large secondary schools supporting the discussions between staff from the science and design & technology departments.

The first school decided to concentrate on a Year 8 group of Gifted & Talented pupils and to augment the current scheme of work in Year 8 design & technology in mechanisms by focusing on cams. This would be achieved by studying the use of cams in relation to “friends” used in rock climbing. The work would be based around visits to a climbing centre and use of the devices plus visits to Sheffield Hallam University materials science laboratory s to look at strength of materials. The work would take place in out of hours learning sessions for science and design & technology. The visits to the climbing centre and the materials science laboratory took place along with visits to the factory to see the design and take part in the production of the “friends”. The outcome of the activity is to be a presentation by the pupils to parents and governors of the school.

The second school decided to develop a common conceptual framework for staff and pupils through exploring common issues such as units of measurement and terminology. The heads of faculty identified two different starting points for the project: one group with and one group without a planning framework. The key interests were the interaction of staff and tools of communication that might facilitate this and the effect of the presence of absence of a given planning framework. There have been two meetings at which staff from the science faculty and the design & technology faculty have discussed common terms and the approaches they take to teaching various topics and what the potential cross over is. Currently the discussions, with and without a planning framework, have stalled.

The Work of a Technology College in Nottingham
The bid to achieve technology college status indicated quite explicitly that teachers of design & technology and teachers of science would become familiar with each other’s curriculum and use links between the two
curricula for mutual benefit. During the initial phase of this development there has been observation of
design & technology lessons by science teachers and observations of science lessons by design &
technology teachers. A key finding to emerge from this is the greater time available for design &
technology to engage pupils in the procedures of the discipline. The long designing and making
assignments employed in design & technology allow pupils to engage in reflective activity in both the short
and long term. In the short term as in “What have I just done? How did it go? In the light of this what
should I do next?” and in the long term “How did my designing and making assignment go? Where was I
successful? “Where do I need to improve?” As a designing and making assignment can last for half a term,
or even longer, there are many opportunities for developing procedural competence. In science lessons the
bulk of the teaching is required to transmit content and the opportunity for investigations relatively small,
especially as investigations rarely, if ever, last more than a single lesson. Science teachers saw
investigations that did take place in design & technology as unscientific because they did not focus on
isolating and controlling variables. They were along the lines of let’s try this and see what happens. It was
in the discussion of a designing and making assignment that could be informed by investigations that a
significant feature of the science – design & technology interaction emerged. The science and design &
technology teachers had decided to run a collaborative Year 7 project. The science teachers had identified
the topic and useful investigations that could be carried out and prepared some stimulus materials. The
design task was to design and make a boat. The investigations were to find out the maximum weight the
boat could carry and how fast it could go. The stimulus sheet consisted of a set of photographs of different
boats and ships – a coracle, an ocean liner, a yacht etc. The science teacher presenting the activity was very
positive but I detected some reservations in the design & technology teacher who was listening. I decided
to intervene and asked if the task was really to design and make a toy boat as opposed to a real boat. The
science teacher said that of course it was. I then asked if the task should be to make a toy boat that was fun
to play with? The science teacher wasn’t so sure but in the end agreed that it might be. If that was the case,
I asked, should the stimulus be pictures of toy boats or even actual toy boats to handle. Well yes, the
science teacher thought that would seem appropriate. In which case I asked where does that leave the
investigations? It might not be important for the toy boat to carry lots of weight. And if it was to be played
with in the bath it might be much more fun to play with if it went slowly, after all most baths aren’t very
long. This was a bit of a puzzler for the science teacher. The carefully formulated investigations that met
science investigation criteria weren’t appropriate any more. Pupils would need to develop their own
investigations to explore features of the toy boats that they thought would contribute to play value. The
design & technology teacher was by this time looking much happier and beginning to see that the designing
and making assignment need not be ruled by the science agenda in which design & technology is being
used to make science investigations more palatable.

The work of the BAE Systems Engineering Initiative
This initiative is in the planning stage but promises to provide a platform where links between science,
design & technology (and mathematics) are a highly valued part of the curriculum. It involves a three way
partnership between BAE Systems who conceived the idea and will provide the necessary expertise
through their engineers, academic staff at Loughborough University responsible for teaching systems
engineering and a group of specialist schools (Engineering Colleges) who are committed to a ‘fusion’ of
science, design & technology and mathematics to develop a GCSE specification, teaching and learning
resources plus on going support for a design & technology course that is concerned with engineering
outcomes and adopts a systems approach to design. The programme promises a dedicated website to
facilitate cross-curricular working by staff from different locations.

The proposal states:

“Courses in Systems Engineering will draw staff from across the timetable. Aspects of the course will be
taught by scientists, D&T and maths teachers and could include English or ICT teachers when particular
focus on the importance of clear communication is required. As described above, these teachers do not
have to reside in school and be drawn from their other duties. They will be available from our website. The
BAE SYSTEMS Education website will be the point of access for much of this material. Access will be
granted through a school log-in. e-Learning approaches will include peer to peer learning groups, peer to
coach learning, video conferencing including software sharing, virtual reality and key note lessons which
can be accessed as and when the school’s timetable demands.”
BAE Systems are quite open about their motives in developing such a programme.

The proposal states:

“The young people of the BAE SYSTEMS Specialist Colleges will have an awareness of the importance and value of engineering. They will all be able to make an informed career choice. They will be well prepared to join BAE SYSTEMS endorsed programmes whether Modern Apprenticeships, Technician Programmes or university courses. Destination tracking will illustrate an increased take-up in systems engineering and engineering courses and training than the take-up from non-Engineering College schools.”

Discussion
The experience of Loughborough University in attempting to develop science – design & technology interaction at two local secondary schools failed due to lack of time and lack of an immediate and obvious benefit in terms of current and pressing requirements, maintaining and improving KS3 assessment and GCSE examination grades despite a promising initial meeting and a potentially useful development programme. Neither of the schools had any policy which could be utilised to justify interaction between science and design & technology. The experience of Sheffield Hallam University began promisingly with two schools but one school lost momentum and the interaction stalled. The other school’s success was to a large extent dependent on the enthusiasm of the science teacher for rock climbing; he is a self confessed addict, and his desire to share this with pupils. The science – design & technology interaction gave him the opportunity to do this and his colleague in design & technology could see the advantages of utilising this enthusiasm in working with a small group of gifted and talented pupils. The school is committed to enhancing the education of the gifted and talented so in this case the combination of personal enthusiasm, opportunism and school policy enable a limited interaction to take place. The Technology College in Nottingham has the interaction between science and design & technology as a significant part of school policy. A senior member of staff champions this activity through his own personal interest and enthusiasm to the extent that he has obtained a Best Practice Research Scholarship (see [http://www.teachernet.gov.uk](http://www.teachernet.gov.uk) for details) based on science – design & technology interaction at the school. This combination of policy plus championing is powerful but not without its pitfalls. Collaboration through the boat design task could easily have been uneven with the science investigation agenda skewing the designing and making task to the extent that the design & technology was marginalized in order to present science investigations in a more appealing context. Any collaboration that is not of genuine mutual benefit is likely to be counterproductive. The ambitious programme proposed by BAE Systems is policy driven at the highest level with the senior management of the participating schools committed to providing quality time for science and design & technology teachers to develop an appropriate and innovative curriculum which utilises science – design & technology – mathematics interactions. There is clearly every opportunity for champions to emerge across each of the contributing departments and at different levels within the hierarchy of each department. And there is the possibility of much kudos for those who are seen to be successful in the endeavour.

Experience so far indicates that the following features need to be in place before interaction between science and design & technology is valued and successful.

- School policy should mention science – design & technology interaction specifically
- The senior management team should champion the interaction by providing mechanisms and resources by which heads of department and teachers from the participating departments can take ownership and enact the school policy
- There should be opportunities for those who are successful in developing interaction between the subjects to receive praise and recognition

Individual staff’s personal enthusiasms can make a significant contribution to the interactions and are clearly valuable but these alone are unlikely to result in sustainable co-operation and collaboration between the two subjects.
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“The Noise around us” - a Problem Based Learning and Collaboration between Science & Technology

Dov Kipperman, The Moshinsky R & D Center, Ort, Israel
Email: dkipperm@ort.org.il

Abstract

This paper describes a curriculum development project in which science lessons are located within a design and technology project in order to enhance learning in both subjects. The approach is illustrated through a framework for collaboration between Science and Technology in class. The framework will be described as a graphical model which emphasize the relation between Society-Technology-Science in order to deal with issues such “The Noise around us”. The paper present examples for implementation of such a framework through an instructional unit that include: a textbook and a web site.

Keywords: Science, Technology, Design, Problem based learning, Collaboration, Critical thinking.

Introduction and rationale

The major education reform effort of the past decade in technology education has addressed the importance of design and problem solving. In the real world, technological problem solving is situated within, and mediated by our culture. That is, technological development influences our culture and our culture influences technological development. For this reason the study of technology should be integrated with most disciplines and school subject areas . (Sanders, 2000).


Sanders (2000) found that technology teachers in United States ranked the integration of technology education with math and science as the fourth among sixteen purposes identified for technology education.

Barlex & Pitt ("Interaction", 2000) describes three possible relationships between science and technology: Co-ordination, Collaboration and Integration. Their report strongly support co-ordination and collaboration between the subjects but rejects integration.

collaboration means teachers in each subject plan their curricula so that some but not all activities within each subject are designed to establish effective relationship.

The report also identified four areas of mutual benefit: metacognition, mental modeling, science knowledge for design decisions, and technology context for learning science.

The Israeli Curriculum Approach

The Israeli curriculum represent a unified approach to teaching science and technology at the middle school level (grade 7-9).

The curricula’s for elementary, middle and high schools is based on relationships (co-ordination/collaboration/integration) between science and technology with regard to social aspects.

“The new unified curriculum (Science and Technology) reflects the connection and mutual impacts between science and technology in the modern society. Collaboration between science and technology is essential
because of the growing linkage between scientific subjects and relevant technologies and also because of the unclear borders between them."


The seven main subjects of the science and technology curriculum for middle schools are: materials, energy, technology systems and products, information & communication, earth and universe, creatures and life, ecology systems.

**Curriculum design**

Our approach of relationship between science and technology is based on collaboration between science and technology teachers focusing on problem solving as a format for learning.

Based on Simulating technology to foster learning Krumholtz (1998), a Didactical Model – STSS for collaboration was established.

**STSS** - (Society-Technology- Science- Society)

Human needs on one side and the impacts of technology society on the other side are factors that serve as “engines” or “driving forces” for development of science and technology for humankind.

The STSS Model focuses on:

- Problem solving.
- The use of social, scientific and technological knowledge for problem solving and decision making.
- Science & Technology are two different disciplines that interact.
- There is a gap between the needs of the society and reality, this gap between play the roll of a “driving force” for the development of science and technology.

This model serves as a curriculum organizer and a conceptual framework for dealing with societal and environmental impacts, such as the unit: “The noise around us”. 
The unit structure
The students are given the challenge - to design and build a solution for a specific noise problem that is relevant to them. They are guided through instructional activities with regard to:

- Social aspects: how we define noise (attitudes), the impacts of noise on our life.
- Scientific aspects: what is voice, how we define noise, how do we hear.
- Technology aspects: solutions in different areas (home, industry, transportation,).

**Instructional activities**
In order to engage students and start them thinking about the noise problem, they are faced with real noise problems taken from the newspapers and had to measure the level of voices in specific areas in school and outside school. Those activities encouraged them to raise and define their own problems with regard to noise.

The following table shows the suggested order of activities. (Next Page)
Defining the collaboration (lessons plan)
The following table is an example for collaboration between two teachers – organizing lessons plan for teaching the unit.

Social aspects:
- Attitude survey
- Impacts
- Legislation
### Timeline

<table>
<thead>
<tr>
<th>First week</th>
<th>Technology Teacher</th>
<th>Science Teacher</th>
<th>Types of activities</th>
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<td></td>
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<td>Introducing the situation</td>
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<td>Identifying the problem</td>
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<td>x Gathering information</td>
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<td>Second week</td>
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<td>x Gathering information</td>
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<td></td>
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<td></td>
<td>x Scientific inquiry + concepts</td>
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<td>x Technology inquiry + concepts</td>
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<td></td>
<td>x Scientific inquiry + concepts</td>
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<tr>
<td>Third week</td>
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<td>Brainstorming and decision making (solutions)</td>
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<td></td>
<td>x Further investigation according to the specific area</td>
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<tr>
<td>Fourth week</td>
<td>x</td>
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<td>Make and evaluate the solution</td>
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<td>Presentations of projects</td>
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**Notes:**
- Activities are provided to each lesson in the unit.
- A website was developed to support learning.
- [Http://www.ort.org.il/sound](http://www.ort.org.il/sound) (Hebrew version)
- The learning is problem-solving centered---each group identify their area of interest with regard to the noise issue.
- This unit is recommended to grade 9, after learning basic design in grade 7 & technology systems in grade 8.
- The unit “the noise around us” was published few months ago and at the moment we are at the process of in-service training technology and science teachers.

**Conclusions**
Ron Ritchie (1995) highlighted three critical features of learning situations that are significant for nurturing technological capability: 1) learning through practical experience; 2) an active learning process that allows children to construct their understanding of the world, and 3) learning within a social context. There is a considerable advantage to linking subjects such as science and technology in the way described in this paper for implementing those features. However, collaboration between teachers from both subjects is needed.

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Technology education and industry links: A Liberal Educators perspective.

Gary O’Sullivan, Department of Technology, Science and Mathematics Education (TSaME), Massey University, New Zealand
E-mail: g.c.osullivan@massey.ac.nz

Abstract

From 1999 technology education became a compulsory part of schooling in New Zealand. Universities, Colleges of Education, and Schools have tried to come to grips with this new curriculum area as a part of their program delivery.

This paper is about one particular aspect of the new curriculum school-industry links. The promotion of these links are often based on personal beliefs and values, they are rarely grounded in educational research or rationale.

The paper explores these key factors

· Theoretical assumptions of school industry links.
· Reconstruction of the school curriculum.
· Technology education and the real world the connection.

Key Words: School-industry links, flexible specialisation, the connected curriculum.

Introduction:

The New Zealand Ministry of Education gazetted (made compulsory in state schools) Technology in the New Zealand Curriculum (MOE, 1995) in February 1999. The aim of technology education in New Zealand is to develop students’ technological literacy. The curriculum statement identifies the characteristics of learning in technology education and highlights how to develop an ‘inclusive technology curriculum’.

The link between schools and the community, including business and industry, tertiary institutions, and local authorities, is important to a well-developed, inclusive technology curriculum. (Technology in the New Zealand Curriculum, 1995, p. 17).

How this is to be achieved or the desired learning outcomes from these links receive little attention.

Background.

In New Zealand, along with other western English speaking countries, there has been a shift in education policy; this shift is away from a liberal-humanist education towards a more vocationally focused curriculum. The change has come about partly as a response to economic targets and objectives set by national policy makers (Price, 1991). An example of this shift can be seen in the growing emphasis on making education more responsive to the needs of industry and business. This policy has led to the development of a variety of school-industry partnerships or links. Although not a new idea, these links have found prominence and a home in technology education. Little research has been carried out in New Zealand to ascertain what actually goes on in a link and the motives that might be behind their push within the technology curriculum (O’Sullivan, 2001).

In 1996, the Education Review Office of New Zealand (ERO) published a report entitled School-Business Links. The executive summary at the beginning of the report highlighted the need for more research.
Many New Zealand secondary schools have relationships of some kind with local businesses. There is little information available, however, about how extensive these relationships are, why they are established and whether they contribute positively to the learning outcomes of students. (ERO, 1996).

**School-industry links: theoretical assumptions.**
Saunders (2000) argues that there are four ‘significant underlying or tacit theoretical assumptions’ used to debate education and work links, they are:

1. Functionalist.
2. Marxist.
3. Liberal.

The first two can be described as ‘structural’ frameworks. They are modernist theories that look at operations from a macro or big picture perspective, invoking notions of the whole society. They imply strong causal frameworks and according to Saunders tend to be reductive, looking for explanations from meta-theories.

The liberal and progressive/emancipatory perspectives look at the relationship between work and school from an education standpoint. Their focus is not on the direct link between education and work, i.e. one leading to the other but more about educational practices and their relationships with work.

Understandings of these four perspectives are rarely debated, however, they form the focus of this paper.

**1. Functionalist perspectives.**
The functionalist perspective views society as a whole, almost like a living organism. In this perspective, each aspect of society has responsibilities for the next and all are mutually dependent. For schools there is an increasing pressure to respond to the needs of society particularly economic concerns.

*Put crudely, if labour market requirements are not being met, we should be looking for policy which brings them in to line. Critically, this view presupposes that requirements can be ‘known’, that they are of a ‘technical’ nature and the ‘norm is that they can be met through the choice of appropriate policies. (Saunders, 2000, p. 686).*

Saunders elaborates to say that in this perspective it is seen as logical that education should ‘co-ordinate with the requirements of work because that is how societies function’. Watts (1983) identifies this notion as ‘human capital’ these bonds or ‘functions’ are the ways in which education can service employer’s needs.

**Human Capital: a restrictive view of how education can service employer’s needs.**

![Diagram of education and employer relationship]

**SELECTION FUNCTION:**
The process of selection matches closely the employment strategies of the industrial era. It relies heavily on industrial practices of division of labour. Educationally it includes systems that regularly test students and
separate them by the results. This separation normally includes splitting into academic and vocational type
courses with those that fail being filtered off into lower level employment. This leads to misunderstandings
from every party, student, employers and society in general. Historical accounts of technology education,
both internationally and in New Zealand, clearly reflect this use of a selection policy (O’Sullivan, 2001).

SOCIALISATION FUNCTION:
The second function identified by Watts is the socialisation process. This is embedded in the pupils’
experience of schools. These experiences can involve explicit or implicit procedures, whereby the pupils
begin to associate themselves with a particular type of work. This is often done by reinforcing stereotypes
i.e. the place of women, class and racial associations with particular employment or courses. Historical
forms of technology education are often associated with this function i.e. craft for boys and food for girls.
In terms of school-industry links, care must be taken to ensure that socialisation does not occur.

ORIENTATION FUNCTION:
The third function of orientation moves from the slightly more subtle socialisation process to deliberate
curricular intervention or steering. Most notably this can be seen through career guidance, work experience
or placement programmes. Additionally one could quite easily associate school-industry links with this
function if they are carried out without a critical or questioning premise. Typically, the words ‘enterprise’
or ‘entrepreneurial’ are used in such orientation practices.

PREPARATION FUNCTION:
The fourth of Watts’s functions is that of preparation. This refers to the role of schools in preparing pupils
with specific skills and knowledge required in the workforce. According to Watts at the general level, this
may mean numeracy and literacy. However, Saunders (2000) argues that it is this preparation aspect, which
underpins ‘new vocationalism’ and the introduction of education as training. It is also evident in many of
the rationales for technology education highlighted throughout the world.

This functionalist view would see people as ‘human capital’ and society would be making an investment in
people a term used in both New Zealand and English education policy directives of the eighties and
nineties. Lee and Hill (1996) state that this was exactly the rationale for the introduction of the New
Zealand curriculum. Proponents of this perspective argue that investment in technology education will no
doubt bring returns in the technological fields of both higher education and employment. According to
Saunders, this human capital theory has proved to be incorrect, citing the English example of higher
numbers of students going on to University but studying in “esoteric courses” rather than science and
technology (Saunders, 2000).

Marxist perspectives.
Marxist perspectives would encourage the study of relationships that exist between people as they go about
their work and how that fits with their family life. According to Saunders, at present we are in a capitalist
mode in which classes of people buy and sell labour, this is not an equal relationship. There are many cases
of labour exploitation, and Saunders argues that these Marxist perspectives are demonstrated in the existing
education system.

Education, according to Saunders, if studied from a Marxist perspective, is there to maintain the status quo,
thus enabling the capitalist mode of production to continue. This is achieved in education following much
the same bonds as described earlier in the functionalist perspective. Functionalist identify socialisation as a
means of creating order, Marxists as a means of maintaining social control. Functionalist identify selection
as distributing recruits into a division of labour, Marxists as a means of sustaining inequalities in the
education system and later life. These are often found in work habits and attitudes and Saunders describes
this as the “hidden curriculum”.

These perspectives are related to industrial practices and are often called Fordism. In England, they are also
linked to the class structure, i.e. the working classes being prepared for work. Identification of cultural
capital, on which the middle classes can draw to try to maintain or improve their position, is the essence of
the vocational and academic divides. Young (1998) refers to a divided system, which has a divided
curriculum and divided qualifications and ultimately has a selective function.
The liberal perspective.  
The liberal perspective, through the delivery of liberal education, has come to signify the opposite view of education from functionalist or instrumentalist. The liberal perspective sees education as important for its own sake not just to fulfil some extrinsic factor such as employment. According to Saunders (2000), this view of education historically was associated with the aristocratic classes, but in the modern era is free from the divisive aspects of class etc.

The liberal perspective would advocate that explicit vocational preparation is best undertaken either at work or just before beginning it. Instead of vocational education, advocates of this perspective believe the best preparation for life is a general education, which is broad, deep and informed by the whole culture not just one aspect of it. This may include interactions with the world of work but not as direct preparation for a particular occupation but as a pedagogical process. Effectiveness within this perspective should not be analysed in a narrow sense related to a particular employment or national economy.

What is important for this perspective is the democratic imperative that no child should be denied access to these forms of knowledge and experience in the mistaken belief that they are not ‘relevant’ either to them or an extrinsic need like that of employers. (Saunders, 2000 p. 692).

The liberal perspective advocates that this ‘general education’ preparation is suitable for future life including work. Saunders describes the main problem for this perspective is finding ways for all pupils to get the opportunity and access. Generally, in education the knowledge is imparted and learned in disembodied chunks and then tested through exam at a latter stage where only those who have the cultural means to accommodate this method succeed. According to Bereiter (2002) liberal education gives learners access to a culture that transcends the particularities of their social and ethnic background. The liberal perspective can support technology education but it would be technology education as general education not vocational.

The progressive emancipatory/perspective.  
This perspective is associated with individual growth and learning styles, which accommodate these. This, according to Saunders, will lead to social goals of civic participation and democratic emancipation. Saunders identifies two sub-themes in this perspective. The first surrounds ‘learner centeredness’ and personal growth, whereas the second is ‘social reconstruction’ through empowerment. It positions education centrally in social and personal reconstruction and is optimistic in nature. This perspective brings these two sub-themes together in the style of learning.

Unlike functionalist and Marxist perspectives, the progressive perspective underplays the social and political context. It also under-emphasises the nature of knowledge and skill that the liberal perspectives see as the starting point. It emphasises the power of the educational process to allow the learner to transform the above to allow the individual to re-orientate him or herself.

A way forward, technology education a connected curriculum.  
Recently there has been a shift internationally in industry away from the Fordist approaches and the division of labour, which has dominated industrial production for at least three quarters of the last century to a ‘flexible specialisation’, characterised as post Fordism. This may bring about changes in educational policy and attitudes towards school industry links.

According to Marshall, a long time ago Dewey was advocating a reconstruction of school methods.

This was not to make the schools an adjunct of industry and commerce and to acquiesce in the ‘untransformed, unrationised and unsocialised phases of our defective industrial regime’, but of utilising the intellectual problem-solving potential inherent in modern technology; ‘to make school life more active, more full of meaning, more connected with out of school experience’. (Marshall, 1997, p 309).
Young (1998) when talking about flexible specialisation and its relevance to education introduced a notion of ‘connective specialisation’. This contrasts with the insularity of the traditional subjects specialists and ultimately with the divided curriculum per se. Divisive specialists see the curriculum from the point of view of their subjects, whereas connective specialists see their subjects from the point of view of the overall curriculum. Young argues for a shift from teacher centeredness to learner centeredness.

According to Young, at the individual level the connective specialisation refers to the need for an understanding of the social, cultural, political and economic implications of any knowledge or skill. It would enable the student to transcend the divisive curriculum and reject the split between ‘educated person’ and ‘competent employee’. In other words, it would do away with the qualification and curriculum’s selective function evident in most western education systems.

The connective curriculum acknowledges that education takes place in a community of practice and that learning is purposive and a social process (Lave and Wengler, 1994 cited in Young 1998). It highlights the need to relate educational activities to developments in the wider society including but not exclusively linked to industry. So connectivity is more than just a curriculum model, it is the purpose of school itself.

Technology education may be a step towards the connective curriculum, as described by Young. It replaces the separatist practices of the past craft subjects. It acknowledges the community of practice; it can be student centred and incorporate the liberal perspective. If technological literacy, is the focus of study in this area and if school-industry links are seen as part of a whole i.e. connecting school with the ‘real world’ and not just as in a functionalist or Marxist perspective of preparation for work, technology education has some promise.

Bereiter 2002, has a list of personal qualities that should be cultivated if the education system is to produce people who can thrive in the twenty first century amongst his list is technological literacy. The technology curriculum in New Zealand has technological literacy as its aim. School industry links are identified part of that inclusive curriculum. What should technology educators see as the potential benefits of such links? Clearly from a liberal educator’s perspective, there must be more than the notion of education as helping to develop human capital for employers.

### Potential benefits of school industry links.

| Increased motivation working in partnership with people outside of the classroom. | Increased motivation for employees able to participate in a social good i.e. education. |
| Purposeful action working with others in the community and an increased awareness of the role industry plays. | Increased awareness for industry of how schools work a chance to develop some connectedness. |
| Improved careers information. | Opportunities for employees to develop communication skills, liaising with a different social grouping. |
| Accurate up to date information about specific enterprises and industries. | Accurate information about school technology education programmes and qualifications. |
| Access to experts in the industry. | Access to experts e.g. language teachers. |
| Access to facilities beyond the scope of the school. | Access to educational facilities beyond the scope of the industry for training etc. |
Possibilities for sponsorship to support the curriculum. | Improved employer / employee relationships allowing staff to have contact with children in their community.
---|---
An increased understanding of the world of work. Including expectations of possible employers. | An increased understanding of the world of education including the expectations of schools.
Increased understanding for teachers of how industries work ultimately improving teaching and learning. | Fulfilment of altruistic desire to help improve the quality of teaching and learning.

**Conclusion.**

Technology education and school industry links have become synonymous with each other. There has been very little research carried out to identify the benefits of such links. However, some educational theorists and those working in this area are questioning the education rationale and policies behind the decision-making (O’Sullivan, 2001). Links of the nature described in the above table may go some way to developing Dewey’s notion of a connected curriculum and partly develop Young’s concept of connectedness. In New Zealand school-industry links with educational goals at their centre rather than economic policy can be developed. Liberal educators with vision have enough freedom within the technology curriculum statement to see such opportunities and pursue them.


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Some new ideas on new ideas: Creative, inventive thinking, values and Design and Technology Education

Dr Howard Middleton, Centre for Technology Education Research, Griffith University
Email: h.middleton@griffith.edu.au

Abstract

The development of Design and Technology curricula has always been premised on the importance of the act of designing and of the value of the contingent activity of creative thinking. Despite this, there has been a great deal of uncertainty about methods for developing creative thinking abilities in design and technology students. However, the results of research from cognitive psychology, engineering and invention suggest some promising strategies for application in design and technology classes. Moreover, these strategies are emerging during a time when issues concerning ethics and values are also being raised. This paper presents a brief summary of the research into creative thinking strategies, and of possible applications, and then goes on to argue that the strategies and settings that promote creative thinking in design and technology make the area not only one that is suitable for addressing ethics and values, but that it may be one of the major reasons for including design and technology programs in school curricula.

Keywords:
creativity, psychology, engineering, invention, design and technology, values, research

Introduction

Design and technology programs have been seen by practitioners to perform various roles in school programs. On the one hand the area has been regarded as requiring low-level intellectual skills and as a suitable vehicle for developing physical skills in manipulating concrete materials. On the other hand, claims have been made that because students regard design and technology learning activities as challenging, and ‘real’, that the activities that take place in these settings involves more profound learning. However, until recently, there was little evidence to support either proposition. In this paper I will draw initially on research into designing to make the point that this is a complex intellectual activity. Then I will draw on material from the literature on mental imagery, engineering and invention to suggest that we now have sufficient research to draw some conclusions about learning in design and technology. Finally, I will draw on recent research on values to suggest an important purpose for design and technology education.

Designing

Designing, or technological problem-solving, has, until comparatively recently, been seen as a largely unproblematic process within the psychological literature (Simon, 1981). The process is often represented in a diagram that generally includes the steps of: identifying a problem, undertaking research, generating solution/s, producing solutions, and evaluating the solutions. The implication contained in the diagram is that each of these steps can be accomplished in the same way that a mathematical problem might be solved if you know the steps. This view has been supported implicitly from cognitive psychology (Greeno & Simon, 1988; Anderson 1993), with information processing theory arguing for a similar process for solving simple or complex problems. Indeed, the same model, illustrated in Figure 1 below, has been used to characterise the nature of all problem types.
In that model, problems are regarded as occurring in a problem space that contains three elements. The first element is what is described as the problem state. This consists of all that is known of the problem at the start of problem-solving. The second element is the goal state. The goal state is intended to represent the solution to the problem. The third element is the search space. The search space is taken to be all of the information the problem-solver has in their memory or can access that will help them solve the problem.

This conceptualisation works for simple problems and problems where it is possible to specify all aspects of the problem space. Indeed, the model assumes that there is a specific and singular starting point and that there is one precise and correct solution. It also assumes that all strategies required to solve the problem will be present in the search space and need only be found by a process of search. However, design problems tend not to have precise starting or finishing points (Schon, 1990; Goel, 1988; Goel & Pirolli, 1992) and they are generally solved by a combination of strategies that come from memory and strategies that have to be created. Over the last few years I have been doing some work developing and examining a modified version of Newell and Simon’s problem space model. The model is illustrated in Figure 2, below.

The modifications were made to account for the particular characteristics of design problems. The modified model does make the point that design problems are complex and ill-defined. As a consequence of this, students in design and technology who engage in designing are also involved in a complex intellectual activity.

Representations of knowledge
One reason for the complexity of design is that the act of designing involves the use of at least three representations of knowledge. The three representations are visual, verbal and tacit. That is, designing involves: producing and using mental images that are in some way isomorphic to objects in reality; producing and using abstract propositions of knowledge that can be likened (broadly) to verbal renditions of knowledge; and using tacit knowledge, which may be derived from either of the two previous representations or from perception of physical action.
Designing involves the devising of solutions to problems where there is the requirement, additional to solving the problem, that the solution be creative. That is, that the solution be original and purposeful (Torrance, 1964). Work by Finke (1989), Finke and Slayton (1988) and Finke Ward and Smith (1995) have provided some important findings that suggest that the use of visual mental images provides a powerful representation for generating creative solutions to design problems. In one large research project Finke and Slayton (1988) demonstrated that with suitable instructions, students could use visual mental images to respond to design-like problems. In doing so, they generating solutions that were judged to be noticeably creative.

**Engineering and invention**

Webber Moder and Solie (1990) examined the way contemporary inventors in engineering produce new solutions to problems. Weber et al found that inventors routinely use visual mental images to both represent possible inventions, and to vary parameters and to test the effects of the variations. Thus Weber et al found that inventors used both static and dynamic visual mental images in the generation and testing of new solutions to engineering problems.

Carlson and Gorman (1992) examined the invention processes of a range of famous inventors such as Bell and Edison. Carlson and Gorman found that in addition to visual mental images, inventors worked from existing objects to create new ones. By working from, Carlson and Gorman meant that they had the physical items available to view, handle and use as idea starting points. Thus, viewing and manipulating objects that had some meaningful relationship to the to-be-invented object was seen as important to the process of invention.

In summary, designing, inventing, and the related activity of design and technology learning are: complex activities requiring higher-order thinking; where that higher-order thinking is facilitated not primarily by abstract thought but by visual mental imagery and the manipulation of concrete materials; in situations and contexts that are meaningful to students.

**So what?**

I would now like to refer back to one of the themes for this conference - What purposes do we value for Design and Technology Education? In June last year I attended the Thinking Conference in Harrogate, somewhere south of Hadrian’s Wall. The Keynote speakers included David Perkins, Bob Sternberg and Howard Gardner - three of the leading researchers in thinking, creativity and intelligence. However, Perkins presentation departed from his previous themes of inventive thinking and was concerned with morality, Sternberg’s paper went beyond his previous work on intelligence to explore the issue of wisdom, while Gardner concluded that performing what he called “good works” which he describes as “when excellence and ethics meet” is important. In other words, all three presenters had come to the not particularly surprising conclusion that intelligence and creativity were not of themselves enough, and that human thought and action, even very clever thought and action, needed to be mediated by what is variously referred to as ethics or values or something connoting “goodness”.

This new information might be interesting and indeed compelling in its apparent logic and contemporary relevance, given current and recent past world events. However, it still begs the question of how this relates to design and technology education, and indeed how it relates to what I have said in the earlier part of this paper. I will make this connection by drawing on research concerning knowledge representation and its role in problem-solving and thinking, two reasonably important processes in learning.

Until quite recently, ideas were only seen to have importance if and when they could be expressed in words. Indeed, some commentators have expressed the view that ideas do not exist until they have been rendered in words. Ideas expressed in images or concrete representations were seen as not so important, and ideas expressed in ways that are neither verbal nor visual, such as tacit knowledge, were seen as least important. Thus there was seen to be a hierarchy of representations of knowledge with abstractness seen as most cognitively demanding and most important. This is played out in education where universities, which are seen to deal with abstract, verbally mediated ideas are seen to be more important than technical colleges, which deal more with visual and concrete ideas, and these are seen as more important than
settings where tacit knowledge is gained through practice of a skill, such as a workshop setting. (Fortunately, this generalisation is becoming less general).

It also used to be thought that only abstract representations of knowledge were used in complex thinking. However, we now know that humans use mental imagery to solve complex problems (Kaufmann, 1990), and moreover, that images can provide the most efficient representations for solving complex problems. Larkin and Simon (1987) have provided some useful evidence to suggest why this is so. Larkin and Simon argue that images provide more efficient representations for problem-solving because the material in an image is organised according to the relations of the problem content rather than being organised according to the rules that apply to the abstract code.

We now know that inventors routinely work from concrete representations of past inventions to generate new inventions (Weber, 1992; Weber, et al, 1990; Carlson & Gorman, 1992), and that idea generation fits within Bloom’s category of synthesis, and is thus a higher-order thinking process.

Work in cognitive psychology (eg Anderson, 1982) suggests that when the mind processes procedural knowledge, or the knowledge of how to do something, it uses the same mechanisms to processes thoughts as it does to process actions. That is, there is no higher-order mechanism for processing abstract thoughts that is separate from one used for concrete thought, using, for example, imagery, or physical action.

This means that because we work with children where they engage with real materials in concrete settings that have personal meaning, we are also working with children in settings where values, or Gardner’s “good works” have the best chance of being taught and more importantly, learnt. This is not a new idea. It was Steiner who said, and I am paraphrasing him “don’t worry about what the child does to the wood – be more concerned with what the wood does to the child”. Steiner knew that profound learning came from engaging with real materials in solving real problems, but did not have access to research to validate his ideas.

The significance of the research work referred to is not simply that we can insert some ‘values’ learning into the design and technology curriculum. Rather, the important point I would like to make is that because of its very meaningfulness to students which is related to the ways in which knowledge is represented in design and technology settings, it is best placed to have students explore questions of value. In such a proposition, the object of the design and technology learning experience is not simply to have students learn how to come up with bigger, faster or cheaper gizmos, but to have students design with values as a key component of the designing and the learning that comes from the activity.

**Conclusion**

In this paper I have used the existing and emerging research literature to argue that designing is a complex intellectual activity that requires higher-order thinking. I have also argued that this thinking is best facilitated by non-abstract representations of knowledge such as visual mental images and concrete representations, rather than the abstract representations previously thought of as those used exclusively for complex thinking. I have then argued that because of the kind of learning environment that occurs in good design and technology settings, which use the representations of knowledge referred to earlier, these setting are both appropriate for exploring questions of value and are settings where such ideas are meaningful for students. In drawing this conclusion I will draw on Herbert Simon’s 1969 book *The Science of the Artificial*, where he argued that all human activity could be divided into two categories. The first he called the natural sciences, and defined them as being concerned with understanding ‘the way things are’. The second he regarded as design and called it the science of the artificial, and defined it as being concerned with understanding ‘how things might be’ thus Simon saw the normative aspect of design as a fundamental and defining characteristic.
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Adding Value to the Teaching and Learning of Design and Technology

Queensland University of Technology, Australia
Email: i.ginns@qut.edu.au

Abstract

It has been argued that design and technology can be used as a vehicle for teaching science and vice versa. In this paper, we report an investigation into Grade 6 students’ understandings of concepts embodied in the Systems strand of a technology syllabus as they grappled with a unit of work in technology for the first time. The unit of work involved students in the design and construction of simple systems, followed by experiences with more complex systems. Qualitative research methods were used to investigate the activities of the students as they engaged in the design and technology learning experiences for eight weeks. Data sources included student and teacher interviews, video and audio recordings of whole class and small group interactions, students’ notes, drawings and diagrams, and researchers’ field notes and reflections. Changes in students’ ability to identify the individual components and analyse how the components worked together in systems, and evidence of students’ use of scientific understandings for explanations, were noted as the unit of work progressed. An improvement was observed in students’ abilities to describe relationships between inputs, processes and outputs, and outline sequences of cause and effect. Recommendations are proposed for enhancing the value of both design and technology and science if both subjects are taught together as part of an integrated program in primary schools.

Key words: Technology: systems

Introduction

The American Association for the Advancement of Science (AAAS; 1993), through Project 2061, emphasised the value of technology by actively promoting its inclusion in the school curriculum in order to ensure that students are informed about its nature, applications, and ramifications. Policy and syllabus documents in other countries (e.g., Curriculum Corporation,1994; DES/Wales, 1990) similarly emphasise the importance of studying technology.

A major thrust of Project 2061 (AAAS, 1993) was the intention that technology should be seen as a vehicle for learning science. Technology and science have much in common, thus it is not surprising that the two curriculum areas should be examined for commonalities and potential for integrated teaching and learning experiences. For example, they share the production and transformation of representations and action–orientation language, and technology related activities provide a rich platform for learning science when they focus on designing and testing artefacts, and critical analysis in explaining successful or unsuccessful performance of the artifacts (Roth, 2001).

The Study

The concept of systems presents the possibility of establishing extensive overlap between technology and science for teaching purposes. Indeed, Chen and Stroup (1993) proposed that general systems theory could be used as a framework to unify science and technology education, arguing that several dimensions of systems theory make this unification possible. The dimensions are: a system – interacting parts operating as a whole; change – transformation with time as a referent for change and dynamics; feedback – provides mediation between the goal and system behaviour; and interactions – the input and output of matter, information and energy. These dimensions are evident in the definition of systems provided in the Technology Syllabus (Queensland Schools Curriculum Council, 2002, p. 16), “Systems are comprised of interactive components and have inputs, processes and outputs that can be controlled in logical ways based on certain principles.” The dimensions also provide an interpretive framework, compatible with syllabus
documents, which can be used to make judgments about a student’s ability to identify system components and the interactions between the components and systemic behaviours.

An investigation into Grade 6 students’ understandings of concepts embodied in a technology unit of work based on the *Systems* strand of the Queensland technology syllabus is reported. The paper examines the technology unit for students’ learning outcomes in both technology and science.

**Methods and techniques**

An interpretive research methodology (Erickson, 1998) was utilised in order to understand the meanings and purposes that the participants attached to their activities (Lincoln & Guba, 2000). Trustworthiness, authenticity and the benefits of the hermeneutic process were the benchmarks for quality interpretive inquiry. Multiple data sources maximised the probability that assertions were valid.

**Participants**

The participants in the study were thirty Grade 6 students who attended a large, Brisbane primary school. All names used in the paper are pseudonyms. The class was engaged in a technology unit consisting of meaningful learning experiences of approximately 2 hours duration each week for eight weeks, prepared and implemented by the teacher in consultation with the researchers. The students worked in groups of three during the unit. Neither the teacher nor the students had experience with the technology curriculum previously. At the beginning of the year, the students had completed a science unit on mechanical energy, its forms and transformations.

**The technology unit**

A platform for students’ learning was established by providing guided learning experiences for the first four weeks, which enabled the students to explore a number of simple systems, for example, bottle diver; telephone system; gears; pulleys; and sub-systems on a bicycle. The remaining four weeks involved students working on the construction of two robots using materials from the *Lego Mindstorms - Dark Side Developer Kit*. The robots included a battery powered motor, light sensor and simple feedback response programs. These components were incorporated in a single Lego block around which the rest of the robot was constructed. A moving robot could be pre-programmed to stop, stop and pause before continuing, stop and reverse, in response to a light stimulus.

The students constructed the first robot using a plan provided in the kit. They were encouraged to incorporate their own ideas in the design and construction of the second robot. Essentially, the unit provided the Grade 6 students with beginning experiences in technology, which could be used as a basis for subsequent activity for developing their own specifications for the construction of a system.

**Data sources**

All students were interviewed in groups of three in order to determine their prior understandings of concepts embodied in systems. Each participant was asked to identify the components of a hand cranked model generator and describe how those components interacted together to produce light.

Six focus students, representing a range of understandings of systems evident from the initial interviews, were selected for in-depth study using video and audiotaping techniques. The purpose of the in-depth component of the study was to observe the actions and discourse of these students as they worked together, interacted with other students, and the teacher.

Other data sources included (a) observations of classroom activity, and (b) each student’s log book, which included, for example, drawings, and descriptions and results of tests on constructed artefacts. All students were interviewed, in their respective groups, for a second time at the completion of the technology unit to assess their understandings of systems, in particular, related to the robots that they had constructed. Salient portions from the interviews, videotapes and audiotapes, containing evidence of students’ use, or development of concepts embodied in feedback systems, were transcribed and analysed using the interpretive framework (Chen & Stroup, 1993). For example, were students able to identify system components, feedback mechanisms, and interactions (input; output)?
The original intention of the unit was to focus on technology only, however, evidence accumulated during the study that students appeared to draw upon their existing understandings of science concepts when discussing and explaining their ideas. Hence, the nature of explanations was also examined for applications of scientific content.

Findings
For the purposes of this paper, the findings for one focus group only (Alice, Kate and Suellen) are presented in two sections - technology learning outcomes, and science learning outcomes.

Technology outcomes.
In the initial interviews, the three focus students provided responses of varying levels of complexity as shown below. Alice identified and described most of the components of the hand-cranked generator compared to Suellen and Kate who provided limited descriptions.

“The crank, there is wire, there is a light, it sort of switches, the crank. This is a magnet and that is copper wire. Well, when the crank is turning around it is generating energy from the magnet, and that is transposed into this thing (the coil), that flows up through there and into the screws and into the light bulb, which makes it light up.” (Alice)

“It is a spinnny thing with wires in it, with the wires wrapped around something (coil) and N and S (unsure what N and S were). They rub together kind of.” (Suellen)

“You move that around (points to the crank). You twist it around and it goes down that (points to the wire) and that would probably go underneath and power the light, it shoots down the wire.” (Kate)

Each student was able to identify the input, that is, turning the crank caused the attached wheel to spin. Suellen was uncertain about the output (“It’s like not doing anything”), whereas Alice and Kate suggested that the output was light and electricity respectively.

During the technology unit, one particular aspect the focus students grappled with was the addition of propulsion systems to the robots. In the first robot, the motor turned a drive shaft connected via an arrangement of axles and cogs to wheels. The students were able to describe the system components and how the components interacted to propel the robot. For the second robot, they decided to construct legs for movement that could be operated by the addition of cams to the configuration of axles and cogs. Conceptualising the orientation of the cams in the propulsion system of the latter robot presented a problem for the group, which involved them in testing several different designs for the legs. They eventually succeeded in making the robot walk by “Turning these (the cams) in the opposite direction,” (Alice). The students also tested and evaluated the effect of the light stimulus on the movement of the robot.

In the second interview, the focus group was able to identify several systems present in their robots, and was also able to identify inputs and outputs. For example, Kate noted, “When you try and make it do things, sometimes you flash a light on it and there must be a system that senses the light.” They all recognised that the light stimulus was the input resulting in the movement of the robot. Alice drew attention to the general walking system in the second robot by stating, “The battery turns the little motor,” and movement occurs. Suellen recognised that the output, in the form of motion, was also linked to the configuration of cogs in the propulsion system. These findings are indicative of an important advancement in the students’ abilities to identify the interacting parts operating as a whole, feedback behaviour, and change.

Science outcomes:
The technology activities could be described as being bound up in what Roth (2001, p. 769) described the “seamless web” of technology and science. In the initial interview, there were already indications the students were drawing upon existing scientific understandings that may have been founded on the science unit completed earlier in the year. For example, Kate had conjectured that the output from the generator was electricity, “Because the light went on.” Although, unable to identify initially the output from the generator, Suellen built on Kate’s assertion by suggesting that spinning the crank faster meant that, “It’s
sort of building up electricity.” Alice provided a detailed description of possible energy changes as shown in the technology outcomes section.

On completion of the unit, the focus students were able to identify energy forms of relevance to the robots (e.g. light energy), outline how gears of different sizes and axles interacted to produce the movement of the robots, and outline cause and effect relationships. For example, they recognised that the motor, when operating, turned a large cog (“The motor turns that cog there,” - Alice pointed to the large cog). The large cog, in turn, caused several smaller cogs (two at right angles to each other) to rotate and turn the wheels of the first robot, or operated the cams for the walking robot. The concept of gear ratio was evident in their observations that the small cogs rotated faster than the large cog, and they rotated in opposite directions. The students also described the effect of friction when comparing the movement of the robot with wheels and the walking robot.

Discussion and Conclusions
It may be concluded that Suellen and Kate’s initial, limited understandings of systems changed to more coherent understandings as an outcome from engagement in the technology unit. All three students were able to identify components of systems, explain interactions of the components, and speculate on inputs and outputs, and how feedback systems might work. Most students’ explanations for how their artefacts worked displayed evidence of the use of the concepts and language of science indicating that they were drawing on prior, or new, understandings of science acquired through designing, constructing and testing artefacts. Hence, there were important learning outcomes for both technology and science for the focus students.

We suggest that the focus students’ learning was enriched because they drew upon their understandings of science to provide more meaningful explanations and observations when probed, for example, about the construction of the robots, and the role of light sensor in varying the motion of the robot. The students constructed links without scaffolding by the teacher. Teachers should build upon students’ ability to make links between technology and science, in particular, to use science to explain important features of the created technology. Therefore, it is recommended that teachers engage students in class discussion to explore and elaborate upon explicit technology and science understandings being investigated at important points in a unit of work. For this to be effective, students may have to be working on similar tasks or the same task. Teacher educators must assist primary teachers with the identification of relevant technology and science concepts embedded in a technology task and where class discussions of the kind described above would be most effective. We must help teachers to capitalise on opportunities to enhance the value of both technology and science if both areas are taught together in an integrated program.

References
Why do pupils do what they do? A theory of action in practice – using the example of technology teaching

Dr. Inga-Britt Skogh, Dept. of Curriculum Studies and Communication, Stockholm Institute of Education
Email: inga-britt.skogh@lhs.se.

Abstract

The rapid development of technology in society puts demands on schools in teaching this subject. Finding ways to increase the interest for technology among young people is an important mission for school and society. When children (or adults) are faced with a technical or a technological task or problem, the actions that follow – what the individual does – are of great importance. The way the person acts – how the individual approaches and deals with the task – leads to consequences for the personal experience (the feeling of success or failure) as well as for the concrete result of the action taken (the result is achieved or not). To learn in different ways how to understand why pupils do what they do is therefore an especially important task for teachers and educators who teach technology.

Using analyses of one’s own pupils’ actions as a starting point for obtaining knowledge (and understanding) as to why the pupils “do what they do” could be a way for teachers and educators who teach technology to find ways of adapting their teaching to the situation and environment in which their pupils find themselves. The explanatory model that I present in this article – a pedagogical application of Georg Henrik von Wright’s theory of logic of event (von Wright, 1983) – considers both the interaction of the individual with the environment and the action of the individual in connection with a particular event or situation – e.g. the actions of pupils in “technical” situations. To be able to meet pupils where they actually “are”, and not where the teacher wants, believes or hopes them to be, should be an important prerequisite when it comes to capturing the pupils interest in technology. After a brief presentation of von Wright’s theory of the logic of events and the pedagogical application of this theory, upon which my analysis model is built, I will give an example of how I have used the model as a basis for analysing pupils’ actions when faced with technical or technological tasks.

Keywords: technology, compulsive comprehensive school, pupil’s actions, logic of events

Technology teaching – visions and reality

Even though young people in Sweden are very active users of technology statistics shows that few are interested in studying or working in the technological sector. Obviously school has a great responsibility in this matter and teachers and educators must find ways to overcome and change this discrepancy between young people’s interest in using technology and their interest in learning about technology. To be able to formulate successful strategies for how we can stimulate pupils’ interest in the subject area of technology we have to consider different parts of the pedagogical process involved. In this article I focus on pupil’s actions in “technical” situations – what pupil’s in fact do when a technical or technological task or problem is presented to them. To learn in different ways how to understand why pupils “do what they do” could be a way for technology teachers to find ways of adapting their technology teaching to the situation and environment in which their pupils find themselves.

Logic of events – a way to understand and explain the actions of pupils.

In Determinism and the study of man (1983) Georg Henrik von Wright formulates his theory about the logic of events. Logic-of-events interpretations are based on the fact that we learn how to identify determinants of individuals (their intensions and epistemic attitude as well as factors and expectations that surround the activity in question). In order to do so we need to create a picture of the individual, in this case of a pupil in a technical situation. von Wright identifies four different intentions;
von Wright’s theory concerns the behaviour of individuals in general, and not the behaviour of pupils in a pedagogical learning situation. In my opinion that leads to a need of extending von Wright’s concept of intention. In addition to the four intentions that von Wright identifies (*wants, duty, ability* and *opportunity*) I add, in my pedagogical application of the logic of events, two “new” pupil-specific intentions. With the help of these new intentions it becomes possible to describe and emphasise aspects that influence the behaviour of the pupil (but not that of the teacher) in the school situation. These “new” intentions are:

- **Concessivity** is an intention tied to the subordinate position of the pupil in the school situation. It is meant to describe to what degree the pupil conforms to and subordinates him/herself (“opens up”) to the teaching – the degree of concession on the part of the pupil. There might be a number of different motives and considerations behind a pupil’s decision to “play along” (a high degree of concessivity) or to withdraw from the teaching situation (a low degree of concessivity) and it is not always the case that the pupil is actively aware of these reasons. This intention is formed within the individual.

- **Curiosity** is the second new intention. Curiosity constitutes an important pedagogic force in the teaching situation. It is in order to emphasise the fact that the inclination to examine and discover “in itself” leads the individual (here the pupil) to act, that the intention curiosity is introduced as an intention of its own.

**The concept of epistemic attitude**

In addition to the intentions mentioned above, the pupils’ perceptions of the demands of the situation – their epistemic attitude – are also included as an internal determinant. An individuals epistemic attitude is connected to (and dependent on) external stimuli or demands. The epistemic attitude – that is how the pupil perceives and handles the “demands of the situation” and his/her roles as a pupil – is of decisive importance as to how the pupil will “succeed” in the teaching situation.

**External determinants in a teaching situation**

In every school there is continuous interplay and reciprocal action between all the different factors in and outside the school that influence the activities of the school. What external determinants a pupil is going to be exposed to depend on external factors (regulations, social, economic and cultural conditions, the tradition of the school and how it is equipped) and expectations that surround the activities of the institution in question. How the pupil perceives and handles the external determinant is dependent on his/her epistemic attitude. The internal and external determinants combined constitute the *interior logic* of the individual.

**Exterior logic – the event’s historical context**

von Wright also points out the need to describe and explain the situation in which the action takes place – the event’s historical context. The more we know about the conditions of the event the more accurate our conclusions are in assessing the exterior logic of an individual’s behaviour. In order to understand the exterior logic of a pupil’s behaviour in “technical” situations, we need to know as much as possible about the conditions of the current events – the current “technical climate” (which manifests itself in political decisions, regulations at different levels, the labour market, educational statistics, public debate on problems of modern society and media, etc.) as well as how people handle the traditionally male image of the subject.
Interior logic (intensions and epistemic attitude) + Exterior logic = Logic-of-events

Logic-of-events interpretations of the actions of individuals can be described as an amalgamation of internal and external determinants (the interior logic) and by the underlying reasons for these determinants (the exterior logic). von Wright points out that there are combinations of determinants that appear with certain regularity, depending on the situation at hand. If we apply this reasoning to a pedagogical situation, it should be possible for a teacher in a given teaching situation to be able to predict, understand and explain with relative certainty the actions of pupils, provided the teacher knows the intentions of the pupils. By observing individuals and situations, we can learn to determine connections between the conditions and the consequences of the intention. However, it should be pointed out that the reliability of such predictions and explanations is to a great extent dependent on the time factor. The longer the time that elapses from the moment an intention is initiated and the time it takes for the individual to realise the intention, the greater the risk that the individual will have changed his/her intention, which naturally leads to the result that the action the original intention could have been expected to lead to is not fulfilled. Figure one shows schematically the different parts and connections of the interpretation process.

**Figure 1**
Overview model of the pedagogical adaptation of von Wright’s logic of events

That brings me to the end of my presentation of the structure of the analysis model and the theoretical starting points, and it is time to show one example of how theory can be put into practice. This example was first presented in my dissertation on young girl’s encounters with technology at home and in school (Skogh, 2001).
Linda (class three) and electrical couplings – an example of a logic-of-events analysis and interpretation

The class is working with electrical couplings. The task is to make a bulb light up in a circuit. The lesson starts with the group discussing together how to do this. Then the girls first try to make one bulb light up and then several. After the discussion, everybody starts. The girls chat to each other and everything seems calm and peaceful.
Commentary

The “coupling problem” is not a problem for Linda; her difficulties are on a completely different level. A requirement for making the connection is that the wire is “peeled” at both ends. The group has practised this work on several occasions and most pupils have become quite proficient. During some of the time that was spent practicing peeling, Linda had previously injured her hands and a friend helped her. When her hand got better she still had help from the friend (of which the teacher was unaware). At the time of the current task, Linda and her friend had fallen out with each other and Linda did not receive any help. The fact that Linda knows what to do but is not capable of practically carrying it out makes her very frustrated.

In accordance with von Wright, the intention ability can thus be described as a limiting intention. Wanting something is not enough in itself – in order for an intention to be fulfilled the individual must have (or acquire) the ability to do what the intention means. Lacking practical/manual ability in technical situations leads to immediate and obvious consequences. Linda knows how to connect the circuit but the fact that she cannot do it in practice makes the situation intolerable to her. She becomes both sad and angry and gives up all attempts. What long-term consequences this failure leads to for her can be said to depend on how she normally perceives her technical ability (degree of technical self-confidence) and the motivation this feeling gives rise to. If she sees this event as a one-time failure, then it is very likely that she will “swallow the bitter pill” and learn to handle the tool in question. However, if due to poor technical self-confidence she sees this event as further confirmation of her own incompetence in practical/technical tasks, then it is very likely that she will try to avoid similar situations.

Logic-of-events interpretations – a pedagogical tool in the teaching of technology

I have attempted to point out how teachers, by systematically analysing pupils’ actions, acquire deeper knowledge about their pupils which makes it possible to relate the teaching of technology to the pupils’ experiences. The analysis model gives us the possibility to discern more general and recurring patterns of behaviour among the pupils – a knowledge that constitutes a valuable help when it comes to dealing with future pupils in similar teaching situations.

The fact that the logic-of-events interpretation model supplies concepts that put words to both the pupil’s “internal life” and the pedagogical situation in question makes us aware not only of the effects of the pupils’ actions but also of possible reasons for these actions.

The systematic structure of the model brings to the attention of the teacher aspects of the pupils (which are of possible pedagogical significance to the teacher) that might otherwise remain undiscovered and unexploited. Furthermore, every logic-of-events interpretation includes the fact that the teacher must decide how the pupil’s behaviour relates to all “categories of intention” – not only those that the teacher him/herself considers to be the most likely, but also other possible interpretations. The intellectual and mental preparedness that this leads to opens up the mind not only towards the particular pupil in the current situation but also towards other pupils in similar situations. Logic-of-events interpretations of pupils’ actions can thus be said to increase awareness of the pupil as an individual and of the pupil as part of a greater context – of the complexity that surrounds every teaching situation. Knowledge and insight about this complexity should be valuable to every teacher and educator – especially when it comes to formulating successful strategies for the technology teaching of tomorrow.

References:


1 The potential of logic-of-events interpretations of pupils' actions is not limited to technology teaching. In my opinion it could
be a useful pedagogical tool in any teaching/learning situation.

2The term concessivity is chosen with reference to the term concessive, which means expressing concession.

3 Among von Wright’s intentions, the intention curiosity could be assigned to the intention wants since the need to satisfy curiosity leads to well-being.

4 The difference between the concept of epistemic attitude and the concept of the intention concessivity is that concessivity can be seen as a quality/skill and epistemic attitude as the individual’s perception of reality.

5 The terms interior logic and exterior logic have been coined by the Swedish school researcher Sverker Lindblad (1994)

The Place of Technology Education in the Finnish Comprehensive School

Aki Rasinen, Senior Lecturer in the Pedagogy of Technology, Ph.D.
University of Jyvaskyla, Jyvaskyla, Finland

e-mail: rasinen@edu.jyu.fi

Abstract

At present there is no such subject as “technology” in the general education curriculum. A variety of technological studies is offered during craft, and particularly “technical work” lessons. Integration between mathematics, science, and crafts has been suggested. Technology and the human being is a new cross-curricular theme launched by the National Board of Education (NBE) of Finland. The new curricula are being planned in the pilot schools following the draft framework curriculum (NBE 2003).

Key words: technology, technology education, design and technology, technology teaching, craft, handicraft

Technology is studied during craft lessons

The origin of Finnish technology education lies in handicraft education which was introduced to Finland in 1866 by Uno Cygnaeus (Kantola p. 18, 1997). Cygnaeus regarded it as important to have “technological” components in craft (sloyd) education. Cygnaeus emphasized dexterity, design and esthetics but also consideration, innovation and creativity. To describe the versatility and emphasis on technical studies, he sometimes called the subject “teknillinen kasityo”, “technical handicraft”.

At present there is no such subject as “technology” in the general education curriculum. Depending on who is speaking about technology education, it is considered to be taught during IT lessons, science lessons and particularly during “craft” or “technical work” (as the subject is called in Finland) lessons. In resent years
several doctoral dissertations have been written on technical work and technology education in Finland. Autio (1997) and Kankare (1997) regard technology education as part of “technical work”. According to Alamäki (1999), “technical work” corresponds to the international term technology education. The studies conducted within the technology education experiment at the University of Jyvaskyla support the idea of introducing technology education as a stand alone subject. Kantola wants to introduce more and more technological contents into craft lessons. He argues that there is no need to be worried about learning results in traditional crafts as these skills can also be learnt while solving technological problems. He also emphasizes the importance of environmental studies during craft lessons. (Kantola 1997, p. 163 and 171.)

Technology on its own or integrated

Parikka (1998 pp. 127 - 128, 162) introduces three different models of studying technology.

1. It would be possible to make technology education a subject in its own right at national level, evolving it from crafts, either partially or entirely, and by some additional resource allocations, also from some areas of mathematics and science. For the senior secondary schools this subject should be designed to account for the characteristics of the local community. Thus, in this solution the new subject would combine elements that are closely related to the practical nature of technology. At school level the subject would allow for flexible integration with other subjects.

2. The model of strong integration would be based on school and municipal level implementation of technology. The subject group responsible for this area would involve mathematics, science, and craft in its present form. Project work in this area would take place in cooperation with other selected subjects.

3. Flexible integration, in turn, could only be designed at the school level in most cases. Practical arrangements would be liable to change on an annual basis. The school should appoint a coordinator or coordinating team to implement these arrangements. Instruction would only take place in the form of project work or as specific theme areas in conjunction with other subjects.

Parikka considers the first option to demand least re-organization of teacher education and it would also be easiest to organize at school level. Alternatives two and three would need a massive re-organization of teacher education both pre- and in-service. He goes on by saying that alternatives one and two would be the most effective ways of implementing technology education.

Marsh (1997, pp. 95) presents many studies which support integrated curricula as a worthwhile alternative. He also gives good examples of how to organize multidisciplinary studies, and presents studies which support the idea of students achieving high results after taking integrated study programs (ibid. pp. 96 – 103).

Integration within school is possible, particularly in the primary school (grades one to six) and given present teacher education and teacher organizations. In today’s junior secondary school (grades seven to nine) many existing school subjects, including technical work in particular, contain plenty of technology education. Technology is also studied in connection with many other subjects (e.g. information technology, mathematics, science, textile work, home economics, history and social studies). Actual integration between different subjects is probably easiest to implement through project and thematic work. For this purpose, information flow, joint planning, and discussions between teachers of different subjects should be increased systematically. Lattu (2000) suggests that improvement of technology education in Finnish comprehensive schools could best be promoted by intercurricular activities. Integration between school and the surrounding society is a more demanding task than integration within the school, because the number of intervening factors is great. The various parties have their own tasks and their own time-tables. The general atmosphere regarding co-operation between different educational institutes, branches of industry, and schools is positive. Also in this case integration is probably easiest to organize through various projects and themes.

The idea of transdisciplinarity goes deeper in the creation of knowledge than just integration. The aim is to create a theoretical consensus which cannot be split into disciplinary parts. Transdisciplinary knowledge develops its own modes of practice, and diffusion is accomplished in the process of production (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow (1994, pp. 4 – 6). Creating knowledge in a holistic
manner should be the aim in all curriculum development. Theories of transdisciplinarity should also be applied in Finnish curriculum development, but at this stage in the development of technology education the first steps in this direction have to be taken through integration.

In the present school system the surest way to study a specific subject is to fit the lessons in the timetable. The experiences from so-called multidisciplinary studies have often been quite negative. The subjects studied in this manner have not had a sufficiently high status within the curriculum, and they have not been taken seriously by either students or teachers. This does not mean that integration between subject areas would not be a good system. On the contrary, both in the class teacher system and the subject teacher system integration increases holistic learning. If technology education were to be integrated fully with other subjects, clear technology contents should be determined. In many industrial countries technology education is an independent subject. This model should also be considered in Finland to ensure proper learning of technology.

As indicated above, at this stage of development strong integration between different subjects (particularly craft and science) is recommended (see e.g. Kantola 1997, Parikka 1998, Rasinen 2000 and Heinonen 2002). All the above mentioned researchers consider integration much easier at grades one to six, where most lessons are conducted by the same person, the class teacher. At upper grades the task is more difficult because subject specialists are responsible for teaching.

The authorities decide

The Finnish Parliament decides what subjects are taught in Finnish schools. Last year a new subject called health education was introduced into the curriculum. There have been discussions on technology education as a stand-alone subject, probably developed from “technical work”, but there is a lot of resistance for this name. Both researchers in textile work and technical work argue that technology is only one part of handicraft (see e.g. Peltonen pp. 175 - 179). On the other hand, there are many researchers who claim that handicraft falls under the umbrella of technology (see e.g. Parikka, Rasinen & Kantola 2000, pp. 31 - 32). However, a working group appointed by the Ministry of Education presented its memorandum, Perusopetuksen uudistamistyöryhmä muistio, 11 : 2001, where they suggest that “craft” should be studied by all pupils and it should include “textile work, technical work and technology”. There is reason to believe that studies conducted in the field of technology education have affected the text in the memorandum. Without a comprehensive research done in the field, there would probably be no note at all about the importance of technological studies under the title of craft in the memorandum.

Following the memorandum, the National Board of Education started planning the Framework Curriculum for the Comprehensive School and also for the Upper Secondary School. The National Board of Education appointed working groups to plan the curriculum of each school subject. The text of the 2001 memorandum naturally led the way for the “craft working group” to incorporate technology education in the curriculum. The draft Framework Curriculum was published early in 2003. The National Board of Education has also decided that there will be seven cross-curricular themes or entities which should be included (if possible) in the curriculum of different subjects.

The themes are as follows:

1) Development of the individual as a human being
2) culture identity and internationality
3) communication and media skills
4) committed citizenship and entrepreneurship
5) responsibility for the environment, well-being and sustainable future
6) safety and traffic behavior
7) technology and the human being


Under the title “technology and the human being”, the meaning of technology in our everyday life and dependency of human beings on modern technology should be studied. This theme will offer basic know-
how on technology, the development of technology and the effects of technology, guidance on making
reasonable choices and on considering the ethical, moral and equality questions related to technology.
Teaching should also improve the ability to understand how different devices, equipment, and machines
work and how to use them.

The aims are as follows:

A pupil will learn

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

The core contents

• Technology in everyday life, in society and in its structures, in producing products and services, in
health care, in protection of the environment, and in local trade and industry
• the development of technology and information technology in different cultures and different
fields of life during different periods
• the integration of natural sciences and other sciences with technology
• development of technology and its phases
• the ethical, moral, well-being, and equality concerns in the development and use of technology
and information technology
• future society and technology. (ibid. 2003, p 16).

In the framework curriculum references to technological studies can be found only under science
(particularly physics) and very extensively under craft (particularly technical work). The subject groups in
other subjects have not considered the cross-curricular theme "technology and human being" in their text.
However, the instructions from the National Board of Education are that the schools have to clearly
indicate in their curricula how these cross-curricula themes are included in different school subjects and
they have to be seen in the schools’ working culture (ibid. p. 13). The framework curriculum does not give
instructions on how this should be done, this is left for the schools to decide and think about.

There has not been any systematic training program in the country to guide schools in their planning work.
Neither has there been a training program to explain the cross-curricular topics, nor has the concept
technology been defined. Only recently graduated teachers and some scattered groups here and there have
received some training in technological studies. Regardless of this, the pilot schools have now started
planning the school curricula and these will be tested during next term (2003 - 2004). The curriculum for
grades 1 - 2 has already been tested and approved. The Framework Curriculum for Senior Secondary
Schools is not discussed in this paper.

After the experiences of the pilot schools and the comments from different stakeholders, the final national
curriculum framework will be prepared. Hopefully after the pilot year there will be consensus on what
technology is, and some basic ideas on how it should be studied in the Finnish comprehensive schools.
While waiting for stand alone subject status for technology, developing the technological contents of
craft/technical work education should be emphasized and strong integration between different school
subjects (particularly science) should be implemented.

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Many Paths to Meaning: Research Support for the Study of Technology in Secondary School Curriculum

Dr. Ann Marie Hill, Professor and Coordinator, Technological Education, Queen’s University, Kingston, Ontario.
Dr. Howard A. Smith, Professor, Educational Psychology, Queen’s University, Kingston, Ontario.

Email: hilla@educ.queensu.ca
Email: smithh@educ.queensu.ca

Abstract

This paper briefly examines the literature on (1) problem-based learning (PBL), including constructivism and problem solving, and (2) learning in context, including mediation, embodiment, distribution, and situatedness. We use this literature, our previous research (Hill & Smith, 1998), and some initial findings from our present research as a basis for a theory that we call “authentic learning”. The Theory of Authentic Learning provides a theoretical framework in which to frame purpose and value for the study of technology in secondary school curriculum. Initial results from Year One of our present three-year, nationally funded qualitative research project (funded by the Social Science and Humanities Research Council of Canada) contribute to the refinement of our Theory of Authentic Learning. First, we begin with the literature, then we illustrate the Theory of Authentic Learning, and we finish with findings and data from our present research.

Problem-based learning

Torp & Sage (1998) define problem-based learning (PBL) as, “focused, experiential learning (minds-on, hands-on) organized around the investigation and resolution of messy, real-world problems. It is both a curriculum organizer and instructional strategy, two complementary processes.” (p. 14). A close examination of curriculum organisers and instructional strategies used in secondary schools for the study of technology reveals that PBL is a preferred pedagogy. This is owing to the hands-on nature in the study of
technology to solve problems through projects. This hands-on approach to solving problems through projects has historically been used as the pedagogical approach to teaching and learning technology in secondary schools. However, technology educators, with their affinity to doing, have not documented, in textual form, this history and development over the years. As such, we turn in part to medical education for literature on PBL.

PBL is well known as a pioneer pedagogy in medical education and can be traced back to the Faculty of Medicine, McMaster’s University in Ontario, Canada in the 1960’s (Barrows & Tamblyn, 1980; Camp, 1996; White, 1996). This pioneer program found its framework in the work of John Dewey and inquiry-based learning (Jones, 1996). Today PBL is evident in most medical schools around the world (Jones, 1996; Vernon & Blake, 1993) and has spread to other schools unrelated to medicine (Camp, 1996), such as education.

The most recurring characteristics of PBL in the literature (Albanese & Mitchell, 1993; Barrows & Myers, 1993; Barrows & Tamblyn, 1980; Boud & Feletti, 1991; Camp, 1996; Greening, 1998; Jones, 1996; Savery & Duffy, 1995; White, 1996; Woods, 1985) are that PBL is a curriculum development and instructional strategy that: (1) is based on a constructivist philosophy where learners construct their own contextualised knowledge; (2) is grounded in real-life problems where knowledge acquisition is steeped in practice; (3) actively engages learners in authentic tasks, activities, and environments where problems are ill-structured; (4) requires an iterative process to solve problems where learners work in groups for collaborate study and where social negotiation of meaning is required in the problem-solving process; (5) encourages learners to think critically and creatively; (6) requires learner engagement in exploration; (7) encourages an interdisciplinary approach to learning; (8) encourages reflection, an important meta-cognition aspect of PBL; (9) results in deep understanding as students retain knowledge much longer; (10) results in transfer of knowledge due to meta-cognitive activities; (11) is student-centered where students assume responsibility for their learning; working independent of the teacher and identifying gaps in their understanding in the context of the problem at hand, and (12) is faculty-facilitated where faculty guide, probe, and support group and individual learning.

In addition to characteristics, models of PBL are found in the literature, notably that of Barrows (Barrows, 1985, 1992; Barrows & Myers, 1993). While there are now many definitions, models, and case studies for PBL in the literature, common features are that it is defined as constructivist pedagogy and a subset of problem solving (Greening, 1998; Savery & Duffy, 1995).

Philosophy forms the framework for how educators view the world, and this framework influences their actions in classrooms and in preparation for classrooms (Hill, 1997). Constructivism is one philosophical view and it is here that PBL is positioned. Savery and Duffy (1995) provide a succinct overview of PBL within a constructivist framework. They posit three primary constructivist propositions and propose eight instructional principles that evolve from the propositions. Not surprisingly, the propositions and instructional principles align with characteristics of PBL.

In addition to a constructivist framework, PBL is seen as a subset of problem solving (Greening, 1998; Savery & Duffy, 1995). The dynamic of problem posing and problem solving in technology is most commonly known as the ‘technological method or process’. Lewis, Petrina, and Hill (1998) indicate that problem solving in technological education manifests itself in numerous forms, “including experimentation, design, invention, and troubleshooting” (p. 22), depending on the technological field to which it is being applied. In addition, Hill (1998) posits that in the real world, technological problem solving is interactive, not linear and step-by-step, because exploring the connections between knowledge, skills, and different materials is fundamental in technological processes. Ideas are important to new inventions, but “there is a further conditioning [of ideas] in terms of the materials and processes available” (Wiener, 1993, p. 37). This joining of thought (head) and action (hand) is critical in technological processes (Arendt, 1958; Franklin, 1990), as is real-life and situated contexts because there are many distinct technological fields, each with its own knowledge base, problem solving process, and materials usage (Hill, 1998; Hill & Anning, 2001a, 2001b). One way to situate secondary school programs in real-life contexts is to link problem solving to projects needed in the community, or to what Hill (1999) has coined Community-based Projects. This approach encourages problem posing, which Lewis, Petrina, and Hill (1998) believe to be at
the creative end of the problem-solving continuum. Activities that are engaging to secondary school students in their study of technology comprise most, if not all, of the characteristics of PBL, of the propositions and principles of constructivism, and of the dynamics of problem-solving discussed here. How then do these curriculum organisers and instructional strategies contribute to purpose and value for the study of technology in secondary school curriculum? Research by Hill and Smith (1998) into student learning in secondary school technology courses provides a basis for a theory called authentic learning. This theory demonstrates purpose and value for the study of technology in schools.

The Theory of Authentic Learning
In earlier research, Hill and Smith (1998) determined that the exemplary technological education classroom that they studied displayed all the essential qualities of the Theory of Authentic Learning. In this classroom, learning processes diverged sharply from traditional settings where the emphasis is on abstract and decontextualized concepts of little apparent relevance to the students. Instead, activity in the exemplary classroom resembled that of everyday learning where learning and context are inextricably linked as people engage in various forms of cultural activity. In this classroom, learning, ability, talent, and intelligence were as much a part of the situation as they were of the individual (e.g., Barab & Plucker, 2002). Four factors constitute the Theory of Authentic Learning as outlined here: mediation, embodiment, distribution, and situatedness. These factors will be summarized next.

The view that learning is mediated originates with the notion that humans use cultural tools, or mediational means, when engaged in action of various forms (Wertsch, 1998). Examples of mediational means include language, musical instruments, hoes, and hammers (Smith, 1995; Wertsch, 1991). The theory supporting mediation has several roots, but the works of Peirce (1992, 1998), Dewey (1938), and Vygotsky (1978) are cited most frequently. Although the secondary school student is usually treated as a passive recipient of knowledge (e.g., Davis, Maher, & Noddings, 1990; Dreyfus, 1995), the mediated view of learning emphasizes the need for learners to engage in authentic cultural tasks using relevant cultural tools (Martin, 1995). As shown in the classroom studied by Hill and Smith (1998), where students constructed such items as bikecars and a dome, human action is shaped by the cultural tools in use, including paper, pencil, drill presses, and welding torches. Hence, authentic learning exposes students to a wide range of cultural tools and their use in cultural tasks.

Authentic learning recognizes that learning involves the body as centrally as the mind and embraces cognitive, emotional, physical, and social dimensions (Epstein, 1994; Hutchins, 1995; Johnson, 1987; Smith, 1999; Varela, Thompson, & Rosch, 1991). In embodied learning, cognition, perception, cultural tools, and action all work together in the learning process. For example, in building a bikecar in the Manufacturing Technology classroom (Hill & Smith, 1998), students made key design decisions based on their own body structures and sizes in determining, for example, where to place the bikecar’s seat, foot pedals, and steering mechanism.

Authentic learning claims that learning is not confined to the individual mind, but extends outwards to include the ongoing actions provided by cultural tools and other persons (Clark, 1998). The idea of learning as distributed also recognizes explicitly that many tasks cannot be completed by one person working alone (Hutchins, 1995) and that, in the classroom, knowledge is distributed among all class members (Rogoff, 1990; Vygotsky, 1978). This perspective conforms to that of most work places, where individuals must work cooperatively in pursuit of common goals and where different abilities are needed to complete projects successfully (Loney, 1995; Hill & Smith, 1998; Premier’s Council, 1988, 1990). Further, both individual and collective memories often reside in artifacts and actions that lie outside the brain (Kirlik, 1998).

In contrast to the view that most learning is abstract and generalizable, research over the past two decades has emphasized the situated and contextually-grounded nature of authentic learning (Brown, Collins, & Duguid, 1989; Cobb & Bowers, 1999; Greeno et al., 1998; Lave, 1988; Saxe, 1988). For example, Hill and Smith (1998) showed that involving students in genuine projects derived from community needs, such as garden tables for a retirement home and a spool rewind system for a major tire manufacturer, provided specific contexts for engaged student learning.
The preceding four factors address qualities of authentic learning. However, an additional element, a focus on the learner, involves the learner himself or herself. Most people recognize that we differ from one another, often dramatically, in our abilities and interests. These observations have been supported by both theory and research which have established that we possess an assortment of ability systems. These systems have been represented by Gardner (1983, 1999) as eight primary intelligences (linguistic, musical, spatial, logical-mathematical, bodily-kinesthetic, intrapersonal, interpersonal, and naturalistic) and by Smith (2001) as seven distinct signways (which parallel Gardner’s array). Authentic learning recognizes a range of abilities and talents and seeks deliberately to foster them across a variety of contexts (Hill & Smith, 1998). The assessment of such learning should also assume diverse forms.

**Preliminary Findings from Present Research**

Our present research examines how the study of technology contributes to the development of young adults’ lives. It does so by following the lives of 12 students in three different technology programs at three different secondary schools over a three-year period. The Theory of Authentic Learning is contextualized and supported by student data and quotations from this qualitative research.

In a preliminary analysis of some of the data from our present research, findings are emerging that confirm the four factors (mediation, embodiment, distribution, and situatedness) and one element (the learner) that comprise the Theory of Authentic Learning (Hill & Smith, 1998). This preliminary analysis serves as a trial run for the analysis model that will be used to analyse all data as the study progresses over the three-year period. The preliminary analysis used the qualitative data analysis program titled, *Atlas.ti*. Initial interviews, or primary documents, from two of four students at one of the three research sites were analysed to determine if the four factors comprising our original Theory of Authentic Learning were identifiable. All four factors were identified. The analysis consisted of using *Atlas.ti* to identify the quotations that related to the four factors, to create codes for the four factors, to apply the codes to the appropriate quotations, to determine the links and relations of the codes, and to generate the network for the codes (referred to as nodes in our network). Together these analyses form the hermeneutic unit used in our preliminary analysis reported here.

In addition to the original four factors of the Theory of Authentic Learning, six additional factors emerged from the preliminary analysis of the partial data. These factors are multiple literacies, motivation, identity, career planning, human relationships, and teacher attributes. *Atlas.ti* was again used in the same procedural and analytical way to incorporate the additional six factors into the hermeneutic unit. The hermeneutic unit, with its 10 factors, was then used for theory transfer. The theory is depicted in Figure 1.
Figure 1. Paths to Meaning in Authentic Learning (Preliminary Analysis).

Symbols:

\[=\] Code 1 is associated with Code 2 (symmetric attribute)

\[\] Code 1 is part of Code 2 (transitive attribute)

\[\ast\] Code 1 is the property of Code 2 (asymmetric attribute)

\[\Rightarrow\] Directed link

\[\Rightarrow\Rightarrow\] Undirected link

*Mediation* is the use of cultural tools of all kinds, such as language, hammers, and computers. These tools are used in authentic cultural tasks, but knowledge of use can extend beyond the specific task at hand. *Embodiment* is learning involving the body and, especially, emotion. It involves the senses and the feeling of comfort in the setting. *Distribution* is learning and knowledge not confined to one mind or body, but extends out to include others’ thoughts and actions using cultural tools, for example, group work. Here, some tasks need more than one person to complete them. Memories reside in both the tools or artifacts and the cultural activities. *Situatedness* is where learning is situated in the existing context. *Multiple literacies* is multiple ways of making sense in the world, or multiple intelligences, or abilities, or signways. *Motivation* is the desire, need, or want to achieve and, presumably, to become competent in given domains. It includes surprise, leading to abduction, and the removal of doubt (Peirce, 1992, 1998). As well, it is connected to feelings. *Identity* is personal growth and the development of identity (who one is) and a sense of self. *Career planning* involves references to future courses, programs, careers, apprenticeships, or other postsecondary education. *Human relationships* are expressions, either positive or negative, about being with others, especially peers. *Teacher attributes* are teacher or supervisor attributes or abilities, including personality, use of humour, and interest in the students.

Figure 1 depicts how these 10 factors are linked and their relationship to each other. The symbols below the figure help to decode the relationships. \[=\] indicates that a code (factor) is associated with another code (factor) and that attribute is symmetric. \[\] indicates that a code is part of another code and that attribute is transitive. \[\ast\] indicates that a code is the property of another code and that attribute is asymmetric. Indicates that there is direction to the link, and indicates that there is no direction to the link.
According to the theory transfer in Figure 1, Mediation is part of ([ ]) distribution, motivation, multiple literacies, and situatedness. Embodiment is part of distribution, identity, motivation, and situatedness. However, it is the property of (**) both mediation and multiple literacies. Distribution is associated (= =) with career planning and human relationships. Situatedness is the property of distribution. Multiple literacies is associated with career planning, distribution, identity, and motivation. Motivation is associated with teacher attributes. Identity is associated with career planning, distribution, human relationships, motivation, teacher attributes, and multiple literacies. Career planning is associated with human relationships and motivation. Human relationships does not have any direct relationships of its own. Instead, distribution, identity, and career planning are associated with it. Teacher attributes is associated with career planning.

This preliminary analysis of some of the initial data from our present research indicates that the paths to meaning found in situations of authentic learning provide a far richer educational environment for students than traditional classrooms, regardless of career path. “I’ve know since Grade 8 that that I’d like to be an architect.” “I want to be a construction teacher, like, in a high school.” These types of leaning opportunities provide young adults with both academics, “we use a lot of thinking like logic, problem solving, math, for example building that sawhorse, and English in writing journals.”, and technological skills and knowledge, “I’m learning how a house goes together, learning the terminology, learning how to read plans, estimate supplies needed to build a house.” They also foster a sense of appreciation and value for school and for what is learned in school because relationships between what is learned in school and life beyond school are inseparable; the learning environment in school reflects the complexity of the environment it represents outside of school, “School is really, really important so if I hadn’t done this program, I probably would have just graduated and work at Swiss Chalet [a restaurant] for the rest of my life.” “It’s more useful. What we learn here we kinda use.”

**Purpose and Value for the Study of Technology**

The study of technology in secondary school has historically been grounded in a hands-on approach to solving problems through projects. Theory on PBL, a sub-set of constructivism and problem solving, previous research leading to the Theory of Authentic Learning (Hill & Smith, 1998), and this present research that documents paths to meaning in authentic learning environments together provide a basis for the purpose and value for the study of technology in secondary school education. They do so by expanding the dialogue beyond dropouts or non-university bound student paths. They add purpose and value to the study of technology by documenting its contribution to education at large and how it can enrich the education of all students. In these learning environments, schooling is meaningful because learning is situated, distributed, mediated, and embodied, “Well, everything is hands on. You can’t do math without grabbing a piece of wood and having to write down on the wood or you just write on the walls. I mean you are always doing something. You are never just sitting around.” Multiple literacies are attended to. This attention to multiple ways of making sense in the world motivates students and leads to both individual and cultural identity, as well as a sense confidence in career planning. Human relationships are important to all factors found in authentic learning environments, as are teacher attributes that guide students in their many paths to becoming young adults.

**References**


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**Foundation Stage framework for design and technology: determining the key areas of need**

**Professor Clare Benson, University of Central England, Birmingham, England.**

Email: clare.benson@uce.ac.uk
Abstract

Since the introduction of Desirable Outcomes, followed by the Early Learning Goals, Foundation Stage teachers (for children aged 3-6 years) have been planning their teaching and learning around six areas of experience. Whilst it has been argued that this is an appropriate method of organising the curriculum content for this stage, it may mean that teachers are not so aware of the nature, knowledge and skills relating to particular subject areas. Thus it is likely that the connections that can be made between all the learning areas and design and technology are not being realised. Indeed, OFSTED reports in recent years have highlighted the lack of knowledge and confidence of primary teachers relating to design and technology.

This paper will seek to investigate:

- the knowledge and understanding that foundation teachers have relating to design and technology
- the links to other areas of experience
- how work in the Foundation stage supports the development of design and technology at Key Stage 1
- the issues that teachers raise in relation to the teaching of design and technology

Key words
Foundation Stage; issues; areas for development

Setting the context

With the introduction of the National Curriculum in 1989 in England and the subsequent introduction of design and technology in 1990, all primary schools (children aged 5-11 years) had a mandatory framework within which they had to work, unlike those in educational settings for children aged 3-5 years.

Change was brought about in 1996 with the development of guidance in the form of Desirable Outcomes for Children’s Learning on Entering Compulsory Education (SCAA 1996). Unlike the National Curriculum, this document was presented through six areas of experience: personal and social development, language and literacy, mathematics, knowledge and understanding of the world, physical development, and creative development. Design and technology was placed in knowledge and understanding of the world—but a review of the other areas shows that this subject is a major component of them all. Thus this was a model that could cause confusion. For the many who have a limited understanding of design and technology (Javis and Rennie 1996), it was not always apparent that activities related to other areas of experience could develop design and technological capability.

Exemplification of the Desirable Outcomes followed through the publication of Looking at Children’s Learning (SCAA 1997), although it offered very limited support and guidance relating to design and technological capability. Out of thirty examples there were only four that exemplified work relating to design and technology, and only one of these focused on looking at made products or using the made environment. The rest detailed work that developed making skills such as cutting, joining and assembling. This again highlighted the fact that those who were unsure about design and technology would have little to support their understanding of how to use the made world appropriately with Early Years children.

A review of the Desirable Outcomes led to changes in Early Years provision in 1999. Firstly, the new Early Learning Goals, based on the Desirable Outcomes, were given to schools in Autumn 1999, with Curriculum Guidance for the Foundation Stage issued in Summer 2000. The Goals became mandatory—a National Curriculum for Early Years. Secondly, the age range was changed and the new curriculum applied to all children aged 3-6 years whatever setting they were in. This was now called the Foundation Stage. Whilst the Goals were very similar to the Desirable Outcomes, the Guidance was written in the form of steps for each goal, not case studies. The Goals were put together with subheading; designing and making and exploration and investigation are two that link closely with design and technological capability. Again this caused confusion. On asking over fifty teachers during Professional Development days about the links, over 90% identified the designing and making sub-title as meaning the same as design and technology. On examination of the two Goals within design and making, it is apparent that the skills and knowledge in this
section are almost exclusively related to making. Again this could lead to confusion about the nature of design and technology. Whilst Investigation and Exploration do have suggestions relating to, for example, ‘find out about objects they observe’ (QCA 2000), it appeared from asking the same teachers that the majority focused on the natural world and objects within that. From this analysis, it could be argued that Foundation Stage educators were not receiving clear messages about the nature of the subject, nor on how to develop the children’s capability through the published documentation.

A review of practice
Every year the Qualifications and Curriculum Authority (QCA) monitor different aspects of their work. As a result of this, a research project was commissioned and undertaken in West Midlands primary schools during the summer and early Autumn 2001, focusing on how the Early Learning Goals (ELG) are supported through design and technology experiences.

Setting up the research project

Choice of schools
It was decided to use schools that had a nursery attached, so that the participants would be working across the Foundation Stage. All the schools involved had had a subject leader, who had taken part in a ten day design and technology Inset course based at the University of Central England, during the past 5 years. It was decided to use these schools as the researcher had already an established link and it would mean that all the schools, in theory, should be aware of the subject and therefore may have some established practice on which the research could be based.

Timescale
With the short timescale allowed for the project, it was decided to use schools with which the researcher already had contact to aid a quick response from teachers. This meant that there was no ‘cold calling’ involved when contacting the schools.

Choice of Case studies
Four were selected; the final choice was based on the availability of staff and the researcher to meet and join the Early Years classes for taught sessions. In this paper it is not possible to include details of these, but the findings are all supported by evidence collected from the case studies.

Methodology
For the main body of evidence, the researcher made the decision to use questionnaires. In the time available it was not possible to do a follow up structured interview with a selection of teachers, though this would obviously have given more detail and allowed for further clarification of issues.
For the four case studies, the teachers completed a questionnaire and were involved in structured interviews. The researcher spent an afternoon in each class to familiarise herself with various aspects of practice including routines, the classroom environment, the children, the methods of teaching, relationships and resources.
Questionnaires were sent to 52 participants of ten day Inset courses for design and technology and 49 questionnaires were returned. The high response rate was almost certainly because, the researcher had already established a good working relationship with the teachers, she had stressed the importance of returning the questionnaire (and that this in turn may lead to additional support for Early Years), and she had carried out some follow up phone calls to ask for the return of their return. None of the teachers who completed the questionnaires were subject leaders.

Limitations of the project
• It was meant as a snapshot of current practice, based on the West Midlands. However, the findings may differ, region to region, according to a number of factors such as the amount of design and technology and early years advisory support that is available, different levels of funding and the ease of reviewing appropriate resources.
• Findings may have been different if the chosen schools had not had a member of staff that had taken part in extended design and technology Inset over the last five years. None of the respondents were subject leaders and none had had substantial amounts of Inset relating to design
and technology. Had they had Inset opportunities for design and technology, they may have approached their teaching differently.

- This was a project with a framework given to the researcher and could not be changed to follow personal interests or initial findings.

Analysis of findings
The findings are reported under the following headings as these were the areas that were identified in the contract for the project.

Teachers’ understanding of the D&T process
Teachers were asked to circle key words that they felt best-described design and technology and to write a short piece about their understanding of design and technology.

- Majority of teachers showed that they thought that the subject focused on the making aspect. Design and technology involved learning about, and using, a range of materials, and tools to make a product. Knowledge and understanding of mechanisms was important and structures were less important. 76% of teachers felt that creativity was important in design and technology and that it was about innovation, trying things out, and changing things as you went along.

- Food was linked to cooking and skills rather than d&t for 53% of teachers; only 45% of teachers identified ICT as relating to d&t.

- 67% of teachers did not identify designing as part of design and technology. Nor did they include product evaluation, using products to investigate other cultures, a need or purpose for the product, or the idea that children should be making their own decisions about the nature of the product to be made.

Links to other subjects and areas of experience

- Other subjects
  83% of teachers responded that they did not identify particular subjects in their planning, nor when thinking about activities. They usually thought about an appropriate activity first, then saw what area/s of experience it linked to and did not look further to see if they had a balance of subjects or if they were building steps to KS1 programmes of study for each subject. They expected that the Goals had done that. 95% felt that their planning had breadth and balance, despite the fact that obvious gaps emerged.

- Areas of experience
  The teachers scanned a handout of all the ELGs and identify where design and technology came in the areas of experience. Not surprisingly, there was a 100% response to knowledge and understanding of the world. However, there were significantly lower responses to all the other areas. Only 27% thought that there was any link between design and technology and Personal, social and emotional development (PSE); 34% mathematical development; and 39% between Communication, language and literacy. This initial response shows that teachers do not think of the subject as spanning the other areas.

How work in Early Years supports later d&t experience
The respondents were given a check-list of ideas and space for other comments.
The following indicates where there was a positive response of over 50%

- Planning an appropriate curriculum
- Making
- Knowledge and understanding

Mechanisms
Structures
Variety of materials/ properties of materials

- Way of working

Choosing activities
Plan do review (High scope)

- Communication
- Basic manipulative skills, including use of a variety of tools and equipment
Technical vocabulary

Under 20% of respondents thought that the following were covered in depth.
- Designing
- Product evaluation
- Values issues

Issues that teachers raise
The respondents were asked to identify three key issues in relation to the ELG and d&t. These were given in over 55% of responses.
- Not a clear understanding of design and technology
- Not a clear understanding of D&T in relation to ELG
- Very limited printed support materials available for ideas
- Appropriate artefacts to use for evaluation
- Is there a need to separate out subjects in Foundation?
- If there is not a clear understanding of subjects in Foundation, how can appropriate links be made with KS 1?
- Do Foundation teachers need to have a deep knowledge and understanding of subject areas?
- Bridging the gap between Foundation and Key Stage 1-this is an increasing area of concern
- What technical vocabulary to use and when
- Health and safety-what can children use/do safely? What regulations are there? How can teachers find out? There are many ‘myths’ surrounding health and safety.

What teachers teach

In summary majority of teachers, focus on making aspects, giving children a choice of materials and tools. They allow the children to ‘be creative’ through free or structured play. They do encourage the children to talk about what they are doing and why they are doing it.

There is rarely a purpose for the product; there is very limited evaluation; designing, including product evaluation is rarely identified or focused on; and there is little direct teaching about materials, joiners or appropriate finishing techniques.

There was a very narrow view about what related to d&t and although teachers teach many other aspects of d&t (the researcher saw evidence of it in the observations in the Case studies) they did not identify them as d&t.

How they teach it
Teachers identified 3 main ways in which the children experienced d&t.
- Free play/choice
  The children are mainly engaged in constructing with kits, a range of reclaimed materials or working with paper and card. They would have a limited choice of joining and finishing materials. No-one identified a ‘collection table’ or ‘fiddling’ type of table where children could find out about products.
- Structured play
  The teacher has identified the main outcome but the children have freedom within this. The activities were similar to those in free play but the teacher would identify a focus e.g. what would/ could you use to join your paper and card? The teacher would have thought about particular questions they want to ask.
- Direct teaching
  Teachers mainly indicated that they did not do much direct teaching relating to d&t. They felt it was a creative activity and they did not want to direct children too much or impose their ideas.

Positive developments
- Teachers were positive about the Early Learning Goals. They felt that the Guidance material had some useful examples but that the steps were sometimes inaccurate, confusing and there was ‘a lot of it to take in’.
The children are engaged in a variety of making activities, using different materials and joining techniques. The teachers had a positive view of ‘d&t type’ of activities and the value for the children. Majority of children are encouraged to talk about their making, what they are doing and why. Many are involving the children in activities linked to other cultures and times past. The respondents felt that it was important to understand what d&t really is and how it links with KS 1 even if they do not know now.

Areas for development

- Understanding of d&t
- Designing, including product evaluation
- Understanding of d&t in relation to the Early Learning Goals
- Planning frameworks to ensure a broad and balanced curriculum
- Liaison between Foundation unit and KS 1
- Inset particularly re the nature of d&t and product evaluation
- Appropriate materials to support teachers
- Exemplar materials
- Assessment
- The role of other adults in the classroom and their professional development

Through this final section, the areas for future development have been identified, and it is hoped that there will be strategies that will take these developments forward.

References

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Considering the impact of design & technology on society – the experience of the Young Foresight Project

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

Abstract
The design tool developed by the Young Foresight Project to help students design but not make products and service for the future is described. The values embedded in three existing products are explored by using the design tool in reverse to reveal the relationship between each product and the society in which it is used. A new material, which has considerable technological potential, is described. The results of students using the design tool to develop products and services using this material as a starting point are presented and analysed to provide insight into the values they bring to bear on the uses to which this, and perhaps other, technologies might be put. The discussion section considers some of the issues involved in introducing socio-politics into a design & technology curriculum that has been dominated by technical education requirements.

Key Words:
design, markets, new and emerging technology, technology and society, Young Foresight

The Young Foresight Design Tool
Young Foresight is an initiative for the subject of design & technology in Year 9 of the English National Curriculum. It requires about one term of design & technology curriculum time and the culmination of the activity is designing but NOT making products and services for the future. The students work in groups and use a new and emerging technology as the starting point for their design. Each student group has to present and justify their design proposals to the other students in the class. Particularly innovative proposals are sometimes presented to audiences from the business community at education – industry link conferences. The design tool is summarised in Figure 1 as a tetrahedron with each vertex having a particular label – technology, people, society and markets. The point is made to the students that a tetrahedron needs four robust ‘corners’, if any corner fails the structure collapses and by analogy they are persuaded that unless they consider each of these features the product or service they develop will be fatally flawed. The need to consider each of the features is justified as follows.

Using the Design Tool to Reveal Values in Existing Products
It is instructive to use the Young Foresight tetrahedron in reverse to inspect existing products and reveal their relationship with the society in which they were or are used. Here are four examples:
• Obsidian spearheads used during the Ice Age
The technology here is ancient – flint knapping. Skilfully applied this technology produces beautiful and deadly spearheads. Early peoples in the Ice Age were highly vulnerable to predators and this technology gave them an equaliser, a tool that could be used to protect and to hunt. The ‘market’ for these tools is difficult to discern as the trading habits of these peoples is poorly known. However the spearheads have been discovered in great numbers and were widely used. This is a product that meets the survival needs of the people using it and one that is highly acceptable and desirable to the society in which it is used. The initial impact was clearly beneficial but some argue that the use of this product had huge effects on the prevailing ecology. 91% of the mammal genera that disappeared at the end of the ice age in the Americas were megafauna. In contrast, during earlier American extinctions megafaunal mammals represented only 22 to 78% of casualties. Animals that vanished include the giant ground sloth, the short-faced bear and the sabre-tooth cat. This jump to a 91% fatality rate is seen as evidence of human hunters, as humans are unique predators in that they target large animals in the prime of their life, rather than taking the young or the sick. They can thus have a very dramatic impact on the populations of the animals they hunt. This in turn would affect the animal predators, like the sabre-tooths, which depended on those prey. The final extinction in the Americas occurred over a much shorter time span (a few thousand years) than some of the earlier events. Again this is seen as the work of humanity, who colonised the whole continent in a relatively rapid period. (See this website) http://www.bbc.co.uk/nature/programmes/tv/monsterswemet/extinction_americas.shtml 14.4.03 8.58am)

• Grand Theft Auto (vice city) – a very popular computer game at the beginning of the 21st Century
Computer games are a highly successful and growing market. This game is widely regarded as one of the most advanced and sophisticated of its kind. The central character is an enforcer, Tommy Vercetti, who works for a gangland boss, Sonny Forelli, who sends him on a variety of illegal missions in his attempts to control and benefit from the crime in Vice City. The missions invariably involve stealing cars, high-speed car chases and violent gun battles. From a marketing point of view this product is a huge success. From a technical perspective it is highly innovative creating a raft of diverse characters and scenarios from 1980’s Miami. It has received the games industry’s highest accolades: PSM Game of the Year 2003, Best PS2 Game of the Year 2003, Best Video Game of 2002 (See News on http://www.rockstargames.com/vicecity/ 14.4.03 9.16 am) Lots of people play the game and enjoy it. But is it acceptable to society? At one level it is as it is legal although it does have an 18 rating, yet at another level it is highly questionable.

• Cadbury Creme Eggs – a popular confectionary at the beginning of the 21st Century
This is a highly popular confectionery item. It is only available during January to Easter and during this time it outsells all other confectionery items. It is about the size of a small hen’s egg and consists of a chocolate shell, which contains a white sugary syrup around a ball of yellow sugary syrup mimicking the white and yolk of a real egg. It is sickly in the extreme. There have been several marketing campaigns over the past 18 years:
1985 the “How do you eat yours?” campaign begins
1990-1993: The first TV advertising campaign to feature the “How do you eat yours?” theme achieved through Zodiac characters
1997-199 George Dawes from Reeves & Mortimer Shooting Stars TV Game
2000 and beyond: The “pointy hand” campaign
(See http://www.cadbury.co.uk/choc_enc/brands/cegg.htm 14.4.03 10.00 am)

The technology in the crème egg is not sophisticated. The materials used are not new and with care it can be prepared in the home kitchen. It is the scale of manufacturing linked to the marketing that is impressive and perhaps cause for concern. The website reveals that the manufacturing plant at Bournville in Birmingham has the capacity to produce more that 1.5 million eggs in a day and 165 million eggs are sold each year – approximately 3 for every person in the UK. So there is no doubt that a market exists and that Cadbury are maintaining the market with extensive TV advertising campaigns and selling into the market very effectively. As a product it is clearly an item that people want and buy even if they don’t actually need it. As a society we are indulgent towards the consumption of confectionery even though there is evidence that the composition of such items is not necessarily nutritionally beneficial. Of course it depends on the extent to which such high sugar, high fat items contribute to an overall diet. Government health guidelines
suggest that they should form a minority component. The nutritional information provided on the Cadbury website leaves much to be desired. (See http://www.cadbury.co.uk/fr_faq.asp?loc=1 14.4.03 11.09 am) By using Nutri-wizard we can find out that a creme egg is not colour free, corn free, egg free, milk free nor soya free but that it is ethanol free, gluten free, nut free and salt free. As such it is suitable for vegetarians and is both kosher and halal. But not a word about the fat or sugar content!

By considering the four features of the Young Foresight the power and value positions of the confectionery industry are clearly revealed.

**Student’s use of the design tool with a new technology**

Young Foresight has produced a short stimulus video about a new material, quantum tunnelling composite, QTC, which has considerable technological potential. The video is used as the starting point for a Young Foresight challenge, which can be summarised as follows:

Quantum Tunnelling Composite (QTC) is a brand new material. It comes as thin sheets or a powder. It can be built into textiles or fixed to hard surfaces. In a relaxed state it is a good insulator. When it is stretched, squashed or twisted it becomes a conductor. The harder you stretch, squash or twist it the better it conducts. It’s already been used in power tools and a robot hand. What would you use it for?

Here are four responses developed by students aged 13/14 years.

**QTC in Fashion**

This design proposal (shown in Figure 2) uses QTC in two ways. Firstly on a graphics tablet worn on the sleeve, which uses the electrical signals generated by changes in pressure on QTC to provide the digital information required to display messages on a ‘soft’ screen in a T-shirt. Secondly QTC in the soles of the trainers respond to the pressure patterns caused by dancing to generate electrical signals that can be used to make the electrically sensitive dyes in the trousers become luminous. The wilder your dance the more extreme your trousers – the ultimate peacock!

**QTC in Road Safety**

This design proposal (shown in Figure 3) uses QTC in car tyres as a means of continuously monitoring the pressure and signalling a gas cylinder when ‘top up’ is necessary. This idea was developed in response to finding out that there are over ten thousand deaths per year in the USA through under-inflated car tyres.
**QTC in Oral Hygiene**
This design proposal (shown in Figure 4) uses QTC in a child’s toothbrush. First QTC in the handle detects whether the toothbrush is being gripped firmly and then the QTC in the head detects whether the bristles are applying sufficient pressure to the teeth. If both these conditions are fulfilled the brush rewards the user by playing a tune.

![Figure 4](image)

**QTC in Health Care**
This proposal (shown in Figure 5) is a device to be worn by a person who suffers from epilepsy. The QTC detects the attack through the rapid expansion and contraction of the jaw muscles that are a consideration of the four features forces students to engage with the impact of the product on the society in which it is being used. It is a natural extension to consider impacts beyond intended use and those who might be disadvantaged by the product (the losers) as well as those who benefit (the winners). In this way the evaluation can be linked to the Nuffield Design & Technology Project Winners and Losers strategy for evaluating the impact of a product or technology (Barlex 2000)

![Figure 5](image)
An important consideration in the use of the Young Foresight Tetrahedron and the Nuffield Project’s Winners and Losers is the role of the teacher. Both these strategies have been developed to give the students a voice about matters that concern them. The role of the teacher is to enable the students to find and use this voice; particularly in discussion and argument with each other. The views of the teacher are, to a large extent, irrelevant. The knowledge pool at the teacher’s disposal may also be irrelevant. Patricia Murphy (in Barlex 2003) has argued that the prevailing mode of teaching in secondary schools is hegemonic and that this is largely inimical to students using, developing and articulating their own understanding of the world. This prevailing orthodoxy, particularly strong in technical education, will need to be challenged if teachers are to extend their pedagogic repertoire to embrace the socio-political dimension of design & technology education.

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TeachandLearn.Net: Using new Technology to support D&T Teachers

Frank Banks, Centre for Research and Development in Teacher Education, Faculty of Education and Language Studies, The Open University
Email: f.banks@open.ac.uk

Abstract
During 2003/2004, The Open University in the United Kingdom, in association with the BBC, will launch a wholly on-line continual professional development environment for teachers to be known as TeachandLearn.Net. Focusing on the example of the materials developed for Design and Technology teachers, this paper will consider the rationale, design and learning purposes of this novel approach to teacher development. The line of pedagogical development of on-line technologies from the Learning Schools Programme (see paper in PATT-11) to the current flexible Postgraduate Certificate in Education (PGCE) course, through to the proposed TeachandLearn.net will be explored.

Key Words: On-line Subject Knowledge Pedagogy
**PATT 13**

**Introduction**

Imagine two methods for educating teachers. The first method requires the teacher to travel to a centre for a particular event, at a time that may not suit them and is unable to take account of their motivation for learning on that particular occasion. The learning takes place outside the school context and the teacher is expected to do much of the transformation and translation of the learning experience to match their own circumstance. Once that learning experience is over, it is not repeatable in that form. An alternative is to allow the teacher to undertake such Continued Professional Development (CPD) activity when they feel like studying and in their own school environment. If they want to go over a point again as they need longer to grasp a concept, or if they wish to re-visit an idea in the light of classroom trialling and further experience, then they are able to do so. For teacher CPD, Open Learning has many obvious benefits over centre-based face-to-face provision. I am not suggesting that Open Learning is a new idea, nor that teacher professional education is really so neatly divided into two separate camps. As long ago as 1986 Lewis said:

> The phrase ‘open learning’ is regrettable in that it has an ‘all or nothing’ ring to it. In fact many traditional classes have some open characteristics…nor is it necessary to wait for new resources to open up learning. Teachers or tutors anywhere can open up one or more aspects of their work by an intelligent redirection of existing resources. (Lewis, 1986)

However, new technologies offer new opportunities. The way that the web enables both pre-arranged and more free-range and *ad hoc* learning experiences to be delivered to the heart of a teacher’s day-to-day concern, their classroom, is indeed –at least for many UK school teachers –a relatively new experience.

The quality of Open Learning experiences can be interrogated by using the questions What? Where? When? and How? What resources such as teacher guides and materials, pupil materials and audiovisual examples are included in the media mix? Where is the learning located - in a fixed location (by being tied to a computer for example) or more mobile, say with the computer as just a delivery device? When does the experience take place – are there just one or multiple start points per year, or is it is continuously available? How is the learning structured - into a course with a beginning, middle and end - or more flexibly with different teachers using a range of ‘Learning objects’ in different ways?

But what professional learning experiences are appropriate for teachers of design and technology (D&T)? What are their expectations for CPD? Must all provision be rooted in practical ‘doing’ subject knowledge? Teachers learn at least from each other as much as they do from other ‘experts’. How can learning within such a community of practice be enhanced? Is on-line learning an acceptable alternative to conventional CPD experiences? It is in attempting to answer these questions and learning from former on-line courses that has influenced the forthcoming on-line CPD environment named TeachandLearn.Net.

**What sort of CPD do technology teachers want?**

As long ago as 1994, the Design and Technology Association (DATA) surveyed the training needs of D&T Teachers in England and Wales (DATA, 1994). That survey assumed that the most important issue to address was in what particular subject elements in the national curriculum for D&T were teachers either untrained, or considered them selves to be inadequately trained, to teach. There was a given assumption that it was the only ‘rectification’ of their subject knowledge ‘deficit’ that was required. For example, 78% of teachers who responded reported that they had no training at all in aspects of ‘Business’, whereas only 8% said that they had no training using metal as a resistant material. Interestingly 75% said that they were inadequately trained to teach aspects of design. No doubt a lot of personal development, both formal and informal, has taken place over the last 10 years. But the way that teacher courses principally focus on updating or re-training in new subject knowledge is an interesting cultural feature of the D&T domain in the United Kingdom. Indeed when the subject content of the English D&T curriculum altered, so did the priority order for teachers’ in-service needs to reflect the need for new subject knowledge.

New pedagogical strategies still have a relatively low priority for D&T teachers. This is unlike teachers of History or Science where the common expectation is that CPD courses will lead on novel pedagogy such as techniques for discussion strategies or group solutions to problems. Mathematics teachers might do some mathematics to model pupil learning, but learning of that subject knowledge itself will not be the main
PUPILS' ATTITUDES TOWARDS TECHNOLOGY

This expectation of technology teachers, however, may change with the recently government introduced (and financed) focus for teachers of the 11-14 age range in CPD topics such as ‘Learning Styles’, ‘Thinking Skills’ and ‘Assessment for Learning’.

Teacher expectations of professional development are very important and such subject-cultural expectations of what counts as ‘good’ CPD cannot be ignored. However, it may be that for Design and Technology as a developing subject in schools, the current subject knowledge/pedagogy balance is wrong. Pupils may indeed like D&T when it is modern, relevant, and uses new and up-to-date equipment; but they will only learn, enjoy and continue their studies in the subject if it is well taught too.

THE OPEN UNIVERSITY EXPERIENCE

The Open University’s Learning Schools Programme (LSP) in relation to the professional development of D&T teachers was described in detail at PATT-11. That programme had a focus on the better teaching of Design and Technology by the use of ICT in the classroom/workshop and consisted of print material, audio-visual examples on a CD-Rom and an on-line D&T teacher community. Over the life of the project, well over 160 000 teachers engaged with LSP and significant numbers (approximately 40 000 across all subjects) shared on-line ideas, resources and collaborative planning. Teachers working together in such a community of practice, using text-based asynchronous computer conferencing, can share understandings, classroom experiences and pedagogical insights.

Lessons learnt on one programme, such as LSP, feed into the next both in terms of practical techniques and in substantive research. For example, LSP faced the logistical problem of welcoming to a flourishing on-line CPD computer conference those teachers new to the programme that had to be quickly brought into an existing ‘room’ colonised by ‘old timers’. Formal research studies provided insights too. For example, research on how teachers engage in on-line professional development suggested that on-line teacher conferences are influenced by three context factors:

• the way in which e-conferencing is organised within the context of a formal course;
• the contrasting character of subject domains;
• the length of engagement of the participants in e-conferencing.

The last factor, in particular, influences the participants’ transition from novices to more experienced users of e-conferencing. Key dimensions of this transition are:

• the formulation of online relationships among the participants;
• the visualization, by the participants, of the online event.

Within successful e-conferences, teachers’ professional development can be stimulated in new ways, through developing communities of practice and through creating new forms of reflection within e-conferences. The role of the moderator is crucial in stimulating effective e-conferences that develop reflective practice and learner autonomy. The moderator’s role, in particular, is in forming the electronic community of practice through structuring the learning resources of the community. (Kyriakidou, 2002)

The open-learning materials developed for the Learning Schools Programme needed to be updated, and good ideas suggested by teachers themselves, or witnessed by academics making quality assurance visits to schools, needed to be shared across the community. Classic Open University systems adopt an industrial model to course design and production. For example, a large resource (often running into millions of dollars) is spent in the development of highly illustrated books, TV programmes and, maybe, multi-media materials. Over the five-year life of the course, thousands of students use and pay for the initial outlay through their course fees. Set up costs are very high, but marginal costs are very low, so a programme can double its student population very easily. With on-line development and delivery a hybrid model is possible, allowing some set-up resource to be held back for responses to suggestions or government regulation that were formally either impossible or highly expensive to achieve. LSP, therefore, developed a series of short web-based units of study called ‘cameos’ which added particular new relevance to the existing examples provided on the CD-ROM.
The new initial teacher preparation course from the Open University, the flexible PGCE, is almost entirely taught on-line. Using a combination of e-conferencing, down-loadable modules and web-links, a student is able to have a course tailor-made to their personal circumstances and prior achievement. Students follow an on-line needs analysis process and, depending on their prior school teaching experience, can be offered the equivalent of a full-year conventional preparation, or two-thirds, or one-third, of such a course; or if they are very competent but do not have ‘qualified teacher status’ (such as teachers trained outside the EU), an ‘assessment-only’ route is possible too. In this way, open learning is now breaking out of the constraints of time to embrace flexible course-lengths and away from a ‘one-size-fits-all’ approach to teacher development. Here professional development is possible at the level of the individual who selects the web-based units pertinent to their individual needs, albeit towards a common set of required learning outcomes determined for all participants at the start.

The next step is to develop a series of resources, across subject knowledge and pedagogy, which can be used by an individual or a group of teachers as a means to address their own specific professional needs.

**TeachandLearn.Net**

In association with the BBC, the Open University is to launch an on-line teacher CPD environment for all teachers across the UK, in primary, and in all secondary subjects including Design and Technology. Schools interested in obtaining access to the professional development site will subscribe at a rate depending on the size of their school. Teachers then logging on with their own individual password will be offered a tailor-made environment appropriate to their declared subject specialism and interests. All secondary subjects follow the same template of twelve so-called ‘web-units’. Six covering aspects of teacher subject knowledge and six on aspects of pedagogy appropriate to their subject. Working with a group of D&T teachers as authors and advisors, the following topics have been identified as being relevant and of particular interest for the initial development of the site:

<table>
<thead>
<tr>
<th>Teaching and Learning Course – developing ideas for teaching your subject</th>
<th>Exploring Subject Knowledge – updating and extending your knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD/CAM</td>
<td>CAD/CAM</td>
</tr>
<tr>
<td>2D 3D modelling</td>
<td>Real Designers in Action</td>
</tr>
<tr>
<td>Creativity &amp; Innovation</td>
<td>Innovation, Creativity and IPR</td>
</tr>
<tr>
<td>Project Management</td>
<td>‘Smart’ Materials</td>
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<tr>
<td>ICT</td>
<td>Systems Thinking</td>
</tr>
<tr>
<td>Responsibility of the designer</td>
<td>Industrial Practices in D&amp;T</td>
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</table>

TeachandLearn.Net: Using new Technology to support D&T Teachers

The web-unit template gives a degree of uniformity to what is a formidable logistical challenge of developing so many web pages with exciting and relevant ‘assets’ such as images, articles, audio-visual resources and appropriate supporting web-links, with copyright all cleared for use. The electronic template also captures the meta-data needed later to enable a teacher to find the particular learning objects they require when the copy is placed on the web site.

**Answering the questions:**
What: Web based information using text, downloadable pdf files, and some video examples of good practice and a supporting on-line computer conference environment
Where: Teachers can work together on the materials at school, for example as part of departmental meeting, or at home. They do need access to a network device.
When: Anytime. If the teacher wants to offer their learning for accreditation, then they do specific related tasks with the resources and submit assignments at points through the year.
How: The environment is a series of web-based learning opportunities offering structured CPD or more ad hoc information including news and guest lectures.

Will it work?
A number of challenges face the programme:

- Classroom culture
  The reluctance of teachers to change classroom practice which currently seems to work for them is a challenge to any in-service programme whatever the model or mode of delivery. If a school is to re-subscribe, school managers will want to see some effect and the benefits of a substantial CPD site such as this may not offer improvement as a ‘quick-fix’.

- Tips or professional development
  There are many existing web-environments that offer classroom resources or lesson plans ‘off the shelf’. TeachandLearn.Net is not a ‘tips for teachers site’, but it needs to strike a balance between challenging existing practice and offering activities that can be easily and quickly tried out by teachers in school.

- D&T Teacher expectations
  This programme recognises that there is an expectation from D&T teachers that when on a CPD course, they will be updating and extending their subject knowledge, so half of the programme is configured in that way. However, new practical skills are not addressed. What has been tackled head-on is the suggestion of how to introduce different teaching strategies and this permeates the more subject-based units too.

- Learning via the net
  Will teachers accept on-line learning? The impact of ICT and its promised revolutionary effect on teaching and learning has been over-hyped since the introduction of the first simple PCs in that late 1970s. However, the way that the World Wide Web has opened up access to knowledge and information has started a cultural change that really has now impacted on schools and on school teachers as much as anyone in the community.

Market research indicates that schools and teachers will value CPD offered in this way. As indicated above, scholarly research and practical experience has informed the design and pedagogic strategy. We are optimistic and excited by the challenge.

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Appropriate instructional methodology for the facilitation of technological problem solving in the Instructional Web Design Programme (IWDP)

Dr. Maria Jakovljevic, School of Economics and Business Sciences, University of Witwatersrand, South Africa.
Ankiewicz Piet and De Swardt Estelle, Rand Afrikaans University, South Africa
Email: mariaj@isys.wits.ac.za

Abstract

The current instructional methodology in project-based classrooms is inadequate to promote the understanding of information system design including web design. The purpose of this paper is to identify and to discuss relevant components and the instructional methodology of the Instructional Web Design Programme (IWDP) and its influence on technological problem solving of learners in the project-based
The IWDP with a set of assessment criteria (AC), range statements (RS) and performance indicators (PI) offers an array of innovative instructional strategies.

This research was based on a qualitative, action-research approach. Seventeen students at an institution of higher education were observed in a project-based classroom and their experiences with regard to the IWDP were evaluated through a focus group interview, as well as journals and essays. In addition, the interview with the teacher was performed to investigate thoughts and feelings during the implementation of the IWDP.

The most important findings were: information system design should be done through the stages of the technological process to counteract for the complexity of it’s analysis; employing practical and cognitive apprenticeships contribute to technological problem solving; step-by-step instruction in a peer-based collaborative learning environment influences thinking skills in the information systems design (ISD) context.

Introduction
The research literature on information systems design (ISD) is mainly concerned with the phases in information systems design and development, technologies, and technical devices with which to aid learning (Powell, 2000; Harris, 1999). The research literature is depleted of instructional aspects, which guide the teaching of multimedia construction (McGrath, Cumaranutunge, Ji, Chen, Broce and Wright, 1997:21). However, researchers appear to be divided over how to facilitate technological problem solving (Custer, 1995:231; Shield, 1996:1; McCormick, 1997; 1998:207) and more specifically in an ISD environment (Jonassen,1996; Jakovljevic, 2002:244).

Learners’ lack the skills for clearly defining the problem; techniques in handling the available data and understanding the methods of problem solving (Cotton, 1995:140). Educators must seek to develop an individual who has the ability to solve technological problems, evaluate the technology product; one who is innovative, critical, responsible and effective (South Africa, 1997:9-91).

The purpose of this paper is to identify and to discuss relevant components and the instructional methodology of the Instructional Web Design Programme (IWDP) and its influence on technological problem solving of learners in the project-based classroom.

The research questions addressed in this paper are:
• What criteria for the IWDP development can be derived from the theoretical framework?
• What should the components of the IWDP be?
• What aspects of instructional methodology are necessary to facilitate technological problem solving?

The framework for the Instructional Web Design Programme (IWDP)

Basis underlying the development of (IWDP)
To explore and identify the appropriate instructional methodology for the facilitation of technological problem solving, an Outcomes-Based (OBE) instructional programme was designed, developed and implemented at a higher educational institution (HEI).

The following aspects provided the basis underlying the derivation of the IWDP: policy documents related to Technology Education and Outcomes-Based Education in South Africa; criteria for the IWDP based on the theoretical framework (mind tools, complex thinking, learning theories, instructional models and strategies); widely accepted ideas on learner-centred instruction; the conceptions of the Illustrative Learning Programme; the roles and competencies of the teacher in technological classrooms (Jakovljevic, Ankiewicz, De Swardt & Gross 2002).
The nature and the scope of this paper highlight the theoretical framework on learning theories, instructional models and strategies.

**Most prominent criteria for the IWDP development derived from learning theories, instructional models and strategies**

An in-depth literature review was performed and different conceptions on mind tools, complex thinking and instructional strategies were analysed and served as the framework in compiling the (IWDP). The development of the IWDP was based on both the behaviourist and constructivist instructional approaches, learning theories, instructional models and strategies (Clark & Lampert, 1986; Smallwood, 1995; Johnson, 1997). To be effective in the facilitation of technological problem solving the teacher must be familiar with the knowledge of the thinking processes and skills in general, the characteristics of the instructional design and the role mind tools play in promoting intellectual skills in any learning context.

Due to the fact that the focus of this paper will be on the teacher activities the most prominent criteria for the IWDP which relate to instructional aspects are presented in the table 1:

<table>
<thead>
<tr>
<th>Criteria (Learning theories, instructional models and instructional strategies)</th>
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<tbody>
<tr>
<td>Direct teaching and fostering observational learning during demonstrations are essential for acquiring factual knowledge and basic skills in the project-based classroom.</td>
</tr>
<tr>
<td>Technological design should be taught through a guided discovery approach, where learners are not presented with the subject matter in its final form.</td>
</tr>
<tr>
<td>Cognitive apprenticeship with coaching, scaffolding, prompting and fading in a collaborative learning environment is essential in the project-based classroom.</td>
</tr>
<tr>
<td>In web page design instructional strategies that supports reflective practice, activity-based practice, and peer-based learning in a rich contextual environment help learners to develop intellectual skills.</td>
</tr>
<tr>
<td>When applying a constructivist or behaviourist approach, a variety of instructional strategies (for example, brainstorming, inquiry/investigation, discussions, case studies, activity-based practice, project work) are essential for technological problem solving.</td>
</tr>
</tbody>
</table>

**Table 1**: Most prominent criteria for the IWDP drawn from learning theories, instructional models and strategies

**The components of the IWDP**

Based on OBE and a nationally agreed definition of a learning programme, the following components of the IWDP, have been identified (See Table 2): Theme; Outcomes: Critical and specific outcomes (CO’s, SO’s); Content: Conceptual, Range statements (RS), Performance Indicators (PI), Procedural (including the ten stages of the technological process); Learners’ tasks (case study, resource and capability tasks); Learners’ on and off-line activities; Teacher’s activities (Instructional strategies), Assessment criteria (AC); Notional time ( Ankiewicz, De Swardt & Stark, 2000:122; Jakovljevic, 2002; Givens & Barlex, 2001; Reddy, Ankiewicz, De Swardt & Gross, 2003).

A brief illustration of the components of the IWDP highlighting only one stage of the technological process namely Initial Ideas is provided in Table 2 below.

<table>
<thead>
<tr>
<th>Time Allocation: 4 Hours</th>
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<tbody>
<tr>
<td><strong>Specific outcome 4 (SO4): Select and evaluate products and systems</strong></td>
</tr>
<tr>
<td><strong>Specific outcome 5 (SO5) – Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TECHNOCALOGICAL STAGE: INITIAL IDEAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASSESSMENT CRITERIA (AC)</strong></td>
</tr>
</tbody>
</table>
Learners should produce work in which:

AC1 of SO5:
Various factors influencing a car purchasing solutions are considered.

AC2 of SO5:
Casual relationships between given/main factors influencing technological development related to car purchasing schemes are reflected upon.

AC3 of SO5:
Different technological solutions are compared

AC4 of SO5:
New solutions are predicted.

Learners should show detailed, logical work which reflects:

Content
Research of three main ideas
Analysis of a list of advantages and disadvantages of relevant ideas

Context and perspective: local, national
Mode: individuals, pairs, groups.
Presentation: oral, written, graphic
Resources: texts, interviews, observation.

This will be evident when learners:

PI 25 Research, observe and analyse communication features of on-line products and systems.
PI 26 Display emotional readiness in composing a proposal structure.
PI 27 Motivate whether and how one solution may be more effective than the other.
PI 28 Show excitement in reﬁning ideas and sensitivity to team members’ contributions.
PI 29 Use numeric, textual and graphical data in searching and locating technological resources.
PI 30 Generate ideas as possible solutions to the problem and describe their advantages and disadvantages.
PI 31 Share and justify propositions regarding risks/beneﬁts and constraints of the business case.

| Tasks, Off-Line, On-Line Activities And Teacher Actions For The Technological Stage INITIAL IDEAS |   |   |
|---|---|---|---|
| Type of tasks | Learners’ activities | Teachers’ actions (Used as a guide) |
| Resource tasks | Capability tasks | Off-line activities | On-line activities |
| Task 6.E-2.1 Formulate the idea of what has to be done in order to create a car purchasing scheme. | Task 6.E-2.2 Write down at least three ideas each on a separate page as possible solutions to the problem. | Ac1. Decompose the problem into sub-problems (different dimensions of a problem can merge or be combined into a net of relationships). | Ac1. Familiarise yourself with the Mind Map software and develop a net of ideas with possible links between ideas. |
| Task 6.E-2.3 List disadvantages and advantages of proposed ideas. Use colours and labels to add a descriptive quality to your list. | Ac2. Elaborate on ideas writing their advantages and disadvantages. | Ta1. Discuss the characteristics of the stage Initial Ideas and relevant performance indicators with learners. |
|   | Ac3. Generate alternatives. | Ta2. Assign tasks, activities to collaborative groups. |
|   | Ac4. Assess and understand the underlying organisation of the proposed solution and decide on important characteristics. | Ta3. Help in conducting brainstorming sessions and questioning to encourage finding and formulating of new ideas. |
|   | Ac5. Reflect on the previous knowledge. | Ta4. Allow a time for ideas to build and settle. |
|   | Ac6. After brainstorming, organise ideas into categories, lists, and patterns. | Ta5. Help learners to focus on the goal clearly. Understand, assimilate, classify and/or verbalise ideas, practice and demonstrate (Edminson, 1995:27). |

Table 2: Technological stage Initial Ideas with its components

In the construction of the IWDP it is necessary to start with outcomes (CO’s, SO’s) following with the AC, RS and PI as these influence the derivation of the teacher’s activities, learners’ tasks, off- and on-line activities, and finally to the fulfilment of the CO’s and SO’s. For every stage of the technological process the contents of these components dynamically change, because the contents are adapted according to the needs of learners and the specific nature of each stage.
Research design

Research approach
This research can be described as a qualitative, single case study as the learning experience of students is investigated relating to a specific event in a bounded context (Creswell, 1994; Yin, 1994; Merriam, 1998). In this case study, action research was applied to simultaneously investigate and create changes during the investigation of web page design with new instructional strategies and tools.

Profile of the students, intervention and setting
In this study two distinct mixed cultural groups of learners were identified. These consisted of five second-year learners (2 females and 3 males – average age of 20) enrolled for the Information Systems Diploma at a Technikon, 12 first-year learners (5 females and 7 males – average age of 19) enrolled for the International Diploma in Computer Studies at a Higher Education Institution. Participants from the two groups presented a purposive convenient sample as they were available and inexpensive to this study (Patton, 1980:104).

The researcher of this study organised an extra-curricular classroom in a well equipped computer centre at a university and presented the IWDP in order to teach learners web design and to facilitate complex thinking (Jakovljevic, 2002). The IWDP was presented once a week for 13 weeks, with duration of four hours per session.

Data gathering methods and analysis of data
An experienced interviewer conducted the retrospective interview with the teacher and a focus group interview with the learners. Learners expressed their expectations of the intervention through an essay administered at the beginning of the course. They also expressed their experience with regard to the IWDP through journals written after each session of the course. Their experience of the adaptation of instruction was recorded in another essay during the IWDP.

The constant comparative method was applied to the data within interviews and between interviews (Merriam, 1998). The following measures were used for judging the validity of the research design: reliability, construct validity and internal validity (Creswell, 1994; Yin, 1994; Merriam, 1998).

Results
Figure 1 presents an overview of the teacher’s and learners’ experience of the IWDP.
Figure 1: An overview of the teacher’s and learners’ experience of the IWDP

The symbols in the diagram (Figure 1) represent the following categories:

a - A pre-defined set of AC, RS, PI, learners’ tasks and a variety of the teacher’s actions set a basis for technological problem solving
b - Explicit teaching of thinking skills and metacognitive strategies within the stages of the technological process help to extend technological problem solving
c - Employing practical and cognitive apprenticeship contribute to technological problem solving
d - Experiential and situated learning through a variety of tools and expert guidance enhanced technological problem solving
e - Step-by-step instruction in a peer-based collaborative learning environment advances the development of thinking skills during ISD.

Findings regarding the teacher’s experience of the IWDP

Emerging from the interview and classroom observation relating to the teacher’s experience of the IWDP, the following findings relevant to the instructional aspects were made:

a) A pre-defined set of AC, RS, PI, tasks and a variety of the teacher’s actions set a basis for technological problem solving

The teacher commented that: “... it was very important to have a structure consisting of tasks, activities, assessment criteria, performance indicators... as well as a variety of the teaching actions which helped me to organise the work and to lead them towards thinking...with the structured work students had the feeling that they were being guided and had more time for research and solving the problem...”

It was observed that the IWDP with its components offered a variety of teacher’s strategies to choose from (for example, explanation, demonstration, modelling, questioning, discussions, dialogues, inquiry/investigation, lecture, whole class instruction) relieved the organisational burden of the teacher leading to the effort in focusing on the facilitation of technological problem solving.

b) Explicit teaching of thinking skills and metacognitive strategies within the stages of the technological process help to extend technological problem solving

The teacher commented: “I had to adapt teaching methods...thinking skills and reflective strategies were taught explicitly...It was useful to have technological stages...”

The teacher observed that learners enjoyed her modelling of thinking skills and metacognitive strategies during the stages of the technological process. Furthermore, thinking skills and their attributes were presented, demonstrated and discussed with learners. Observations revealed that learners were thinking aloud, reflecting on their past experience and demonstrating thinking processes and skills to peers. Practising metacognitive strategies and an active involvement in learning thinking skills stimulated technological problem solving.

c) Employing practical and cognitive apprenticeship contribute to technological problem solving

The teacher reported that: “students helped each other ...I was active with one group and then I would go to the next group... learners experienced help from the project leaders, help from peers, from other groups.”

During the ISD expert-novice type of interactions were observed reflected through practical and cognitive apprenticeship. For example, a higher achieving student was assisting a less able student. Learners enjoyed the individual help provided by the teacher or peers as they were exposed to expert strategies in the context which contributed to their technological problem solving.
Findings regarding learners’ experience of the IWDP

d) Experiential and situated learning through a variety of tools and the expert guidance enhanced technological problem solving

Learners noted that: “only in class there was somebody, right Maria was there, but when we met up on our own...we need more guidance...”
Learners further commented: “when you’re designing a web page, there is a lot of tools that you can use to design it, we experienced a lot of things, we had to interview managers...we found material on the Internet, there are different applications that you can use.”

It was observed that the real-world nature of the problem as well as its open-ended characteristics was welcomed by the learners. Learners were exposed to interviews and observations in the real environment, which enhanced their thinking skills.

e) Step-by-step instruction in a peer-based collaborative learning environment advances the development of thinking skills during ISD

Learners reported: “the processing of developing software, it's a step-by-step process, you can’t just start at one point and finish at a certain point. You have to keep things going a certain order”.
Learners further commented that: “you find that if we were working as individuals the stress would have been a whole lot more, but we were working as a group we could divide what should be done in a certain step... it’s taking less time to complete the step and then we can have less stress on everybody else...everyone in the group gives ideas and you build on the ideas together...George helped me with my design”.

Observations revealed that learners actively discussed web design aspects with peers positively responding to the step-by-step instruction. Observations revealed that the implementation of the IWDP provided learners with the opportunity to experience step-by-step instruction within a collaborative environment utilising a variety of tools. The fact that they were involved in the generation and refinement of ideas with peers and exchanging their knowledge, skills and experiences on different problem solving strategies enhanced technological problem solving.

Discussion

This section presents discussion with regard to the findings of this study and their relation to the research questions.

The comparison of the findings with the criteria (see Table 1) assists in establishing the extent in which the most prominent criteria have been satisfied. Furthermore, the findings reveal that the wide range of criteria provided a sound basis for the relevant instructional methodology in the project-based classroom.

By comparing the findings it is possible to conclude that the theoretical framework on learning theories, instructional models and strategies was adequate and relevant in the development of the IWDP. Criteria for the IWDP could lay the basis for learning and instruction in the ISD context.

The components of the IWDP are regarded as necessary and sufficient due to the findings of this study and the fact that these components are based on OBE and a nationally accepted standards regarding learning programmes.

Providing the environment in which practical and cognitive apprenticeship is nurtured through peer-based learning and creative involvement of the teacher (Eggen & Kauchak, 1996:323), through an activity-based practice an effective facilitation of technological problem solving could be obtained. An interaction between an expert and novice aims at enhancing the cognitive and metacognitive skills of learners (Arzarello, Chiappini, Lemut, Marara & Pellery,1993:284). Cognitive apprenticeship promote situated
Learning by giving learners the opportunity to “…observe, engage in, and invent or discover expert strategies in context” (Johnson & Thomas, 1992:7).

Learners enjoy structured guidelines in a collaborative environment (Johnson, 1997), which support varying knowledge demands in the technological classroom (McCormick, 1994). DeLuca (1992:29) remarks that a “teacher should establish a sequence of instructions that will lead learners to independent thinking”. The incorporation of structured guidelines makes it easier to select and sequence learning experiences as one of the procedures relevant for cognitive apprenticeship (Johnson, 1997). Learners prefer a structured approach, which helps them to concentrate on content and processes (McCormick, 1997) rather than on the organisational aspects of the design (Jones, 1997).

There is a need for an explicit identification and a clear conception of thinking skills in a technology-based learning environment (Johnson, 1997:172). This was established through the explicit teaching of thinking and their attributes (Beyer, 1991).

The teacher had chosen a real-world problem taking into account learners’ experience, which resulted in experiential and situated learning. Jonassen (1996: 193-204) suggests the need for real-world problems that promote learners’ motivation, thinking skills, enthusiasm and creativity. The problem should be one that learners want to solve; it must be real and relevant to them (McCormick, Murphy & Hennessy, 1994:106), then it is more likely that the learners will transfer these skills to other areas.

An array of instructional strategies served as a guide to the teacher in promoting technological problem solving. Based on the findings, it is reasonable to conclude that learners’ performance during web design activities led to the enhancement of thinking skills.

**Conclusion**

Based on the findings of this research, in the development of programmes for an ISD context, attention should be taken to the relevant conceptual framework, the components as well as an appropriate instructional methodology.

The programme should cater for carefully selected components (see Table 2) based on the accepted standards in technology education. The programme should be based on both the behaviourist and constructivist instructional approaches and strategies and reliable and effective criteria (see Table 1) so that technological problem solving capabilities of learners are nurtured.

The instructional methodology that the teacher and learners perceive as adequate for technological problem solving is:

- Utilising peer-based learning, practical and cognitive apprenticeship stimulates the attainment of system design skills.
- A pre-defined set of AC, RS and PI, the instructional strategies and learners’ tasks and activities relieve the teacher of the organisational aspects and provide the opportunity to concentrate on the facilitation of technological problem solving.
- The step-by-step instruction with explicit teaching of thinking skills and reflective strategies cater for both conceptual and procedural knowledge that promotes technological problem solving.
- Experiential and situated learning suite the dynamics and complex nature of learning and teaching in the ISD context.

The implementation of the IWDP revealed new paths in the facilitation of technological problem solving which served as a foundation in constructing an instructional web design model (IWDM).

**References**


Are they getting enough? Preparing and supporting teachers to teach technology education in Scottish Primary Schools

S.V.McLaren, Faculty of Education University of Strathclyde, Glasgow
Email: s.v.mclaren@strath.ac.uk

Abstract

Within the context of the development of National Guidelines for technology education (1993 & 2000) in Scottish primary schools, this paper explores provision at initial teacher education and continuing professional development (CPD) short courses for primary technology education.

Is the limited experience provided at initial teacher education or through short CPD sufficient?

Issues arising from three models of support and implementation of National Guidelines are discussed. The paper argues that severe restrictions on the time available both within the university degree programme and for the short continuing professional development courses, limits the development of personal technological capability and impedes professional confidence which has subsequent impact on classroom experience for the pupils.
Keywords: continuing professional development, initial teacher education, teacher confidence, technological capability

Introduction

The National Guidelines for 5-14 Environmental Studies (1993) provided the first framework, rationale and key features for Technology to be included in the primary school curriculum and continue through to the second year of secondary education (1). There was no national professional development provided to accompany the introduction of technology education to the school curriculum.

A research survey conducted prior to the introduction of National Guidelines for Environmental Studies (1993), into the confidence of primary teachers found that many primary teachers lacked confidence in their ability to teach the science and technology components and did not have a sound grasp of the ideas they expected to develop in pupils. Harlen, Holroyd & Byrne (1995) concluded that the confidence of Scottish primary teachers in science and technology was lower than any other curriculum subjects with technology lower than science. There was little significant change between the initial 1993 survey and the follow up survey conducted (Harlen, 1997). Teachers identified their own lack of background knowledge as a source of their problems in teaching aspects of the subject.

Problems with implementation of Environmental Studies, across Scotland, led to a review and revision of the guidelines. 5-14 National Guidelines (2000) Environmental Studies: Society, Science and Technology was pared down (2). Attempts were made to simplify the language and terminology. The reduction in detail of what constitutes knowledge and understanding allows freedom for personal and institutional interpretation. A new initiative in the form of a publication, ‘A guide for teachers and managers’, (Learning Teaching Scotland, SEED 2000) attempts to support the schools in their interpretation and implementation of the guidelines.

To gauge primary teacher’s perceptions of their own confidence and their own technological capability, nearly ten years on from the introduction of Technology Education to the Scottish curriculum, a survey of teachers with varying lengths of service (from 1.5 years to over 30 years) was conducted (McLaren, 2002). It explored the teachers’ rating of their own ability and level of skill with materials, tools, components and processes of technology. The questionnaire also asked the teachers to note their personal strengths and weaknesses, and their own thoughts on the value of technology education in the primary curriculum.

83% of the most recently qualified group (1-5 years experience) indicated a fairly reasonable personal knowledge of the 5-14 Technology Guidelines. Overall, 83% of this same group rated themselves as low in confidence in teaching technology. The confidence rating of their own ability to teach technology tends to increase with length of service, contrasting strongly with the findings of the earlier study by Harlen.

Teachers were asked to note their personal ‘talents/assets’ which would be useful in teaching technology. Comments such as ‘willingness to try’, ‘willingness to learn’, ‘enthusiasm’, ‘comfortable with taking a risk’, ‘don’t mind if I get it wrong’, ‘not afraid to try things out’ were offered. Investigation of rankings of their own perceptions of their ability/competence with technological media, components skills and process revealed a very low level of personal competence.

It has become apparent that when understanding of technological capability is limited there is a tendency for the teacher to focus on the actual production of a product or artefact rather than process of arriving at the outcome. This indicates a lack of understanding of the aims and nature of technological education. Embedded and informed practice, requires the teachers to develop a technological knowledge base through practice and also to be able to reflect on and critically analyse the rationale, purpose and worth of such learning for their pupils (Jones & Compton, 1998).

A bench mark survey of 278 student teachers (McLaren, 2002), conducted prior to the technology education unit provided by their undergraduate course from 1997-2002, indicates the limited technology skills and capabilities (self rated) they bring with them from previous experience. In comparison with the in-service group, there is a marked difference in personal perception rating in designing and hand tools, with many
more students rating themselves as more competent than the in-service teachers. However, this survey illustrates the extent of the issues related to content (skills, processes and concepts) to be addressed in the B.Ed Primary degree course in order to address the quality of teaching technology and low teacher confidence in Scottish primary schools.

The effect of low confidence and poor understanding can influence approaches to teaching. For example, strategies vary from:

- teaching as little of the subjects as one can get away with;
- stressing process aims rather than conceptual development;
- spending more time on construction work and less on design and more on social and less on other;
- placing heavy reliance on kits, prescriptive texts and pupil work cards where pupils have to follow clear instructions step-by-step;
- emphasising expository teaching and underplaying questioning and discussion.

The distribution of curriculum guidelines, followed by revised curriculum guidelines to teachers who have not themselves experienced any further support or education to enable them to present, in pedagogical terms, an aspect of the curriculum which has no clear identification of what constitutes subject knowledge, inevitably causes consternation. As a result curriculum development is avoided or attempted piecemeal.

The following sections begin to explore in more detail the attempts that are being made to overcome these inherent difficulties and attitudes.

Supporting professional and personal development
There are three common models adopted to support the development of primary teachers in the teaching of technology education across Scotland, albeit on a localised and ad hoc basis. This section examines the influence and potential impact of each.

Secondary school specialist supporting primary colleagues
Secondary school technical teachers provide advice to the associate primary school teachers. The resultant interpretation of 5-14 Technology seems to rely on the development of skills required for the practical activity of making set piece models devised to provide experience with specific resistant materials, as had been the approach in technical workshops in secondary schools for many years. Little attention is given to designing and none to textiles, food, technology in society/value based work. The traditional S1/S2 technical education algorithm approach has little in common with Environmental Studies, Technology which is intended to provide a continuum of experience from 5-14 years.

Continuing Professional Development : in-service provision
To support qualified primary teachers, one to three day courses are made available by some local authorities, private consultants and Teacher Education Institutes (TEI). Some are devised specifically to suit requests of individual schools e.g. as a consequence of a HMI report or to develop staff awareness or skill base. From the author's own experience, a common focus of CPD sessions is to develop increased understanding of the revised Environmental Studies, Technology (2000), the characteristics of effective technology education and to encourage design thinking as a pedagogy central to developing technological capability.

There is apparently a large number of teachers who find themselves in the classroom teaching Technology with limited personal capability and confidence, whilst others continue to use the avoidance strategies discussed earlier. Nevertheless, evaluations indicate that the participants feel more confident as a result of their participation on a short course. Comments indicated that the rationale, purpose, value and teaching methodology had been clarified. The teachers feel more aware of what they have to offer and could identify with the value and worth of such learning experiences for their pupils. They could relate to the design thinking and this suggested that the National Guidelines for Technology had been demystified. The big ideas had been extracted for the teachers to ponder. Where teachers are given a chance to develop their own attitudes there is often a more positive response to CPD. This is evident in successful translation of the CPD into actions on return to the classroom. (Soloman & Tresman, 1999)
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Initial Teacher Education (ITE): pre-service provision

Student teachers arrive at university with a limited personal academic background in technology related aspects. Technological content and pedagogy need to be addressed in order to prepare them to teach primary Technology Education. No guidance is given to Teacher Education Institutes (TEIs) as to the time allocation for Technology within the undergraduate or one year post-graduate primary education courses. Across Scotland this currently varies between none to twenty hours. In the limited contact time available, tutors are required to be very selective in what to focus on in contact hours and create directed study tasks which enable students to explore Technology Education in theory, practice and philosophy. As Potgieter (1999) comments, there is an ‘unrealistically high expectation’ of what can be achieved when such limited time is made available for personal and pedagogical development.

Little has been done nationally since Harlen et al (1995) noted that there were variations across Scotland, in approach and purpose of the inputs for student teachers. They observed that tutors with a secondary background emphasised the need for appropriate materials and resources and concern for student understanding of content came second. This contrasted with the primary, general education tutors where the priority lay with developing the teaching skills. Yet, some practicing teachers in the Harlen et al survey felt that their initial teacher training has concentrated too much on imparting of adult content and knowledge rather than teaching methods. It is common practice to engage student teachers and in-service teachers in activities such as would be planned for pupils and to consider the overview from a teacher’s perspective simultaneously or retrospectively. The handling of the issues of such duality of developing the teacher’s own understanding and providing them with the skills and knowledge to help pupils’ understanding is tricky. [Harlen et al 1995; Buzzard & Jarvis, 1999; Jones & Moreland, 2000; Moreland & Jones, 2001]

A case study of shifting models of pre-service provision

Since there is no ‘national curriculum’ for content, time allocation and general guidance for teacher education courses, each institution devises their own approach within the parameters of accreditation by the General Council for Teachers (Scotland) and local university requirements. This case study, based on data, evaluation reports and personal experience of the author, examines the curriculum development that has taken place over the last ten years with regard to the technology education in B.Ed (Hons) Primary at one university.

Some of these changes have been made to provide a greater pedagogical input and other changes have been imposed due to outside constraints on the primary technology tutor team.

‘Tips for teachers’ model, circa.1993

The sessions for the B.Ed 1 and B.Ed 2 student teachers were based on practical skills using kits and set piece models with technical technology as main feature. Tutors tended to be secondary Science specialists. The format of the short course (8 hours total in each year) was as a ‘carousel’ model with no integration between session content nor continuity of contact between tutor and student. No assessment nor record of work was required. Little direct relationship with the rationale of thinking of the 5-14 Environmental Studies (1993) was made explicit. There was also little consideration of what progression planned for B.Ed1 to B.Ed2. Session attendance records indicated students placed little value on the sessions in the scheme of their studies.

A themed model, introduced 1997

A restructured approach within the limitations of the timetable and further restrictions of time together with a change of staff offered opportunities to present sessions to students in a more integrated manner. This model attempted to address some of the issues and problems raised by the previous approach. Students attended workshops connected by a theme and worked with the same tutor for each session. The theme was to allow for knowledge, understanding of subject matter and also provide vehicle for pedagogical issue to be covered with direct and explicit reference to 5-14 Environmental Studies (1993) throughout.

As a conclusion to the short unit (10 hours total), all B.Ed1 students were involved in a piece of spontaneous reflective writing Elbow (1973) on the Value of Technology Education in the Primary school curriculum. The students were asked to submit this piece to be given formative feedback from tutor, not grades.
After the B.Ed 2 technology unit (10 hours) students submitted, again for formative feedback, a sample of their approach to planning for teaching and learning of their chosen technology activity. The efforts and attendance of the students in general improved. Evaluations from students illustrated a shift in appreciation of the value of technology as a curriculum learning area and also that the students perceived it as worth investing own learning time. (internal short course review report, McLaren, 1997) However, there was little evidence to indicate that students engaged in any reading about and for technology education.

Themed Model 1998 (revised)
Personal reflective log-books were introduced to note a personal evaluation of the session in terms of experiences, learning and observations. Evaluations indicated that students were benefiting from the 1 and 2 year programme which catered for a shift from student teacher developing own skills and capability to planning for teaching technology by the end of the short course. (internal review report, McLaren, 1998, 1999)

Revised B.Ed (Hons) Primary degree, 2000
Significant structural and assessment changes to the 4 year B.Ed (Hons) Primary resulted in the creation of module entitled Science and Technology with no technology provided in B.Ed 1. The time share ratio in B.Ed 2 was 2:1 in favour of science. An assessed assignment for Technology was introduced (worth 0.5 credit). With the contact time reduced by 40% to 12 hours total, the technology tutor team had to decide what could be done as the bare minimum. It was important to encourage the students to think on a deeper level in order that they might construct their own working, informed rationale which had at its foundation the concept of technological capability. The student teachers would have no more than these technology sessions throughout the whole 4 year undergraduate course, unless they opted for an elective class giving a further 15 hours contact time maximum.

Therefore this inevitably led to a review of the past provision and future inclusion in terms of content, activities, continuity, support and guidance to ensure an appropriate balance of engaging students in activities as learners of technology and engaging students as teachers of technology.

The two-part assessment included the design of an outline teaching programme of work for which they had to refer to their log book reflections. The students were also required to submit a written comparative discussion based on the study of texts and journal papers related to research into Design and Technology teaching and learning. The students were to close the discussion by exploring the influence the study had had on their own thoughts of themselves as a teacher of technology education in the primary school. The format of the work resembles what Elbow (1973) describes as ‘cooking’.

Evaluations indicate that there is great improvement of student attendance to lecture and tutorials (average 96%) and a highly positive response. The technology component is no longer seen as ‘playtime’ where students carried out simple primary technology tasks and tended not to think beyond the hands-on task. (Internal review report, McLaren, 2000, 2001) Previously, even those students who had a high level of personal technological capability and relevant experiences (McLaren, 2002) from previous learning were guilty of making no effort to extend their understanding into the professional teacher realm. The improved status and worth is in part achieved by assessment contributing to the Science and Technology credit grade, but also in student learning for personal and professional advantage.

Further developments in 2002, resulted in Technology being given 0.5 credit rating as a ‘stand alone’ module. Adjustments were required to meet credit rating regulations and subsequent changes were made to the assessment tools and components. However, the teaching and assessment strategies remain generally the same as they had proved beneficial although demanding.

Future: model unknown
The future place of Technology Education in the B.Ed (Hons) Primary is at present unknown. The results of the current review and development process of undergraduate degree courses offered by the institution discussed above are as yet not available. Suggested models imply that less time will be allocated to curriculum specific teaching. Evidence to date suggest that the consequences of such imposed restrictions
will inevitably have a detrimental impact on the development of technology education in the primary school.

**Conclusion**

Since its introduction ten years ago, recurring issues hinder the implementation of the National Guidelines for Environmental Studies, Technology (1993 & 2000). These are well documented across both secondary and primary schools in Scotland. (e.g. HMI, 1999; HMI, 2002)

The continual changes and developments in the models for Technology Education in TEIs, and of CPD, make longitudinal study of the effectiveness of such provision difficult to evaluate whether students and teachers are getting enough from the current models of provision to overtake the weaknesses that are highlighted through personal perceptions and HMI inspections. However, it is evident that for coherent introduction and implementation in schools across Scotland, long term, sustainable curriculum development programmes for Technology Education are required, as Jones argues (2000) for New Zealand.

Evidence collected to date for this paper suggests concern for the future, particularly in light of changes to B.Ed Primary degrees. While student teachers learn how to learn as reflective, generic practitioners, support will also be needed for them to develop their own technological capability, in content, pedagogical and attitudinal matter. This requires a carefully planned balance between direct contact time and hands-on experience with reading, research and practice. It is becoming apparent that some models of provision may be more effective than others. Policy makers and senior managers must recognise this. National guidelines for pre-service provision, based on improving and ‘best’ practice, could offer an effective way forward to address the identified needs and better prepare the qualifying teachers who arrive on course with little personal confidence and competence in this curriculum area.

If CPD is to be the main provider of teacher support to address the issues of confidence and technological capabilities of in-service practitioners, a coherent, national strategy and professional development programme is required to ensure entitlement and quality is available for all teachers in Scotland. At present provision is limited, ad hoc, localised and intermittent.

The potential and value of Technology Education and technological capable citizens is too great to let such matters drift.

(1) Introduced as part of a roll out programme of by the Scottish Office for Education and industry Department (SOEID) the National Guidelines for Scotland: 5-14 aimed to create a national approach to the structure and balance of the curriculum for pupils from 5 years to 14 years old. [English (1990), Maths (1990), Expressive Arts (1992)]

(2) The rationale (albeit much summarised), continues to emphasise, as did Environmental Studies (1993), the importance of the environmental and value laden context in which technology education sits.

**References**


**Significance of sustainability issues for design and technology education: rhetoric, reality and resources**

**Mike Martin, University of Central England**
Email: mike.martin@uce.ac.uk

**Abstract**

In August last year a World Summit on Sustainable development was held in Johannesburg, South Africa. This, largely political event might appear to have had limited direct impact on education in the UK, but was important in highlighting once again the very real issues faced by our world: that of finite resources and interlinked social and economic structures.

This paper explores the significance of sustainability issues for design and technology education from two perspectives. Firstly, an overview of the content and possible influences of the Education for Sustainable Development section of the UK National Curriculum is considered. Secondly the significance of sustainability issues for designers is considered along with the range of tools, resources and case studies available to further their understanding.

The issues from the two perspectives are drawn together and a number of issues highlighted that are of significance to design and technology educators. The paper then describes a research project looking into the resource requirement of teachers to enable them to integrate sustainability issues into design and make activities. Conclusions are then drawn, highlighting the need for resource development and professional development in the future.

**Keywords: sustainability, values**

**Introduction**
This paper explores the significance of sustainability issues for design and technology education. It achieves this by looking at the content and possible influences of Education for Sustainable Development and sustainable design practice. In addition, it outlines a pilot research project based at the University of Central England that is exploring the requirements of teachers and resources available in this area.

The Design and Technology National Curriculum in the UK aims to provide a unique contribution to children’s general education, enabling children to:

“… combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices.” p15, QCA(1999)

Whilst this rhetoric is very worthy, the reality of the legal entitlement is quite a different thing. Looking at the Programmes of Study, and the Schemes of Work produced by the Qualifications and Assessment Authority (QCA 1999), it is a little unclear how children will be given opportunities to explore social and environmental issues in depth.

Interestingly, it is common practice, particularly at primary level, to make practical use of re-claimed materials when designing and making. Yet it would seem, from recent conversations with teachers, that the educational value of using such resources is rarely exploited. The potential to explore issues beyond the simply functional and aesthetic is considerable in design and technological activity. Reality, however, is that there has been limited encouragement from government documentation. Rather, the focus has been on providing some basic experience for all pupils.

This is understandable in helping the subject become established in schools. However, for Design and Technology to survive as a subject, it could be argued that it must take into account sustainability issues and live up to the widely supported statement about its unique contribution.

Education for Sustainable Development

Education for Sustainable Development (ESD) is gaining status and profile within the UK National Curriculum. This is exemplified by the recent publication of web pages specifically devoted to ESD on the UK National Curriculum website (www.nc.uk.net/esd).

The publication of the web pages follow several years of development by the Panel for Education for Sustainable Development (ESD) set up by QCA. Of particular importance was their first report (QCA 1998). This presented a structure of 7 key concepts of sustainable development:

1. Interdependence
2. Citizenship and stewardship
3. Needs and rights of future generations
4. Diversity
5. Quality of life, equity and justice
6. Sustainable change
7. Uncertainty, and precaution in action

The Panel for ESD developed specific learning outcomes for each Key Stage. Quite a number relate specifically to the domain of knowledge and understanding covered by design and technology education. These include all of the statements relating to the Needs and rights of future generations and Sustainable change. Below are some extracts to illustrate the point:

Pupils should:

• be able to discuss the way they live and the products and services they use (KS1).
• have begun to be able to distinguish between actions and products which are wasteful or more sustainable (KS2).
• be able to explain why wasteful production and disposal is harmful to the environment and why they cannot continue indefinitely (KS3).
• be aware of the role of advertising, product innovation and popular culture in promoting different lifestyles and be able to critically consider choices and alternatives in the context of defining needs and wants; evaluate the benefits and drawbacks of the application of scientific and technological developments for individuals, communities and environments in relation to sustainable development; ...(KS4)
• be familiar with the basic principles of sustainable design of physical and living systems and their application, such as transport systems, farming, or housing” (16-19).

Clearly there are significant contributions that design and technology education can make to pupils understanding of sustainable products and developing their awareness of the relationships between technology, society and the environment.

Sustainable design
The second influence explored in this paper is sustainable design. In helping to understand what this term means a useful comment is given in the editorial of the first edition of the Journal of Sustainable Product Design:

“The key aspect of ‘Sustainable Product Design’ is the addition and balancing of social and ethical issues, alongside environmental and economic issues into the product design process …” p5, Charters and Chick (1997)
The Journal provides many examples of the growing number of companies that are taking environmental issues seriously with case studies from companies such as Philips, Hoover and Patagonia. In addition, the ISO 14000 series of international standards have been developed to incorporate environmental aspects into operations and product standards (www.iso14000.com). Whilst it will take time for these standards to be adopted, there are significant changes already occurring in a number of industries.

“In the field of packaging various examples can be given of such changes: for instance, new distribution techniques leading to less and reusable transport packaging; adaptation of packaging materials into mono-materials; new display techniques in shops using less packaging material.” p9, Cramer (1997)

One of the central issues in developing sustainable products is the environmental impact of materials. This has been made easier with the development of more than 30 software programs, such as IDEMAT (www.io.tudelft.nl/research/dfs/idemat/index.htm) and EcoScan (www.ecoscan.nl) that make it easier to analyse the environmental impact and cost of products.

Slightly more digestible as useful concepts for teachers are the five basic principles of sustainable product design outlined by Edwin Datschefski:

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• Cyclic – products should be either be part of natural cycles, made of grown materials which can be composted, or else become part of a man-made cycle, like closed-loop recycling.
• Solar – all the energy used to make or run the product should be from renewable energy in all its varied forms, most of which are ultimately driven by the sun.
• Efficient – increasing the efficiency of materials and energy use means less environmental damage.
• Safe – products, and importantly their by-products, should not contain hazardous materials.
• Social – a product cannot be great if its manufacture exploits workers.”
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p10-11,Datschefski (2001)

His book The total beauty of sustainable products is a testament to the growing number of products that now exist as a result of sustainable design thinking and includes many useful examples.

Significance for design and technology education
It is clear from the brief outlines above that both of these issues will need to be taken account of by design and technology educators and that ways of integrating them into everyday practice need to be found. For example, when discussing choice of material with pupils, consider not only cost and appearance but also environmental and social impact.

**Contexts**
One of the most significant factors in enabling pupils to address broader values and sustainability issues is the way in which their design and make activity is presented. To present an activity to pupils without putting it in context will not enable them to discuss needs and wants in relation to design and technology. In developing pupils capability they should have opportunities to consider social and environmental issues in relation to what they have made and be able to justify decisions they have made.

**Materials**
Materials are at the heart of design and technological activity and their careful use is clearly important for a sustainable future. There needs to be an increased respect for an increased use of reclaimed materials and a genuine increase in emphasis given to the choice of materials according to criteria other than aesthetic. It has to be said that understanding the consequences of using particular materials is not necessarily easy but an important consideration in pupils design work.

**Life cycles**
Exploring the life cycle of products is extremely important in enabling pupils to see that products are part of a process and integrated into our everyday culture. The design, development, manufacture, transportation, purchasing and eventual disposal of modern consumer products has a profound impact on people and the environment. It is only by recognising this broader picture that pupils will fully understand technology in its broadest sense. Developing pupils as informed users of technology rather than passive consumers is surely an essential part of design and technology education.

**Design criteria**
Perhaps more than anything else the broadening of design criteria, developed by pupils when starting a design and technological activity, is crucial. It will only be when pupils actually take account of the issues in their own designing and making that they will really learn of their significance.

All of the above is rhetoric and purely academic if teachers are unaware of the significance of sustainability and there are no resources to support those who are interested. What is of much more interest than rhetoric is the question of how can pupils learn more about sustainability and apply their understanding to their own designing and making. It was with these issues in mind that I developed a project to investigate the reality of teaching and learning about such issues through design and technology education.

**Research project**
My personal interest in sustainability issues goes back more than 10 years. I decided recently to take the opportunity to research not only what teachers and learners might require in terms of resources, but also what was available.

**Overview**
The aims of the project are:
- Explore the resources requirements of teachers of design and technology that they might need to address sustainability issues in the classroom.
- Identify available sources of information: books, papers, articles, case studies, people, schemes of work, teaching and learning activities that might prove useful.
- Compare the resource requirements of teachers with the sources available and highlight areas for future resource development.

**Methodology**
Initially a comprehensive questionnaire was developed that asked for quite detailed information about resources and preferred format. In considering how such a form would be filled in on the Internet, I decided to simplify the questions. I felt that a general question about resources would be appropriate. Teachers’
responses could then be analysed and supplementary questions asked to individuals. The questionnaire asked the following questions:

1. Are you familiar with the concept of sustainable development?
2. Are you aware of the Education for Sustainable Development part of the National Curriculum?
3. How relevant do you feel ESD is to design and technology education?
4. Have you discussed issues of sustainability with pupils?
5. How confident do you feel about teaching sustainability issues?
6. What resources would help you in addressing sustainability issues with pupils?
7. Any other comments about this area?

In searching for available resources about sustainable development and sustainable design, I chose to look for free, readily available information – starting with the internet. The resources found tended to be general in nature and aimed at either Geography teachers or towards product designers.

**Early questionnaire results**
Initially 85 teachers were sent an email asking for their views. At the time of writing, two weeks after the mailing, 14 of them have replied. Although not a statistically significant number of responses it is worth noting that:

Most (10) understood what was involved in sustainable development.
Few (4) were aware of the existence of the QCA web pages.
Half (8) felt that sustainability was highly relevant to design and technology.
The majority (12) had little or no confidence in teaching about sustainability.

Of more interest at this stage of the project were the types of resources that they felt might be useful to teachers of design and technology:

- samples and sources of materials, case histories, what if scenarios, costing activities, fact sheet on sustainability, articles in Designing magazine, video resources, information packs, CDROMs, schemes of work.

**Future developments**
It is intended to broaden the distribution of the questionnaire so that a more statistically significant number of responses can be analysed. In addition some follow up questions, for clarification, will be asked of those who have already responded. This will be accompanied by further research into online and printed resources and the development of web pages that will list what has been found and suggested uses for design and technology educators.

**Conclusions**
The increased profile of ESD along with increased interest in sustainable design is indeed significant for design and technology education. Although in its early stages the project has identified a few resources that might help teachers of design and technology but there is clearly much more that can be done to support teaching and learning.

It is true that:
“… design and technology provides opportunities to promote education for sustainable development, through developing knowledge and understanding of the principles of sustainable design and production systems, developing skills in creative problem solving and evaluation, and exploring values and ethics in relation to the application of design and technology.” p9, DfEE / QCA (1999)

The key words in this are *provide opportunities*. What is now required are the resources to support both teachers and pupils understanding of these crucial issues for our technological world. This will require considerable resource development and profession development in order for teachers to develop appropriate pedagogical approaches and enable pupils to genuinely engage with what are difficult but significant issues for the subject.
Impacts of Learning Systematic Inventive Thinking Methods

Moshe Barak, Education in Science and Technology Program, Ben-Gurion University of the Negev, Beer-Sheva, Israel
Email: mbarak@bgumail.bgu.ac.il

Abstract

One of the essential objectives of education is to promote pupils’ problem solving and creative thinking competency. However, a gap exists between the high rhetoric in fostering pupils’ creative thinking and what actually takes place in schools. This study aims at illuminating several aspects of fostering creativity in industry and in modern organizations, particularly regarding problem solving and new product development, while examining the possible implications for education. A case study carried out in an Israeli tools manufacturing plant is presented. The company held a series of Systematic Inventive Thinking (SIT) workshops, which resulted in the development of a diversity of original and successful new products. The study shows that it is possible to teach people efficient problem solving techniques by breaking down a system or artifact into its basic components and systematically “playing” with objects or functions in order to achieve new results. Teaching creative thinking methods to pupils and teachers has gradually been introduced into the Israeli educational system. The challenge for education is to find an optimal combination and balance between fostering creativity by imparting freedom and openness to pupils, on the one hand, and teaching systematic methods for innovative thinking and problem solving, on the other.

Key words: systematic inventive thinking, problem solving

Introduction

One of the essential objectives of technology education is to promote pupils’ problem solving and creative thinking competency. Despite the tremendous amount of literature available on creativity and ways of fostering creative thinking, the concept still remains somewhat unclear. We will adopt the common approach perceiving creativity as being the production of an idea, action or object that is new (unusual, original, novel, unexpected) and valued (useful, adaptive, appropriate) (Csikszentmihaly, 1996). Many people admit that a gap exists between the high rhetoric in fostering pupils’ creative thinking and what actually takes place in schools. This study aims at illuminating several aspects of fostering creativity in industry and in modern organizations, particularly regarding problem solving and new product development, while examining the possible implications for education.
Theoretical Background
Guilford’s (1963) distinction between convergent and divergent thinking was considered to be one of the milestones in the development of creative thinking research. Even though Guilford claimed that convergent and divergent thinking complement one another and are both essential in the thinking process, many identify creative thinking only with divergent thinking. Different techniques evolved from this approach, aimed at raising a wealth of ideas, unusual associations of ideas and thinking “outside the box.” Methods such as brainstorming, lateral thinking and mind mapping are implemented in courses for managers and engineers in industry and academia, but are much less known in K12 education (Barak and Nizzan, 2002). It is more common for teachers to reward pupils for finding the right answer rather than for varied thinking, flexibility, risk taking and coping with the unknown. Pupils’ expectations for reward hinder their creative thinking development (Hennessey and Ambile, 1998). Educators have recently been struggling to promote creativity in schools through projects, open tasks, teamwork and a rich learning environment. Nevertheless, very little is known about how to teach pupils to think creatively.

Systematic Creative Thinking
Over recent years, the body of knowledge claiming that disorder and cognitive anarchy are not the best ways to foster creative ideas has grown. Lateral thinking or brainstorming methods are not as productive as they had been considered to be. The correlation between divergent thinking tests and creative achievements tends to be low, and the cognitive approach of creative individuals does not differ qualitatively from normal individuals except in the speed and quantity of ideas produced (Simonton, 1990). Goldenberg and Mazurski (2002) state: “research indicates that most brainstorming groups did not generate more ideas than control groups in which individuals worked alone with no contact between them... The quality of the ideas themselves and their level of originality were inferior to the ideas generated by individuals working without any group effect.”

A creative solution for a problem does not necessarily require a large number of ideas, and postponing judgment does not increase the creative value of ideas. Creative solutions may be arrived at through focused thinking and early judgment of ideas according to well-defined criteria. In Israel, research teams have been working for the past 20 years in developing the Systematic Inventive Thinking (SIT) method (Horowitz and Maimon, 1997), which was inspired by TRIZ – a systematic approach to creative problem solving in engineering, suggested by the Russian scientist Altshuller (1988). SIT method developers reported its successful implementation in problem solving, new product development, marketing and advertising in many countries in Europe, North America and South America. SIT method end-users include international firms, such as Motorola and Intel, as well as a range of leading Israeli companies. Academic courses on SIT are being offered at Tel Aviv University and in Israel’s Open University. Based on the Israeli SIT method, and the roots of TRIZ, Sikafus (1997) developed another model called Unified Structured Inventive Thinking (USIT). This method has been used to train hundreds of engineers at the Ford Motor Company in the USA. In Japan, Nakagawa (2000) introduced USIT in industries like Fuji Photo Film as well as in academia.

In this article, we will provide a brief overview of creative thinking methods by mentioning the following five idea-provoking tools from the recently modified Advanced Systematic Inventive Thinking (ASIT) method (Horowitz, 2001):

1. **Unification**: Solve a problem by assigning a new use to an existing component.
2. **Multiplication**: Solve a problem by introducing a slightly modified copy of an existing object into the current system.
3. **Division**: Solve a problem by dividing an object and reorganizing its parts.
4. **Breaking Symmetry**: Solve a problem by changing a symmetrical situation into an asymmetrical one.
5. **Object Removal**: Solve a problem by removing an object from the system.
Below is a brief example illustrating the use of the unification tool. Huge pools located on fishing vessels are used to store fish caught at sea while they are being transported ashore. In order to preserve their delicate taste, the fish must be forced to swim quickly in the pools, just like in the open sea. The ‘world of the problem’ includes the following components: fish, sea, pool, and vessel. In order to apply the unification tool, we formulate the following sentence: “An XXX type component from the ‘world of the problem’ will cause the fish to swim quickly in the vessel’s pool.” We systematically test this sentence by replacing the XXX with another component every time. If the word ‘water’ replaces the XXX, we find that water could be pumped into the pool causing the fish to swim against the stream. This is only a partially creative solution since it requires adding pumps – a component that does not naturally belong to the ‘world of the problem.’ If the word ‘fish’ replaces the XXX, we find that another type of fish could be added to the pool, a baby shark for example. This is a much more creative solution since it is based on components naturally located in the ‘world of the problem’ – many sharks are caught together with the fish and are usually thrown back into the sea. This example illustrates how the method leads to a focused formulation of the problem and a systematic search for possible solutions. This method differs intrinsically from lateral thinking or brainstorming methods.

Applying Systematic Creative Thinking to an Israeli Plant
A case study was carried out in a medium-sized Israeli tools manufacturing plant, KAPRO (2003), for professional and domestic tool users (Barak and Nizzan, 2002). The researcher participated in an 80-hour systematic creative thinking course for instructors offered by a team experienced in implementing the SIT method. Twelve engineers and senior managers from electronics, electro-optics, communications and heavy container transport companies participated. During the course, the researcher, together with KAPRO’s quality and innovation manager, learned in-depth about the reasons for the plant’s adoption of the SIT method, the method’s implementation process in the plant and its contribution to new product development. The researcher talked with the plant’s managers, engineers and production line employees, and participated as a guest in the internal new product development workshops.

KAPRO adopted the SIT method, with the objective of competing with cheap factories in developing countries, by introducing innovative and unique products into the market. Following the first workshops held in the plant, new and original products were developed within a very short time that became commercially successful on the world market, boosting the plant’s status and prosperity. One example of an innovative product developed was a lightweight spirit level called “Set and Match.” The instrument consists of a thin ruler with two sliders holding the horizontal and vertical levels. These sliders enable the user to set a measured distance between two points very easily. Following this successful experiment, internal new product development workshops using the SIT method were held 3-4 times a year in the plant. These workshops taught efficient problem solving and new product development techniques by breaking down a system or artifact into its basic components and systematically “playing” with the objects and their functions in order to achieve new results. The case of KAPRO shows that systematic training can enlarge the circle of people perceiving themselves as being capable of creating something new, and that social interaction and teamwork play a pivotal role in the process.

First Steps of Implementation in Education
Teaching creative teaching methods to pupils and teachers has gradually been introduced into the Israeli educational system.

1. In the Science Education Department of the Weizmann Institute of Science (one of the main bodies developing curricula for science and technology education in Israel), Eylon and Helfman (2003) developed a comprehensive unit for Systematic Inventive Thinking. This unit is based on over 10 years of experience in holding creative thinking workshops for pupils (Helfman, 1991). The unit is offered as an elective subject within science and technology studies in junior high schools.

2. Within the “Physics and Industry” program in the Weizmann Institute of Science, 30 high school pupils completed final projects in physics as part of their matriculation exams. The pupils worked
under the guidance of engineers from industry and attended an SIT workshop. The interim evaluation of the project (Eylon, 2003) reported that: “the pupils expressed great satisfaction and proved to be remarkably successful in their matriculation exams... a follow-up of the pupils showed that a combination of systematic inventive thinking and engineering approaches fostered creative thinking while seeking alternative solutions and suggesting strategies for choosing between alternatives, taking diverse approaches into consideration... great importance in teaching is afforded to the help provided by the systematic inventive thinking expert, at least during the first few years, even though teachers, with time, will gain competency in this area.”

3. A college in southern Israel offers SIT workshops to newly qualified teachers in the field, teachers’ instructors and high school pupils taking a university preparatory course (Margaliot, 2003). Over 150 pupils participated in these workshops over a two-year period, and the demand for them is growing. Teachers reported that they applied the SIT method to solve education-related problems such as the school curriculum or teacher-pupil relationships.

4. The author of this article taught parts of the SIT method to a group of experienced teachers studying for their Master’s Degree in Science and Technology Education in Ben-Gurion University of the Negev. The feedback from these teachers was very positive. Some immediately implemented ideas from the course in their classes and reported on the results to the other course participants.

The examples presented above demonstrate the growing process of introducing the teaching of systematic creative thinking methods into the Israeli educational system through the initiatives of scholars in science and technology education who came from different directions but shared a mutual interest in the area.

**Concluding Remarks**

Systematic creative thinking methods are a kind of convergent thinking method aimed at finding original solutions to technological problems or inventing new products. This type of thinking compliments the traditional divergent creative thinking, which essentially seeks a wealth of ideas and postpones judgment. Systematic thinking methods should not be applied too strictly in science or technology studies. Educators must remember that creativity is a complex process, involving both non-directed and directed thought, and states of disorder and order. The challenge for education is to find an optimal combination and balance between fostering creativity by imparting freedom and openness to pupils, on the one hand, and teaching systematic methods for innovative thinking and problem solving, on the other.

**References**


In July 1998, the College of New Jersey received an Instructional Materials Development grant from the National Science Foundation (NSF) to support the Children Designing and Engineering (CD&E) Project. Building on two previous initiatives, Project UPDATE (Upgrading Practice in Design and Technology Education) and UPDATE/TEI (Teacher Enhancement Initiative), Children Designing and Engineering reprised the approach of developing contextual learning units to integrate children’s experience of science, mathematics and technology. By adapting contexts from the various enterprises of New Jersey businesses, CD&E tapped children’s interest in “playing grown-up” while addressing a growing concern in the business community about the technological literacy of its future workforce. Perhaps most unique about the collaboration was the focus on young children, Kindergarten through grade 5, the level from which research suggests later interest in technology and science, especially for girls, must be nurtured.

Project staff worked with personnel from the New Jersey Chamber of Commerce to identify businesses representative of the state’s major industries: leisure and tourism; communication; pharmaceuticals; manufacturing; agribusiness and utilities. The Chamber helped to establish links with six businesses which became the focus of curriculum efforts, each serving as the starting point for a lower (K-2) and an upper (3-5) elementary unit.

Each of the twelve units produced by the project had to balance the diverse interests of the various partners: the curriculum developers, who represented a design and technology perspective; the National Science Foundation; and the business community. The National Science Foundation’s primary interest is the improvement of children’s understanding of science, for which design and technology is seen as a vehicle. The business community supports the idea of learning through practical application—with emphasis on developing basic collaboration, communication and problem-solving skills, as well as an introduction to careers involving science and technology. The curriculum team worked from a design and technology perspective to address the need of teachers and districts to meet emerging standards in science, mathematics and technology. This meant providing engaging, age appropriate problem-solving experiences for children in formats appealing and user-friendly to teachers. It also meant conveying transferable insights about the designed world to teachers to whom technology is largely invisible.

**Evaluation Design**

An evaluation plan was designed and implemented by Dr. Kenneth Welty, University of Wisconsin, Stout. The purpose of the evaluation was to provide the principle investigators of the Project the information...
needed to determine the usefulness and impact of the CD&E instructional units on elementary students and teachers. The evaluation focused on the learning activities, resource kits, and teacher guides that make up the following units.

- Bright Ideas Playhouse (grades K-2)
- Say It With Light, Inc. (grades 3-5)
- Opening Day at the Safari Park (grades K-2)
- Camp Koala (grades 3-5)

The evaluation addressed the following questions to determine the usefulness and impact of the CD&E units on elementary students and teachers.

- To what extent did the field-test teachers utilize the teaching strategies and resources featured in the instructional units developed by the CD&E Project?
- What specific features of the instructional units developed by the CD&E Project did field-test teachers find especially useful in their efforts to address selected standards, frame their curricula in authentic contexts, and engage students in meaningful learning activities?
- To what extent did the instructional units developed by the CD&E Project engage students in situated learning, hands-on activities, and reflective thinking?
- What effect did the instructional units developed by the CD&E Project have on student performance in mathematics, science, technology, and design/problem-solving?
- Did field-test teachers engage their students in design-based learning experiences that utilized contexts from business and industry in other aspects of their curriculum and instruction as a result of their participation in the CD&E Project?

The information needed to address the key questions was obtained from a variety of information sources throughout the evaluation process. These included field-test teachers, test site students, and project staff. The seven field-test teachers and sites were selected based on logistical, demographic, and methodological considerations. It was originally planned that two field-test teachers would teach each unit, one experienced in design and technology methods, and one a novice. Pairs of teachers field testing each unit were permitted to work together as closely as they liked, and collaboration models varied greatly. Shortly after the start of field testing, one novice teacher dropped out of the study for medical reasons. The average class size of the remaining teachers was 25.

The evaluator solicited pre-assessments of students’ knowledge, monitored the implementation of the CD&E units at each site in the sample, and administered post-tests to uncover gains in student achievement. In the absence of standardized tests focusing on the application of science and technology understandings from which to draw appropriate items, the evaluator designed four assessment instruments based on objectives stipulated in the units. Students recorded multiple choice answers in test booklets in response to questions posed. At the first and second grade levels, scenarios were enacted and questions posed orally for students, since the children spanned a wide range of reading abilities.

The level of implementation that each unit received during field-testing was surveyed, along with perceptions from field test site teachers regarding their students’ achievement, the attributes and shortcomings of the CD&E units, and their plans to use a design or thematic approach in the future. Samples of documentation from the units’ guided portfolios provided insights into students’ performance on activities that contributed to the achievement of unit objectives. Triangulation of multiple data sources was used to assess the significance of findings in each category.

**Findings**

Development of the CD&E units was informed by examples of best practice drawn from research in technology education, elementary education, science, mathematics, and cognitive science. These principles were used to inform a series of thematic units that were compatible with existing curricula and attentive to the needs of elementary teachers, and that would ultimately help students develop understandings and skills that contribute to the attainment of standards.
The results of the field-testing process suggest that the principles that underpin the design of the units contributed to student achievement. For example, data gathered after first graders carried out investigations that enabled them to present a shadow puppet play provided evidence of significant learning about light and its role in the projection of images. Second and third graders who had designed safari park environments to meet specific animal needs exhibited more than basic understanding of animals and their habitats. Similarly, evaluation data provided clear indications of fifth graders’ understanding about electrical circuits, mechanisms, multiview drawings, and the roles of scientists and engineers in new product development upon completion of a unit in which they formed design teams and envisioned new devices for communicating with light. The results also suggested, however, that students do not develop the targeted understandings as fully as desired if the implementation of these units is compromised. Therefore, evaluation results suggest that framing instruction in authentic contexts, providing students first-hand experiences with new concepts, teaching new vocabulary in conjunction with experiences that add meaning, utilizing design-based activities to facilitate constructivism, and having students present the results of their learning in a variety of formats all have merit.

In their first encounter with long-term contextual units, however, some teachers expressed concern about tensions that can emerge between the students’ interest in the project and the teacher’s desire to capitalize on the projects to teach important concepts. Although the CD&E contexts, projects, and culminating activities are intended to capture the students’ attention, create a need for new knowledge, and engage students in inquiry, teachers felt they also have the potential to distract the students from the learning targets. To be truly effective, the contexts and activities that are used to engage students in learning have to work in a symbiotic manner with the teacher’s desire to build important concepts and skills in the minds of the learners. Many teachers, on reflection, felt that they would have to develop focusing and, in some cases, disengagement strategies to achieve the desired balance in future contextual work.

A fundamental premises underpinning the Children Designing and Engineering Project is the notion that children can develop important understandings and skills if they are actively engaged in the learning process. One of the techniques used to focus and sustain the students’ attention was to frame each unit in the context of an enterprise that the students would find interesting and meaningful. Particularly useful to the unit designers was the concept of a “big challenge,” adapted from the work of Barlex and Welch in Ontario (Ministry of Education and Training, 1998). In the four units field tested, the challenges included: designing a classroom safari park; creating a visitors’ center for a habitat for endangered koalas; staging a shadow puppet play; and designing a new device to communicate with light. Without exception, the field test teachers reported that the technological challenge, which provided a context for scientific investigation and math applications, was one of the most powerful attributes of the CD&E units. They all reported that their students were able to learn more under the auspices of the thematic units than they would have if all the topics were taught separately.

One of the benefits of framing a unit of instruction in the context of a salient enterprise from the community is that it creates an authentic climate for teaching and reinforcing basic employability skills at an early age. This was found to be particularly true of contexts drawn from the world of business. Activities such as product design, model-making, packaging and marketing, consumer surveys, product testing and presentations are common to many industries. According to the field-test site teachers, these activities yielded noticeable gains in students’ ability to work together in teams, to negotiate disagreements without teacher intervention, to speak in front of adults with greater confidence, to carry out research and to recognize the value of planning.

Another premise that underpins the CD&E units is the proposition that the thought processes used to design or engineer a solution to a problem are consistent with those used to learn new concepts (Kimbell, R., Stables, K., Wheeler, T., Wosniak, A. and Kelly, J., 1991). In many ways, the two processes are parallel in terms of creative development of a new entity. More specifically, engaging students in design projects requires them to think deeply about the problems that they need to solve. They must tap existing knowledge to begin formulating potential solutions to their problems, and then seek answers to the questions that emerge during the design process. Furthermore, as designers, students must use their new knowledge to develop their ideas into products or processes that can be tested. The results of the testing process validate the knowledge that the students used to solve the problem. Often, they also inspire the
need to refine or revise one’s thinking even further. In short, the CD&E Project aspired to develop design activities that required students to activate prior knowledge, seek new knowledge, integrate new knowledge with existing knowledge, apply this enlarged understanding, and reflect upon their learning experience. The results of the field testing show gains in student understanding across a wide range of ideas due, at least in part, to their engagement in gathering information, generating ideas, building and testing models, and presenting the results of their work to others.

Although some participating teachers asserted that they often used themes in their teaching, most reported that they would not have taught the topics used to frame the CD&E units in an authentic context if not for their role in the field-testing process. All the teachers indicated that they would have addressed the academic concepts and skills that were central to each unit regardless of their participation in the project. This suggests that the CD&E units have some face validity in terms of their consistency with the existing curricula. However, it also suggests that the implementation of these units hinges on teachers’ willingness to address the balance of the content in an already swollen curriculum.

Project staff observed that since the CD&E units were designed to address a three-grade span, teachers at different levels found particular elements of the units appealing. For example, Bright Ideas Playhouse, in which youngsters design shadow puppet plays based on nursery rhymes, appealed to first grade teachers because of the strong language arts component. Time spent on science concepts was seen to be excessive, despite the fact that the children learned a great deal about light, since light was perceived to be a second grade topic. Meanwhile, second grade teachers who had implemented the Safari Park unit, looked forward to trying Bright Ideas Playhouse because of its obvious fit with their science curriculum. Interestingly, using instructional time to create readiness for a topic associated with a later grade appeared to most teachers as an extravagance, while reinforcing concepts taught previously was always considered justifiable. According to the testimony of the field-test teachers, they were willing to teach things not specified in their curriculum, like puppets, Koalas, and lighthouses, because of the learning activities associated with these topics. The field-test teachers associated these activities with opportunities to help students develop generalizable skills. More specifically, they had their own form of face validity because their inclusion provided students with opportunities to learn how to work collaboratively in a group, to use simple tools and materials to develop their fine motor skills, and to learn how to gather information and to use it to solve problems. However, if gone unchecked, the appeal of these topics and their accompanying learning activities can consume time that could be used to target more important concepts and skills.

Closing Thoughts
While technology education is not new to elementary classrooms, it has never been viewed as a serious focus of study, but rather as a way to enrich the curriculum beyond core subjects. One of the factors tempering the study of technology at the elementary level is a lack of curriculum materials that are attentive to the nature of elementary children, responsive to the needs of elementary school teachers, and respectful of the demands being placed on the elementary school curriculum. The materials developed by the CD&E Project represent just one contribution that the project has made to the study of technology at the elementary level. The development and testing of these materials has also resulted in an instructional model and an approach to developing curriculum that integrates the study of technology into the existing elementary school curriculum. The findings of the field-testing process support the notion that the study of technology can be blended with a variety of core subjects in a manner that allows teachers to address objectives for the study of technology while addressing other objectives in the core curriculum. Upon reflection, the field-test teachers all felt their students were able to learn more under the auspices of the thematic units developed by the CD&E Project than they would have if all the topics were taught in isolation of one another.

References

ORT’s Approaches to Teaching Technology in the Countries of the Former Soviet Union: Goals, Implementation, and Results

Dr. Sergey Gorinskiy, ORT Russia
Email: gor@ort.ru

Abstract

As a subject, technology became a compulsory part of the national school curriculum in Russia in 1992. Pupils have an average of 2 hours per week of technology class from the first to eleventh grades. There are several curricula based on different approaches to teaching technology, but most of secondary schools either continue to use handicraft and primary vocational training or teach only information and communication technologies (ICT).

Aiming to introduce a technological literacy approach, ORT - one of the largest non-governmental education and training organisations in the world, founded in 1880 in Russia - launched its Technology for All (TfA) project in Russia, Ukraine and Moldova in 1998. We started this experiment from the needs analysis and definition of technology teaching purposes. This paper describes the founding ideas, content and the current state of the TfA project.

Keywords: technology, design, education, school, curriculum, Russia, Ukraine, Moldova

Needs Analysis, 1998

What does society expects from technology education in secondary schools? ORT Russia decided to begin in 1998 with a survey teachers, parents, and pupils to better understand the demands placed on technology education.

1142 parents and 174 teachers from several schools in Moscow, St. Petersbourg and Samara region were asked to answer the question: “What approach to teaching technology is the most correct?”

About 30% of parents considered the “development of skills necessary for solving practical problems” to be the most important. 20% chose “study of computer technologies.” and a bit fewer preferred “development of the simplest skills necessary around the home.” A review of different technologies was of interest to only 11% of parents, while only 9% wanted to see secondary school technology taught as initial vocational education.
It is of special importance that the majority of parents didn’t want to consider secondary school technology training as having anything to do with vocational school training. They were also not interested in a simple academic review of different technologies.

45% of teachers also considered the “development of skills necessary for solving practical problems” as the main aim of technology education in general schools. The second (12%) aim of technology education was considered the “practical application of natural sciences studied in school”.

But when we asked what approaches were currently being taught, the answers showed a broad gap between needs and reality. 32% of teachers answered that the real aim of technology lessons in their schools was development the simplest (home) skills.

A conflict clearly existed between teachers’ vision of aims and the content of technology education and the current situation at schools.

It is also interesting that neither teachers nor parents considered design as one of the main aims of technology education at school. This is largely due to the fact that the questionnaire used the Russian synonym for design – roughly equivalent to “constructing”. The Russian word “design” could not be used because for most Russians design is related to “fashion” and “style”, but not “the process of problem-solving which begins with a detailed preliminary identification of a problem and a diagnosis of needs that have to be met by solution, and goes through a series of stages in which various solutions are conceived,
explored and evaluated until an optimum answer is found that appear to satisfy the necessary criteria as fully as possible within the limits and opportunities available” (Eggleston 1994).

Thus, we concluded the following needs:

Need 1:
To change the content of technology education from handicraft and housekeeping to technological literacy.

Analysing the answers given by teachers and parents, we can say that Russian society considers technology education at school as a tool to foster skills needed to solve practical problems. This emphasis on the practical side of school education is a societal reaction to the traditional and fundamental character of Russian school (which was often overly theoretical and too far removed from reality). Society recognises the role of what Peter Drucker entitles “specialized knowledge”. He writes: “In this society, knowledge is the primary resource for individuals and for the economy overall. Land, labor, and capital - the economist’s traditional factor of production - do not disappear, but they become secondary. They can be obtained, and obtained easily, provided there is specialized knowledge… For the knowledge of the knowledge society is fundamentally different from what was considered knowledge in earlier societies, and in fact, from what is still widely considered knowledge. The knowledge of the German Allgemein Bildung or of the Anglo-American liberal education had little to do with one’s life work… Whatever the base, knowledge in application is specialized” (Drucker 1995).

Of course, not only parents and teachers, but also pupils were the focus of our study.

913 pupils aged 10–14 were asked to answer questions concerning science and technology, current interests and plans for their future employment. Analysis of the answers shows a lack of understanding of technology’s place and role in modern society. As a result of years of “labour education,” many pupils responded that technology has something to do with housekeeping, cooking, or handicrafts and did not connect the term “technology” with modern industry. This, despite the fact that all the pupils questioned live in the most industrial cities of Russia where airplanes and space rockets, cars and ships, atomic reactors and semiconductors are designed and produced.

Technological activities including computers were among the most popular hobbies. Writing about their hobbies, they mentioned sport (41%), computers (23%), music (15%), reading (12%), and technical, fancy and other hands work (9%).

We tried to “measure” pupils’ attitudes toward technology as a school subject and suggested five possible answers from “it’s not interesting to me” (1 point) to “I have a strong desire to study technology” (5 points). For pupils of age 10 with little technology education, the average was 3.6 points. After 4 years of studying technology as a school subject under the pre-existing system, the pupils’ attitude toward technology education decreased to 2.9 points.

To summarize, the more pupils studied technology at school, the less the subject was interesting for them.

There are 11 subject areas in Russian national curriculum. We asked pupils to range them from the point of view of importance for future life. The answers showed the same tendency.
At the same time, interest in technological professions increased from 18% at age 10 to 28-33% at ages 12-14 – the opposite tendency in pupils’ attitude to “school technology” and “real technologies in the adults’ world”.

Need 2:
To demonstrate a relation between technology as a school subject and technology in modern society as a way to make technology lessons more attractive.

Here the focus is on raising the attraction of technology lessons in school, but not the attraction of technology itself because the aim is to provide all pupils with technological literacy, but not to prepare all of them for an engineering career. It is interesting that 31% of parents in our research were engineers (not in ICT), but only 8% of surveyed parents hoped that their children would take up engineering. The opposite example is true with ICT: only 4% of parents worked in this area, but 11% wished that their children work in ICT-related professions. The plurality of parents, 24%, wanted their children to become lawyers even though (or perhaps because) there were only 2% of the surveyed parents were lawyers.

The above-mentioned needs have appeared as the result of great economical and social transformations in Russia and other countries of the former Soviet Union during last several years. In new social and economical conditions, traditional “labour education” can not provide pupils with the knowledge and skills necessary for life. Local educational authorities in several regions asked ORT to help renovate technology education at their schools and ORT Russia began analysing world experience in technology education in 1998.

The Study of International Experience
The Russian educational system continues to be very isolated from the global educational society. Russian educators participate in international conferences very rarely and conference proceedings and pedagogical journals are usually not translated into Russian. Russian educators and teachers of technology as a rule do not know English.
First of all, we examined the experience of Design and Technology curricula (England and Wales). The design approach is extremely important for the new generation of Russian pupils because they are traditionally very good at problem solving, but meet with difficulties defining and identifying problems as well as presenting and utilizing their results. This is a legacy of decades in conditions when individual initiative and self-dependency were not welcomed.
Another approach that we wanted to introduce into our curricula based on our needs analyses was Science – Technology – Society. In this capacity, we studied the experience of New Zealand’s “Technology” and the US’s “Technology for All Americans” projects as well as ORT Israel’s “Science and Technology” program (Semla, Sofer 2000).

The Pilot Project
To introduce and test these new approaches to technology education, ORT launched a pilot project which included:

- Establishment several school-based technology centres equipped with computers, technology kits, machines, etc.
- Development of curricula, student textbooks and methodical materials for teachers.
- Training of teachers.

The typical school technology centre consists of:
- one or two ICT labs;
- one technology lab (studio) with “clean” and “dirty” zones;
- resource lab;
- network centre;
- media library.

See table 1 below for details concerning technology centres.

<table>
<thead>
<tr>
<th>Room</th>
<th>Function</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT lab (one or two)</td>
<td>Informatics and ICT lessons. ICT usage in non technological lessons.</td>
<td>15 PCs, scanner and printer, multimedia projector.</td>
</tr>
<tr>
<td>Technology lab (studio)</td>
<td>Technology lessons.</td>
<td>“Clear zone”: 15 PCs, LEGO Dacta sets, TfA kits, scanner and printer, multimedia projector.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Dirty Zone”: tools and machines.</td>
</tr>
<tr>
<td>Resource lab</td>
<td>Class preparation, printing, and multimedia teaching aids.</td>
<td>2-6 PCs, scanner and printer, digital photo, desk top publishing equipment, video.</td>
</tr>
<tr>
<td>Network centre</td>
<td>Providing local networking and Internet connection for all of the school’s PCs.</td>
<td>Server(s), network equipment.</td>
</tr>
<tr>
<td>Media library</td>
<td>Individual work with books, CD-ROMs, Internet for pupils.</td>
<td>2-5 PCs, scanner and printer.</td>
</tr>
</tbody>
</table>

Table 1

Taking into account the mandatory national curriculum, ORT suggested a three-step structure for its TfA program:

- In grade 5, pupils study the module “Introduction to technology” to answer why technology appears, what influence technology has on the future, and what the social issues of technological development are. Pupils study several applications of technology, for example, telecommunications, transportation and food technology. The important part of 5th grade technology curriculum is the introduction to technological modelling on the base of LEGO Dacta “Simple Mechanisms” sets.
PUPILS ATTITUDES TOWARDS TECHNOLOGY

Annual Conference
June 2003

• In grades 6-9, pupils study Technology Education modules and ICT supporting materials based on a system approach. The main modules are Design Process, Technological Systems, Materials and Products, Energy and Information.

• In grades 10-11 some secondary schools give their pupil elements of initial vocation training in certain technological domains (for example: ICT, CNC, video).

Technology courses are studied in parallel with ICT, which is utilized from the first year of program (grade 5, age 10) as a real tool for studying technology.

Several ORT Israel’s textbooks, such as “The World of Tomorrow”, “Design Process”, “Technological Systems”, “Materials and Products”, were translated to Russian. They are used as student guides and/or as references to generate instructional ideas. Several new student textbooks and teacher guides were prepared by local educators, but not all modules of the program are prepared and used at schools today.

The Design approach is one of the key elements of ORT’s technology curricula. In grade 6 “Design Process” is the main subject of technology study. Drawing on the experiences of the UK, Israel and New Zealand, ORT considers design not just a part of vocational training and the preparation of industrial workers, but also as a tool for the development of technological capabilities. It is a tool and a skill that pupils use later in grades 7-11 not only at technology lessons, but also in learning other subjects. Interdisciplinary projects are an essential part of education in ORT schools.

To implement a new approach to technology education, ORT has had to pay a great deal of attention to teacher training and support. There are several problems in this case:

• Former teachers of handicraft and vocational training have a poor background in modern technology, particularly in information and communication technologies.
• There are many new teachers of technology who in time of economic crisis came to school from industry. They have good technological backgrounds, but largely have poor pedagogical skills and experience.
• Both former handicraft teachers and former engineers are unfamiliar with modern approaches to technology education.
• Both former handicap teachers and former engineers have no knowledge about subject environment of technology (marketing, management, etc.).

To solve these problems ORT conducts special training programs, including both formal and informal education, seminars, Internet collaboration, and e-learning.

Instead of a Conclusion: Today’s Situation and Problems

Today six schools participate in the full-scale pilot project. The school-participants design their own technology curriculum based on common approaches tailored to meet the requirements of national, regional, and local educational authorities. In March 2003, local project managers were asked how they used the joint curriculum, recommended books, equipment and teacher aids with three possible responses:

aids with three possible responses:
100% = “We use it in classroom”;
50% = “We use it just as idea for preparation to lessons”;
0% = “We don’t use it at all”.

The averages for each component of TfA project and for each school were then calculated. The results concerning joint curriculum, recommended books, equipment and teacher aids are shown in the table 2.

<table>
<thead>
<tr>
<th>#</th>
<th>TfA Component</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Curriculum module “Introduction to technology”</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>A textbook “The world of tomorrow”</td>
<td>75%</td>
</tr>
</tbody>
</table>
Table 2

School-participants have entered the project at different times and are at different stages of development. The average usage of TfA components depends on the amount of time spent in the project as shown on figure 4.

![Figure 4](image-url)
Thus, it is obvious that the TfA project is being realized with a number of difficulties and non-uniformly. Some difficulties have a transient nature, but some are fundamental for the approach being tested. A lot of problems are the consequences of insufficient financing of state schools. Here, we have tried to outline several of the pedagogical problems we are faced with:

**Sliding into the theoretical instruction**
The burden of pedagogical traditions predisposes technology teachers toward the use of methodologies that are based on theoretical explanations. From the point of view of lesson organization, it is easier for the teacher to remain theoretically focused than to try to steer pupils’ creative activity toward defined educational goals.

**Sliding into the technical games**
LEGO Dacta and similar educational sets are widespread tools for teaching technology. Usage of instructional cards allows the “atomization” of the pupils’ activities. The typical danger of such “atomization” is a risk not to see the forest for the trees.

It’s difficult to ply between these Scylla and Charybdis of technology education.

**Uncertainty of assessment.**
This problem is widely discussed (see for example Kimbell 1994), but we are still far away from a common approach for such traditional subjects such as mathematics and physics.

**References**
An investigation into the relationship between preferred learning style and successful achievement in contrasting design and technology activities

Dr Stephanie Atkinson, Sunderland University, UK.
Email: Stephanie.Atkinson@sunderland.ac.uk

Abstract

The aim of the study was to investigate the differences between the preferred learning style of design and technology trainee teachers and their successful achievement in contrasting design and technology modules studied during their degree programme. Achievement data were collected from a sample of 30 students studying on an Initial Teacher Training degree at a University in the North East of England. Data concerning design and technology experience prior to starting the course was obtained through a short questionnaire. They were also given the Cognitive Style Analysis to complete. This assessed two fundamental dimensions of learning style, Wholist-Analytic and Verbal-Imagery. The sample was found not to have subjects at the extremes of either dimension. This was particularly noticeable at the Analytic end of the Wholist/Analytic dimension and the Imager end of the Verbaliser/Imager dimension. The possible implications of this finding are discussed along with the differing level of success achieved by students in design modules and electronics modules when grouped by learning style, gender and past experience in design and technology activities. The inference of these results in relation to the success of these students as impending teachers of design and technology is also examined.

Key words: Learning Style, Design and Technology Achievement, Gender, Design and Technology Teacher Training.
Introduction
The aim of this study was to investigate the relationship between preferred learning style and successful achievement in contrasting design and technology modules taken by thirty trainee teachers studying on a design and technology education degree programme at a University in the North East of England.

Initial Teacher Training (ITT) National Curriculum Requirements
In order to teach in State Schools in England, all trainees need to have Qualified Teacher Status (QTS). To gain this they must collect evidence to meet stringent Teaching Standards set by the Teacher Training Agency (TTA, 2002). The Government recognised that due to the breadth of subject content covered by National Curriculum Design and Technology newly qualified teachers (NQT) could not be expected to have degree level subject knowledge across all aspects of that curriculum. The ITT subject standards for Design and Technology have therefore been divided into a common core and four fields of knowledge (DATA 1995). The four fields of knowledge are Resistant Materials, Systems and Control, Food Technology and Textile Technology. An NQT is expected to be able to teach the common core and a minimum of two fields of knowledge. The trainees in this investigation all completed subject studies modules in the common core, Resistant Materials, Systems and Control, and Textiles. This study centred on achievement in the two contrasting areas of learning found in Design and Electronics modules.

Cognitive Style and Teaching Strategies
The terms cognitive or learning style have been widely used by educational theorists for the past sixty years. Terminology has varied from writer to writer (Curry, 1983; Riding & Cheema, 1991) although, many (e.g. Biggs & Moore, 1993; Goldstein and Blackman, 1978; Riding & Pearson, 1994; Tennant, 1988; Witkin, Oltman, Raskin & Karp, 1971) have agreed that cognitive style is a distinct way for an individual to encode, store and perform, and one that is mainly independent of intelligence.

As the relevant research base into cognitive style has grown so have the number of terms used to describe cognitive style groupings. Riding and Rayner’s (1998) analysis of the multiplicity of constructs concluded that the terms could all be grouped into two principal cognitive styles and a number of learning strategies. They referred to these cognitive styles as a ‘Wholist-Analytic Cognitive Style Family’, and a ‘Verbaliser-Imager Cognitive Style Family’. The ‘Wholist-Analytic style’ dimension they defined as the tendency for individuals to process information in wholes or in parts, while the ‘Verbaliser-Imager style’ dimension they defined as the tendency for individuals to represent information during thinking verbally or pictorially. These dimensions they believed were independent of one another. Because of the nature of the activities being assessed in design and technology it seemed appropriate to utilise Riding’s definitions of cognitive style for this study.

Gender Issues
Equal opportunities within an educational context continue to concern the government and educationalists, in spite of much research, the introduction of equal opportunities legislation and many government-sponsored initiatives. In Design and Technology this has manifest itself particularly in the area of gender imbalance both in terms of opportunity and achievement (e.g. Bryne, 1978; Gilligan, 1982; Smail, 1984, NCC 1989; Kimbell, Stables, Wheeler, Wosniak & Kelly, 1991; Riggs, 1993; Banks, 2002; Harding, 2002). In this study there was no gender imbalance in terms of opportunity whilst the issue of gender differences with regard to achievement in design and technology is pursued and will be discussed within the results section of this paper.

Method
Sample
The purposive non-probability sample comprised thirty trainees (sixteen male and fourteen female) studying design and technology modules during their ITT Design and Technology degree programme at a University in NE England.

Data Gathering Instruments
The following materials were used:
1 Cognitive Style. A well-established Cognitive Styles Analysis (CSA), which was computer presented and self-administered, was used (Riding, 1991). This indicated a trainee’s position on both the ‘Wholist-Analytic’ (WA) and the ‘Verbal-Imagery’ (VI) dimensions of cognitive style (Riding and Rayner, 1998) by means of an independent ratio for each. Every member of the sample carried out the CSA in the manner prescribed in the CSA administration document (Riding, 2002).

2 Achievement. Two mean marks were obtained for each trainee, one for design activities and one for electronic activities. The first mean mark was calculated for each trainee using the results of assignments in three modules in which design activity had been assessed at levels 1, 2 and 3. The second mean mark was calculated using the results from a set of three electronic modules where the type of learning was considered to be fundamentally different to that which occurred in the design modules. Although the application of electronic skills within design contexts did occur in the degree programme the modules in question provided marks purely for electronic skills, knowledge and understanding.

3 Previous Design and Technology Skills. A piloted, short questionnaire ascertaining previous experience in design and technology activity prior to starting the degree programme was collected from each member of the sample.

Results and discussion

Cognitive Style of the sample

The WA ratios of the total sample ranged from 0.700 – 2.910 with a mean of 1.412 (SD = 0.515) and a median of 1.320. The VI ratios ranged from 0.750 – 1.430 with a mean of 1.093 (SD = 0.149) and a median of 1.105. The correlation between the two cognitive style dimensions was -0.154 attesting to the orthogonality of the two dimensions (cf. Riding and Cheema, 1991, Riding and Douglas, 1993). In comparison to the CSA Standardisation Sample (N = 999) referred to by Riding (2000) the sample reported in this study did not have subjects at the extremes of either dimension, this was particularly noticeable at the Analytic end of the WA dimension and the Imager end of the VI dimension (see Table I).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Wholist/Analytic (WA)</th>
<th>Verbaliser/Imager (VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA standardisation Sample</td>
<td>0.370 – 4.050</td>
<td>0.400 – 5.610</td>
</tr>
<tr>
<td>(N = 999)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAL Sample (N = 32)</td>
<td>0.700 – 2.910</td>
<td>0.750 – 1.430</td>
</tr>
</tbody>
</table>

Table I. Comparison between the Cognitive style ratio found in the CSA Standardisation Sample and the Sample reported in this study.

This later result was considered surprising, as it had been expected that many of the sample would be ‘strong’ imagers as they were training to become design and technology teachers where the manipulation of images in the mind during design and technology activity was recognised as a valuable skill. However, it was also recognised that as prospective teachers, the ability to work equally competently with both text and images and communicate with pupils who may themselves be at the extremes of a dimension would suggest that being at the centre of the VI dimension could be an advantage. In this study the VI cognitive style split was nine Verbalisers, eleven Bimodals, and ten Imagers (see Table II).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Style</th>
<th>No.</th>
<th>Style</th>
<th>No.</th>
<th>Style</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholist/Analytic</td>
<td>Wholist</td>
<td>5</td>
<td>Intermediate</td>
<td>6</td>
<td>Analytic</td>
<td>19</td>
</tr>
<tr>
<td>Verbaliser/Imager</td>
<td>Verbaliser</td>
<td>9</td>
<td>Bimodal</td>
<td>13</td>
<td>Imager</td>
<td>10</td>
</tr>
</tbody>
</table>

Table II. Distribution of the sample on the two Cognitive Style Dimensions
With regard to the WA dimension, the researcher would suggest that in both the task of being a successful teacher and a successful design and technologist, being strongly Analytic or Wholist could be an advantage at certain times and a disadvantage at others. Data from this study indicated that the sample was predominantly Analytic with only six Intermediates and five Wholists making up the sample on this dimension. It was recognised by the researcher that the skewed distribution on the WA dimension could affect results and needed to be borne in mind during data analysis.

With regard to the gender distribution of cognitive style, the equal balance observed by Riding et al (1995) was repeated in this study on the VI dimension. However, on the WA dimension there was considerable gender imbalance between the three categories. This did not replicate Riding et al’s findings (see Table III).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Wholist n=</th>
<th>Intermediate n=</th>
<th>Analytic n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>percentage</td>
<td>percentage</td>
<td>percentage</td>
</tr>
<tr>
<td>Male</td>
<td>2</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>12.500</td>
<td>31.250</td>
<td>56.250</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>21.428</td>
<td>7.143</td>
<td>71.429</td>
</tr>
</tbody>
</table>

Table III. Gender differences in Cognitive Style

Achievement

All trainees in the sample completed the assignments in both the design and electronic modules. In the first instance the mean mark for each trainee was calculated using the combined data from Level 1, 2 and 3 modules in both design and electronics. For some analyses the overall mean marks were split into five categories, these were in line with university degree classification boundaries (see Table IV). Gender differences were found in each of these categories and will be discussed in the following paragraphs.

<table>
<thead>
<tr>
<th>Percent</th>
<th>Design Total</th>
<th>Design Male</th>
<th>Design Female</th>
<th>Electronics Total</th>
<th>Electronics Male</th>
<th>Electronics Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;40%</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40-50%</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>50-60%</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>60-70%</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>&gt;70%</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

Table IV. The number of trainees in each mean score category for Design and Electronics modules.

In the combined marks for the three design modules the total sample achieved a mean mark of 57.100 with a Standard Deviation of 10.516. The maximum mark awarded was 76 percent and the minimum was 38 percent. In an analysis of achievement in terms of gender it was found that results were in-line with recent research (e.g. Skaalvik & Rankin, 1994; Wong, Lam and Ho, 2002) in that females outperformed males by achieving an overall higher mean mark, although this was not by a significant amount (unpaired t-test P-value .6442) (see Table V). The marks for female trainees tended to be compressed around the mean whereas the marks for male trainees were spread across the full mark range with a higher percentage of males (18.750) than females (14.286) achieving over seventy percent, and the top two marks for the whole sample being awarded to males. At the opposite end of the achievement scale thirty-one percent of males as apposed to only twenty-one percent of females were awarded marks of under fifty percent, and the only trainee to fail with a mark of less than forty percent was male.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Design Mean Mark</th>
<th>Electronics Mean Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>56.250</td>
<td>69.375</td>
</tr>
</tbody>
</table>
Table V. Mean marks for the combined Level 1, 2 and 3 marks for trainees in both Design and Electronic modules

All trainees in the sample completed each of the electronic skills modules at levels 1, 2 and 3. The results indicated an overall mean mark of 65.167 with a Standard Deviation of 11.350. In this case the maximum mean mark awarded was 86 percent and the minimum was 43 percent. In contrast to the design modules male trainees in the electronic modules achieved a higher mean mark than female trainees (see Table V). Once again this result was not significant although there was a greater gender difference than in the design modules. It was also found that a significant fifty percent of males achieved a mark of over seventy percent in comparison to only fourteen percent of females (Variance 18, df 1, chi-square 18.000, P-value < .0001). At the opposite end of the mark range a disappointing fourteen percent of females achieved a mean mark of less than fifty percent whilst only six percent of male trainees were found in this category. (see Table IV).

Achievement in relation to Cognitive Style

In the first instance the overall mean mark for each trainee in design modules were viewed using the two cognitive style dimensions separately. The mean mark achieved by each cognitive style category was then placed in rank order (see Table VI). On the WA dimension, Analytics were the most successful and Intermediates at the centre of that dimension were the least successful. On the VI dimension, Imagers were the most successful and once again those at the centre of the dimension, were the least successful. In comparing the success rates of the six cognitive style categories together it was found that Imagers were overall the most successful and Intermediates were the least successful. As already explained, it was not a surprise that Imagers were the most successful group in design activities, due to the nature of the activity. However the nature of the activity could not explain the lack of success for Intermediates on the WA dimension. In fact the researcher would have expected Intermediates, who had the ability to oscillate easily between viewing the task as a whole and concentrating on segments of the task, to have achieved a much higher level of success in this area of design and technology. It was recognised that although this result provided interesting food for thought, it had to be remembered that the skewed distribution in terms of both cognitive style and gender distribution could have affected the result (see Table III).

As with design marks, the electronics overall mean marks were viewed using the two cognitive style dimensions separately and the results were placed in rank order (see Table VI). On the WA dimension Intermediates who had been the least successful in design activities were found to be the most successful in electronics whilst Wholists were the least successful. On the VI dimension the results replicated those found in the design modules, Imagers were the most successful and Bimodals, at the centre of that dimension, were the least successful. In comparing the mean marks of the six cognitive style cells together it was found that overall Intermediates were the most successful and Bimodals the least successful. For the reasons given in the paragraph above there was no surprise in finding that Intermediate trainees were the most successful. However, as the teaching materials were provided in an evenly balanced mixture of text and images it was unexpected to find that Bimodals, who were considered equally able to process information in both forms, were in fact the least successful. Nor could the gender balance be a factor as...
there was little difference between the number of males and females in this cognitive style category (see Table III).

When viewing the achievement data for design modules in isolation it was found that on the WA dimension a similar pattern was followed by males and females (see Table VII). Intermediates from both sexes did equally badly although no one cognitive style category achieved a significantly high or low mean mark. On the VI dimension male Imagers achieved a high mean mark and Bimodal males achieved a very low mean mark, whereas once again there was little difference between female achievements in any of the three cognitive style categories.

In an analysis of the achievement data for electronic modules, it was disappointing to find a large gender difference in that the best female achievement was lower than the poorest male achievement (see Table VII). It was also found that the achievement of female trainees was similar across each cell of the WA dimension whilst there was a difference between male trainees in each cell. On the VI dimension a mirror image was found between the data for males and females. Female Verbalisers achieved better results than other females and male Verbalisers obtained worse results than other males.

When achievement in the contrasting areas of design and technology were compared using gender as well as cognitive style as the variables the data indicated that there were interesting differences (see Table VII). In many ways this was to be expected as a search of the literature suggested a fundamental difference in the information processing skills of males and females (e.g. Riding & Rayner, 1998). This was further compounded in this study by the need for very different types of information processing in the contrasting areas of design and technology under scrutiny. The data analysis indicated that female Verbalisers did well in electronics and poorly in design modules, whilst female Imagers did well in design modules and poorly in electronics. In contrast male Imagers did equally well in both electronics and design activities whilst Bimodal males achieved very poor results in design activities and male Verbalisers achieved poor results in the electronics modules (see Table VII). Unfortunately as mentioned previously the distribution of cognitive style was skewed on the WA dimension (see Table II) and when split by gender many cells became too small for meaningful statistical analysis. However, the data did provide support for the need for further research into gender differences in the context of design and technology, preferred learning style and achievement, using a larger sample in the future.

<table>
<thead>
<tr>
<th>Male Success Rate</th>
<th>Design Modules</th>
<th>Electronics Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WA Mean mark</td>
<td>VI Mean Mark</td>
</tr>
<tr>
<td>Most Successful</td>
<td>A 58.000</td>
<td>I 64.200</td>
</tr>
<tr>
<td></td>
<td>W 57.000</td>
<td>V 55.400</td>
</tr>
<tr>
<td>Least Successful</td>
<td>INT 52.800</td>
<td>BIM 50.333</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Female Success Rate</th>
<th>Design Modules</th>
<th>Electronics Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WA Mean mark</td>
<td>VI Mean Mark</td>
</tr>
<tr>
<td>Most Successful</td>
<td>A 59.200</td>
<td>I 59.600</td>
</tr>
<tr>
<td></td>
<td>INT 56.00</td>
<td>BIM 58.200</td>
</tr>
<tr>
<td>Least Successful</td>
<td>W 55.000</td>
<td>V 57.000</td>
</tr>
</tbody>
</table>

Table VII. Achievement in Design and Electronics modules split by Cognitive Style and Gender

Achievement in relation to previous experience

With regard to previous experience in design activity, the sample was split fairly evenly into those who had little or no experience prior to beginning their degree programme, those with some experience, and those with considerable experience (see Table VIII). In an analysis of design achievement data using these categories, a positive relationship was found (see Table VIII). Those trainees who had the most previous experience were the most successful, and those who had minimal experience were the least successful. When gender was added to the equation the data indicated that the female sample continued this expected
pattern, whereas the male sample provided a different picture. However, the result for males did not indicate a reliable trend as there were only four males in this category and whilst one trainee achieved the anticipated high design mark the other three had pulled the mean down with very low marks which had unfortunately occurred across all their University studies.

### Design Modules

<table>
<thead>
<tr>
<th>Level of previous experience</th>
<th>Sample size</th>
<th>Total Sample</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considerable previous experience</td>
<td>n = 10</td>
<td>59.700</td>
<td>54.500</td>
<td>63.500</td>
</tr>
<tr>
<td>Some previous experience</td>
<td>n = 9</td>
<td>58.222</td>
<td>69.500</td>
<td>55.000</td>
</tr>
<tr>
<td>Minimal previous experience</td>
<td>n = 11</td>
<td>53.818</td>
<td>54.000</td>
<td>47.000</td>
</tr>
</tbody>
</table>

### Electronics Modules

<table>
<thead>
<tr>
<th>Level of previous experience</th>
<th>Sample size</th>
<th>Total Sample</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considerable previous experience +</td>
<td>n = 2+3</td>
<td>76.400</td>
<td>66.000</td>
<td></td>
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<tr>
<td>some previous experience</td>
<td></td>
<td>79.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal previous experience</td>
<td>n = 25</td>
<td>62.920</td>
<td>66.167</td>
<td>59.923</td>
</tr>
</tbody>
</table>

Table VIII. Achievement in Design and Electronic modules split by Previous Experience and Gender

In electronics it was found that there was skewed sample distribution (see Table VIII). As twenty-five trainees (seventy five percent) had no previous experience of electronics before they began their degree programme in comparison to only three that had some experience and two (both male trainees) who suggested that they had considerable previous experience. As these two later categories had so few trainees in them it was decided to amalgamate them, thus providing a category, ‘with previous experience’ (n = 5) and one ‘with no previous experience’ (n = 25). When achievement data was then scrutinised it followed the expected trend identified in the design data, those trainees who had no previous experience were the least successful and those with experience were the most successful (see Table VIII). A disappointing feature of this data was the gender difference in terms of achievement. Once again the data provided a clear indication of the poor level of female success in the electronic modules with the top mean mark for female trainees who had previous electronics experience being lower than the bottom mean mark for the male trainees who had no previous experience.

### Conclusion

The cognitive style groupings of the sample were not as expected although it was recognised that there was a possible conflict between the cognitive styles compatible with acquiring design and technology skills and those considered helpful to teachers of that or any other subject. On the VI dimension it had been expected that there would be either, more Imagers due to the nature of the design and technology being studied or more Intermediates as the trainees were intending to become teachers, however on this dimension there were an even number in each cognitive style category. The significantly large proportion of Analytics on the WA dimension was surprising as it had been anticipated that if any of the three categories were to have a larger number of trainees in it then that would be Bimodals, both due to the nature of the design and technology activities being studied and the fact that the sample were training to be teachers.

With regard to achievement in relation to past experience, the expected positive relationship was found throughout both design and electronic modules. Those who had previous experience achieved higher results than those who were new to the subject even after having studied modules at Levels 1, 2 and 3. This finding would suggest that even more support is required for those trainees studying areas of design and technology that are new to them, if we are to produce NQT’s who are confident enough in their own subject knowledge to apply for teaching posts that include that aspect of design and technology within the job specification.

However, the main area of concern that this study has highlighted has been the relationship between gender and achievement. In design activities although female trainees achieved a better mean mark than male trainees, it was males in the sample who achieved the highest marks. In electronics male trainees outperformed female trainees even though there were a similar proportion of both sexes who had no
experience of electronics before starting the programme. When cognitive style data was added to the picture it was found that the relationship between cognitive style and achievement was different for males and females. In the case of the male sample, Imagers were the highest achievers in both design and electronic modules whilst the female cognitive style category that achieved high marks in design modules achieved low marks in electronics and visa versa. Unfortunately the size of the total sample was such that when split into the six cognitive style categories the cells became too small for meaningful statistical analysis to be carried out. However, the picture that has emerged could be significant if the same results were replicated in a larger sample. It is therefore the intention of the author to collect data from other institutions training design and technology teachers so that the gender and cognitive style differences witnessed in this study can be investigated further.

References
D&T curriculum dancing - a case of treading the light fantastic, under a bushel, with bow legs.

Steve Keirl, University of South Australia  
Email: steve.keirl@unisa.edu.au

Abstract

This light-hearted, but conceptually grounded, paper uses the metaphor of dance to highlight current Design and Technology (D&T) curriculum issues. Its aim is to blend humour with some observations that reflect a spectrum of curriculum developments happening asynchronously but in a similar general pattern across the globe. Dance(s) are used to illustrate the kinds of issues faced historically and contemporarily in the field.

It will be seen that D&T curriculum leads the life of the mixed metaphor with a sprinkling of analogy, proverb and adage thrown in. A concluding position asks the question of whether D&T is ready to bring its light from under the bushel and dance publicly. It is hoped that the different style of paper nevertheless offers stimulus for curriculum thinking and debate.

Apologia

The author is not a dance specialist but has tried to use the artform authentically. There are myriad dances to choose from and all those cited here are to be found in either the references or the ‘other sources’ (appended). This style is intended to help with flow and clarity.
The mixing of metaphors, analogies and adages is a deliberately light-hearted but grounded commentary on Design and Technology (D&T) curriculum concerns. Such use of the English language is problematic and unorthodox for such a paper. It is hoped that neither dance nor D&T have been unduly treated.

To set the tone, a *caper* can be a frisky movement or a playful leap, rather than a dance. It has been defined as a ‘fantastic proceeding’ which is a desirable outcome of this conference. Thus by *cutting a caper* a double entendre is heard - shaping the fantastic proceedings as well as invoking the rhyming slang for *putting a paper*.

**Commonalities and otherwise**

Both technology and dance are as old as the species and both express identities of self and culture (Mumford, 1934; Royce, 1977). Both are non-verbal forms of human expression. Perhaps neither can be appreciated or criticised without some initiation into their ways and values. Both continue to take on new forms but are grounded in old ways. Just as Lange (1975:82) suggests that “…dance forms are inherited by…following generations as part of their cultural equipment”, so it is with technology. Many dances are complex and subtle, so too with technology. Many dances are led by men, so too with technology.

There are differing dance locations – for oneself, with others, alone or for audiences. Lange (1975) describes the long lineage to be traced. From beginnings in animal-human biological mimicry, there developed two genres of magico-religious dance and dance-as-art. From these descended ritual, liturgical, dramatic dance, and dance as entertainment. However, when the dance as performance is done, it is done. Nothing but memories and images are left for the observer or critic. Not so the case for technology where its presence is real, lasting, and ready for critique both immediately and long afterwards.

There are educational commonalities too. Greene (1981) describes dance literacy as more than a form of entertainment or a social practice - as an object in aesthetic space. Such an approach begs comparison with articulations of technological literacy (see sources: technological literacy). Amongst the organising ‘strands’ used in Australian technology curriculum is the process strand of ‘design, make and appraise’ (AEC, 1994) while the same year Smith-Autard (1994) articulated three dance strands of Creating, Performing and Appreciating.

**Knowing D&T curriculum dancing**

It is important to know what is D&T’s dance bag and what is best avoided. For example, most primitive dance types (*bird*, *animal*, or *insect* mimicry) have little curriculum value (although a *technology curriculum tiger dance* could have merit). While our field is experienced in health and safety matters, *sword dancing* of the Balinese and Korean kind is best left to experts as serious injury is not unknown. Similarly, *war dances* are of little value. More appropriate are *stick dances* (modelled in Spain and England) where injury is confined to one’s colleagues. The solo version of curriculum *stick dancing* is the Welsh *broom-dance* - but most colleagues bristle at the thought of such individuality and flare.

*Rain dances* may be helpful to those working with agricultural technology curricula but the *phallic rain dance* of the Hopi people of Mexico is unnecessary. Any curriculum addressing the built environment may gain from some Ukrainian, Montenegrin or Central Himalayan *two-storey dancing* but this can mean inequitable workloads. In these circumstances or in hot countries, *fan dances* cannot be used for cooling purposes. The fan-dance proper, along with any *abdominal* (including! *belly*) *dance*, is inappropriate to industrial workplaces. Totally avoid the *Bourée de la Chapelotte* from France as the curriculum guidance is both unclear and thoroughly inappropriate viz: ‘…at the end of the dance the man bends forward waiting for the girls to kiss his cheeks.’

Commonly mistaken as D&T curricula are *ecstasy dances* of the Whirling Dervish and Sri Lankan ilk. The induction of trance-like states in both dancers and audience is poor D&T form. However, one exception stands out. *Wrench-dancing* articulates designerly behaviours with its ‘…mingling of the genuinely intuitive and…grotesquely ridiculous thoughtfulness.’ (Sachs, 1937:45). Again, the trance must be avoided.
There are some D&T curriculum dances that could be dropped. Setting aside any stripping of willows, there are dances for chimney-sweeps, harvesters, hunters, millers, scissor-grinders, shoemakers, smiths, washerswomen, and weavers. Two examples show why we might play these low-key. The hammersmiths’ dance from Germany offers lively movements (of the men) representing the rise and fall of the hammers - not the most contemporary of technological images but where are the girls? Standing three feet behind the men who slap their own thighs and chests and clap alternate right and left hands with another man. There is an English equivalent. In the nutters’ dance the men have blackened faces, short white skirts, white plumed hats, black breeches and clogs as well as wooden ‘nuts’ like castanets fastened to hands, waist and knees. Time is kept by clapping their nuts. Whilst a common sight in former technology practice, this dancing with all its white-maleness is now improper.

Recent centuries have produced many technological dances that were mere curriculum fads. The locomotion moved on. Both the volta and courante were amply provided for, and the reel – analogous of rotary apparatus (the dance is windlass in Czech) – is unsustainable as, being reel, it cannot be virtual. A curriculum tradition still very much alive is woodwork and, from dancing to the rhythm of cotton mill machines, came the need for people both trained to use the machines and to make clogs to dance with. Thus the educational term ‘clever clogs’ began in D&T. Also came the philosophical question of whether we should only dance to the tune of the machinery or we should give a broader education e.g. in foreign languages and learning that sabot means ‘clog’ in French; - or in anarchy, as in ‘throwing your clogs in the machinery’ meaning sabotage in English. (Branle des sabots – clog dance.)

Take your partners please for curriculum dancing couples which have been both bane and boon for D&T. The classic is the pairing of science and technology. Proof of the error of this unhelpful misnomer comes from the Portuguese Gota and the Swedish Snurrebocken. In the former, the partners look at each other over their shoulders as they turn in the dance while in the latter the partners bow and curtsey back to back then, with body bent slightly forward, partners turn slowly inwards looking coyly at one another. Not only are they mutually wary, but they are technology and science the wrong way round.

Fads, fashioning and futures in D&T dancing
If partner-changing is needed then a progressive dance will be better. There are also exciting possibilities in re-working the jig with some Morris dancing (being mindful of ‘fools’) then there will be hope for an all-new dancing bells and whistles curriculum. But beware the critics:

When the tango made its appearance in the old world in 1910, it released a dance frenzy, almost a mania, which attacked all ages and classes with the same virulence. You may shake your head, smile, mock, or turn away, but this dance madness proves nonetheless that the man (sic) of the machine age with his necessary wristwatch and his brain in a constant ferment of work, worry, and calculation has just as much need of the dance as the primitive. (Sachs, 1937:446).

How can technology curriculum dancing alleviate such ‘constant ferment’? Of late, the hokey-cokey style of D&T curriculum development, developed in England, has become globally popular. Different bits were put in, then put out, then in, then out, in, out, and always shaken all about. Recent design-based developments in Russia (Pavlova & Pitt, 2000) have been articulated through the Karapyet dance, with its sharp and neat movements, and after the third iteration, dancers flinging their outside arms upwards and outwards and shouting “Hoi” on the last beat.

Leadership matters and while D&T curriculum is rather being lead a dance it is gratifying that there is no lord of the dance with an aligned and rapidly moving support act. Another analogy for the metaphor might be that of a wandering conga or a chaîne anglaise leaderless, intricate but ending up in the same place. Perhaps ice-dancing would be more figurative – at times graceful, often all over the place. It might be best to continue with the sitting and standing dances and staying rooted to the spot to conserve energy. The only alternative to this stagnation is a cushion dance where one waits to be kissed by the clown.

Knowing one’s place in the order of things has long been D&T’s problem. To mix the metaphors and balls we have long been wallflowers on the sideline waiting to be picked, plucked (in the heritage sense), or
thrown into the ball. This is a sad inheritance of undemocratic and class-based institutionalism. Louis XIV rated dancing for ‘forming the body’ and assisting in bearing arms – an early vocational training for the hoi-polloi. The belle danse back then contained ‘…essentials for displaying the social hierarchy or the order of succession to the throne.’ Garlick, (1994:122). At the English court ball (which is not tennis, the technology of which is entirely different from dancing) matters were much the same. If uneven ground prevailed, as is the case for D&T masses, then an appropriate (peasant) dance with a bouncy step was danced – the Estonian Viru Vals.

One might see D&T curriculum as pantomime, either in its original sense of a play without words, or in its current sense of seasonal show of song, dance, and political parody - reflecting Layton’s (1994) ‘curriculum drama’ of competing stakeholders. From the pantomimic dance genre the galliard exemplifies D&T. Does our field not have moments of ‘incontrollable zest’? Is it not ‘…danced forward, backward, sideways and diagonally’? Given that one chronicler of dance needed 50 pages to cover the galliard’s ‘varieties and deviations’ what hope for D&T’s? (Sachs, 1937:359)

Wouldst that our dancing curriculum were more embracing. Sachs (1937) points to a whole group of initiation dances and curriculum philosopher R.S.Peters (1965) writes lucidly on initiation. We have tried the likes of the Hungarian recruiting dance with limited success. Perhaps the Aboriginal brolga dance would help. (An Aboriginal girl refused to marry “I want to be free…to dance and dance and dance”. Usually only the men danced but she couldn’t sit and watch. She performed the corroboree dances very well but was forever creating new dances. Eventually she was turned into the first brolga (a bird) by a mean man who had learned evil magic. But she still danced beautifully and, ever since, Aboriginal people have protected brolgas (Ellis, 1991).) There are many brolgas waiting to dance the D&T dance.

Other, more political, dance arrangements are apparent. The Estonian Sadala Polka depicts events in a village following the visit of a snuff pedlar. The dance shows offering and taking of snuff (computers in schools?), sneezing, a quarrel and, finally, reconciliation. Meanwhile, the Polish Kokotek depicts a quarrel in the marketplace over a chicken (vocational dollars?), finishing with all the dancers on their knees pulling and grabbing at the bird.

By contrast, we can enjoy the being-ness of the D&T polonaise. Remarks from 1645 are no less applicable to D&T now: ‘I know of no dance in which so much loveliness, dignity and charm are united as in the polonaise… (It) is marked by poetic feeling and the national character, the outstanding trait of which is a ceremonial dignity.’ (cited in Sachs, 1937:424).

Today, excesses of nationalism are eschewed and we should share cultural differences as Tolstoy apparently describes in War and Peace, ‘…an aristocratic ball in Russia at the beginning of the 19th Century consist(ed) entirely of écossaises and anglaises.’ (Sachs, 1937:438). These are respectively Scots and English in French and not to be confused with a française which is both French and in French. The allemande is also in French but is German while the danse de Canaries is not French, is in French and is not about birds. This is excellent modelling for today’s democratically globalising D&T curriculum.

However, this is not to advocate faddishness. The waltz exemplifies what can happen when mere fashion informs curriculum design. Described as bourgeois by some and resisted by others it swept Europe. In 1804, Arndt commented that ‘…the waltz together with tobacco-smoking and other vulgar habits (have) become common.’ (Sachs, 1937:432). (The reader can offer their favourite D&T dance fad here.)

There has been curriculum contention over matters of the sexiness of design process too. Is it linear, cyclical, interactive, chaotic, non-existent? Just what is its level of eros? Behnke (n.d.) discusses the analogy of dance and sexuality and ‘…the notion of climax, a structural feature of much Western theatre dance and an abiding preoccupation of contemporary sexuality’ (Behnke, n.d:13). She discusses the temporal themes of love-making and dance and how each is often geared to the climax – an end state, or the necessary outcome of a build-up (prelude = foreplay in Latin). Alternatively there are dance forms which can defy the linear one-event-following-another and ‘…where climaxes are optional or fortuitous rather than obligatory and prearranged’. Herein lie the D&T process-product debate and the linear design-line
problem. Is the design process rich in multiple climaxes or is it a pedestrian build-up to the single grand climax of the product? The preferred curriculum dance, of course, engenders both.

Some commentary on dance partnerships has been given but partnership quality – who benefits – and partnership type both matter. For example, some guidance notes are simply inequitable and inappropriate (‘Man stands behind the girl and slightly to her left. She has her hands clenched and the knuckles at her waist. Man holds her wrists.’). Occasionally, some curriculum flirtation may seem necessary but this must be mutual as in the Swedish Fjällnäs Polska and the Sicilian Tarantella, (flirting dances). The latter is to be ‘gay and free – but movements should still be controlled’ Dignity matters if D&T is to develop its own integrity. Circle arrangements are beneficial and the cooperative nature of the Fyrtur from Norway comes from joining hands at shoulder level – so both hands and shoulders can be put to the wheel. Moreover, the step-close-pause movements ‘give the dance a character of its own’ and, no doubt, time for deliberation. More subtle is the Breton Ridée de Baud where contact is by ‘little finger hold, hands held at shoulder level.’ Happily the style is gay and the dance is repeated as often as desired.

Not every dance is partner-dependent. In some ritual dances ‘...the dancers may form a shapeless group...when every dancer is concerned only with his (sic) own spiritual experience.’ (Lange, 1975:82). Perhaps the odd solo can-can (an enfant terrible employing the fertility motif of throwing legs high) might bear fruit where other fertility or hunting dances don’t. Disco dancing is best moderated, avoiding mass individuality or mass trend-dancing. Jigs have always been helpful in D&T and are ecologically low on energy consumption using lively stamping of the heels and rapid footwork with a quiet torso. With origins in mountain districts (viz: Ancient Greece, Norway, the Scottish fling, Basque aurrescu, and the Morlaks kolo (Sachs, 1937:26)), occasional leap dancing must benefit higher-order thinking. (The kolo was accompanied by a mug of cocoa but cultural plundering saw the theft of the recipe and its later marketing as cocoa-kolo.) From leap-dancing it wouldn’t be a major step to develop a D&T ballet – again colleagues can imagine the possibilities.

What desirable balance might we pursue? Clearly dignity, pace and respect matter and, while minuet, gavotte, and pavane can all play a part, it is argued that the key is a sacred circle dance. Here, all can participate in a democratic whole. All have equal shares of space and share equal vision. ‘When we participate in sacred circle dancing, we are recalling the reverence our ancestors felt for life... The feelings engendered by moving in harmony and unison with others, touch the hearts of people who experience this form of dance.’ (Thomas, 1994:293). Thomas (1994) talks of awakening our inner realms, of resonance at heartbeat level, and of introducing gentleness and respect with others at conferences.

D&T dancing has a long and rich history but it surely has a central role in any education in the future. We can choose our dances and have the ball we deserve. We can invite partners and show them the carriage at midnight if we wish. We can develop an international D&T curriculum culture. We can circle dance and enjoy myriad localised dance varieties too. The masquerade, where we hide in our own show, might cease to be. A new era is envisaged where we have our own integrity and permanent place in the programme.

Bushels and bow legs
When the curriculum analysis is done it could be time for a public appearance. We can dance amongst ourselves and, either through participation or performance, enjoy ourselves but when we have our act together we can articulate it by cutting more capers and by strutting our stuff. Before we decide to bring our light, to tread it fantastic, from under the bushel three cautionary notes remain. First, why did we keep it under the bushel anyway? Second, if one’s light is under a bushel, it can be difficult to find the bushel itself (Barker, n.d). Finally, we must know our strengths and weaknesses and which we should publicise – as one of my grandmothers would say, ‘Never tell anybody you have bow legs’.

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Program of Study for ‘Design and Technology’ in 1999’s Revised National Curriculum in England

Masataka ISOBE, Graduate Student, Hyogo University of Teacher Education, JAPAN
Sadato YAMAZAKI, Associate Professor, Joetsu University of Education, JAPAN

Email: d02702j@cc.juen.ac.jp
Email: yamazaki@juen.ac.jp

Abstract

The purpose of this study was to examine what was comprised ‘developing, planning and communicating ideas’ as one of the aspects in the ‘Program of Study (PS)’ for ‘Design and Technology (DT)’ in 1999’s revised National Curriculum in England by the Multidimensional Scaling. There were twenty-four items regarding ‘developing, planning and communicating ideas.’ This study was set out these items as a statistical variable to compare these items with assessment criteria for DT of the ‘Assessment and Qualifications Alliance’ examination board.

In concluding, (1) ‘developing, planning and communicating ideas’ was comprised three types of learning abilities: ‘designing planning’ and ‘expressing and explaining;’ (2) the three learning abilities were introduced pupil’s development aged 5 to 16 in accordance with pupils’ performance systematically; (3) their types and assessment criteria of the AQA examination board were related to ‘designing’ as a ‘whole process of technological activities.’
Keywords
England, the sequence of ‘Program of Study,’ Multidimensional Scaling, ‘developing, planning and communicating ideas,’ Assessment Criteria

Purpose
The purpose of this study was to examine what was comprised ‘developing, planning and communicating ideas’ which is one aspect of the ‘Program of Study (PS)’ for ‘Design and Technology (DT)’ in 1999’s revised National Curriculum in England by the statistical method of the Multidimensional Scaling (MDS).

Problem
The Japanese national curricular scopes and sequence for lower secondary technology education have been influenced by classification based upon traditional industrial education. It has been comprised processing materials; electricity; mechanics; cultivation; and information technology. However, scopes and sequence related technological process of technology education as the Japanese national curriculum standard have not been cleared. Therefore, it is very difficult for technology teachers and educators to know the relation between technology education of lower secondary education and primary and upper secondary education. In Japan, there have not been any technology related subjects as general education in primary and upper secondary schools.

The Ministry of Education, Culture, Sports, Science and Technology (MECSST) has entrusted to make assessment criteria of lower secondary technology education to each school. For this reason, weights of viewpoints for evaluation have differed from each school. Schoolteachers should evaluate by absolute evaluation from 2002 school year. It is necessary to explore new general technology education as the Japanese national curriculum standard and assessment criteria based on technological processes as well as technological objects.

Technology education in U.K. has been developed the curriculum and assessment criteria, as can be seen in the following quotation: ‘Technology in the curriculum has been formed in the last 30 years in parallel with a sequence of developments in examinations and assessments. This has forced us constantly to confront and debate the definition of performance (ie what do we mean by technology?) and the appropriate standards of excellence (ie what counts as good and poor) (Kimbell, 1997: p.13).’ The current ‘Design and Technology (DT)’ in the National Curriculum (NC) in England has been revised since 1999. It is characterized that the curricular scopes and sequence have been set out in accordance with both technological objects and design processes (designing) (Murata et al., 1995; Kimura, 1998; Yamazaki, 1999). Opinions are divided among researchers of technology education on a concept of ‘designing’ (Layton, 1993; Province of British Columbia Ministry of Education, 1995; Hill, 1998; Mioduser, 1998; Williams, 2000; Custer et al, 2001).

This study follows the concept of ‘designing’ which is shown in a school textbook for ‘Craft, Design and Technology Suitable for Key Stage 4’ by Collins Educational. Since this textbook was used in many schools according to Yamazaki’s, the second author, both long and short field surveys in U.K. from 1994. This study has conformed to ‘designing’ concept of this textbook. The textbooks in U.K., unlike Japan, have been adopted and published freely (Shibata, 1997: p.34).

According to the description, ‘designing’ is defined as follows: ‘designing is concerned with the whole process from identifying a problem, through to creating a solution and then testing it (Breckon, 1991; p.6).’ Namely, it is reasonable to think that ‘designing’ means ‘whole process of technological activities’ and is a kind of the technological processes. In U.K., ‘designing’ has been very stressed in technology education as a general education. Therefore, in order to explore the curricular scope and sequence of ‘designing,’ this study was concerned with ‘Program of Study (PS)’ and ‘Attainment Target (AT)’ in DT.

PS in DT has been set out ‘what pupils should be taught: knowledge, skills and understanding.’ Concretely, PS in DT has categorized six areas: ‘developing, planning and communicating ideas working with tools, equipment, materials and components to make quality products evaluating processes and products,’ ‘knowledge and understanding of materials and components,’ ‘knowledge and understanding of...
structures’ and ‘knowledge and understanding of systems and control.’ PS in DT has been instituted according to ‘Key stage (KS) 1-4’ systematically (Figure 1).

Figure 1. The Relation between Pupils' Age and Key Stage

It was supposed that ‘developing, planning and communicating ideas’ of PS in DT was one of the scopes and sequences related to ‘designing.’ The data of Table 1 summarizes all contents of ‘developing, planning and communicating ideas.’ As the data of Table 1 indicated, it seems reasonable to suppose that twenty-four items were revealed mixing and composing of three aspects: ‘developing of idea,’ ‘planning of idea’ and ‘communicating of idea.’ For this reason, it was supposed that it was very difficult to explore common factors between variables as well as the scope and sequence of ‘designing.’

Therefore, the purpose of this study was to examine what was comprised ‘developing, planning and communicating ideas’ of PS in DT in order to explore concept of ‘designing.’

The Method of This Study

There were twenty-four items in ‘developing, planning and communicating ideas’ of PS. This study was set out these items as a statistical variable to compare these items with assessment criteria of the ‘Assessment and Qualifications Alliance (AQA)’ examination board. Designing skills of assessment criteria in the AQA examination board is shown in the data of Table 2. This study was compared each designing skill of Table 2 with twenty-four variables of ‘developing, planning and communicating ideas’ and then made a matrix. Three persons including the authors carried out this procedure. The other person was the second doctoral program graduate student of technology education who had no teacher career. Next, the result of matrix was analyzed by the statistical method of the Multidimensional Scaling (MDS). This study was used SAS to practice this statistical method.

Table 1. Twenty-Four Items of ‘Developing; Planning and Communicating Ideas’ of PS in DT. This table was a modification of part of the ‘Program of Study’ in the National Curriculum for England, Design and Technology (Department for Education and Employment and Qualifications and Curriculum Authority, 1999).

<table>
<thead>
<tr>
<th>KS</th>
<th>Developing, Planning and Communicating Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pupils should be taught to:</td>
</tr>
<tr>
<td></td>
<td>(1) generate ideas by drawing on their own and other people’s experiences</td>
</tr>
<tr>
<td></td>
<td>(2) develop ideas by shaping materials and putting together components</td>
</tr>
<tr>
<td></td>
<td>(3) talk about their ideas</td>
</tr>
<tr>
<td></td>
<td>(4) plan by suggesting what to do next as their ideas develop</td>
</tr>
<tr>
<td></td>
<td>(5) communicate their ideas using a variety of methods, including drawing</td>
</tr>
<tr>
<td></td>
<td>making models</td>
</tr>
</tbody>
</table>
Pupils should be taught to:

6. generate ideas for products after thinking about who will use them and what they will be used for, using information from a number of sources, including ICT-based sources

7. develop ideas and explain them clearly, putting together a list of what they want their design to achieve

8. plan what they have to do, suggesting a sequence of actions and alternatives, if needed

9. communicate design ideas in different ways as these develop, bearing in mind aesthetic qualities, and the uses and purposes for which the product is intended

Pupils should be taught to:

10. identify relevant sources of information, using a range of resources including ICT

11. respond to design briefs and produce their own design specifications for products

12. develop criteria for their designs to guide their thinking and to form a basis for evaluation

13. generate design proposals that match the criteria

14. consider aesthetics and other issues that influence their planning, for example, the needs and values of intended users, function, hygiene, safety, reliability, cost

15. suggest outline plans for designing and making, and change them if necessary

16. prioritise actions and reconcile decisions as a project develops, talking into account the use of time and costs when selecting materials, components, tools, equipment and production methods

17. use graphic techniques and ICT, including computer-aided design (CAD), to explore, develop, model and communicate design proposals, for example, using CAD software or clip-art libraries, CD-ROM and internet-based resources, or scanners and digital cameras

Pupils should be taught to:

18. develop and use design briefs, detailed specifications and criteria

19. consider issues that affect their planning, for example, the needs and values of a range of users; moral, economic, social, cultural and environmental considerations; product maintenance; safety; the degree of accuracy needed in production

20. design for manufacturing in quantity

21. produce and use detailed working schedules, setting realistic deadlines and identifying critical points

22. match materials and components with tools, equipment and process, taking account of critical dimensions and tolerances when deciding how to manufacture the product

23. be flexible and adaptable in responding to changing circumstances and new opportunities

24. use graphic techniques and ICT, including computer-aided design (CAD),
to generate, develop, model and communicate design proposals, for example, using CAD software to generate accurate drawings and part drawings to help with manufacturing.

KS: Key Stage, KS 1 (5-7 years old), KS 2 (8-11 years old), KS 3 (12-14 years old), KS 4 (15-16 years old)

**Table 2.** Designing Skills of Assessment Criteria in the AQA Examination Board (Assessment and Qualifications Alliance, GCSE, Design and Technology: Resistant Materials Technology; Full and Short Course, 2000).

1. Research  
2. Analysis (of problem / task and research)  
3. Specification  
4. Generation of ideas  
5. Development of ideas  
6. Planning of making  
7. Evaluation, testing and modification  
8. Use of communication, graphical and use of ICT skills  
9. Social issues, Industrial practices and systems and control (including the use of CAD)

**Figure 2.** The Result, Which 21 Items of ‘developing, planning and communicating ideas’ were Analyzed by the Multidimensional Scaling
Results and Discussion
The results of the MDS are presented in Figure 2. Twenty-four items of ‘developing, planning and communicating ideas’ were classified into three main groups.

Items plotted in the plus direction of dimension I were ‘(2) develop ideas by shaping materials and putting together components,’ ‘(6) generate ideas for products after thinking about who will use them and what they will be used for, using information from a number of sources, including ICT based source’ and ‘(14) consider aesthetics and other issues that influence their planning, for example, the needs and values of intended users, function, hygiene, safety, reliability, cost’ etc. It was supposed that these items were very relevant to activities of planning and designing. Therefore, this group was named ‘capability of designing.’

Items plotted in the plus direction of dimension II were ‘(3) talk about their ideas,’ ‘(9) communicate design ideas in different ways as these develop, bearing in mind aesthetic qualities, and the uses and purposes for which the product is intended and ‘(24) use graphic techniques and ICT, including computer-aided design (CAD), to generate, develop, model and communicate design proposals, for example, using CAD software to generate accurate drawings and part drawings to help with manufacturing’ etc. It was likely that these items were very relevant to express and explain students’ ideas for themselves. This group was named ‘capability of expressing and explaining.’

Items plotted in the minus direction of dimension II were ‘(4) plan by suggesting what to do next as their ideas develop,’ ‘(6) generate ideas for products after thinking about who will use them and what they will be used for, using information from a number of sources, including ICT-based sources,’(22) match materials and components with tools equipment and processes, talking account of critical dimensions and tolerances when deciding how to manufacture the products’ etc. It was guessed that these items were very relevant to activities of planning. Thus, this group was named ‘capability of planning.’

Next, this study was investigated a curricular sequence of each group. The data of Table 3,4,5 appears the sequence of each group.

Table 3. The Relation between Each Key Stage and Criteria of ‘Capability of Designing.’ This table is a modification of part of the ‘Program of Study’ in the National Curriculum for England, Design and Technology (Department for Education and Employment and Qualifications and Curriculum Authority, 1999).

<table>
<thead>
<tr>
<th>KS</th>
<th>Capability of Designing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a. ability to use pictures by drawing on pupils' own and other people's experiences</td>
</tr>
<tr>
<td></td>
<td>b. ability to generate ideas by drawing on other people's experience and products</td>
</tr>
</tbody>
</table>
a. ability to collect important information from a number of sources, including ICT-based sources
b. ability to generate ideas for products after thinking about who will use them and what they will be used for

a. ability to generate ideas considering aesthetics and other issues that influence their planning, for example, the needs and values of intended users, function, hygiene, safety, relativity, cost

a. ability to generate ideas considering issues that their planning, for example, the needs and values of a range of users; moral, economic, social, cultural and environmental considerations; product maintenance; safety; the degree of accuracy needed in production

As for Table 3, it was said that pupils' performance was developed from using pictures by drawing on pupils' own to generate ideas thinking about who would use them and what they would be used for. Regarding Table 4, pupils' performance was gradually developed the state of affairs in considering selection of materials, components, tools, equipments and production method. In the matter of Table 5, it was supposed that pupils were required to use graphic techniques and ICT as key stage gets higher.

**Table 4.** The Relation between Each Key Stage and Criteria of ‘Capability of Planning.’ This table is a modification of part of the ‘Program of Study’ in the National Curriculum for England, Design and Technology (Department for Education and Employment and Qualifications and Curriculum Authority, 1999).

<table>
<thead>
<tr>
<th>KS</th>
<th>Capability of Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a. ability to plan by suggesting what to do next as their ideas develop</td>
</tr>
<tr>
<td>2</td>
<td>a. ability to plan what have to do, suggesting a sequence of actions and alternatives, if needed</td>
</tr>
</tbody>
</table>
| 3  | a. ability to suggest outline plans for designing and making, and change them if necessary  
    b. ability to prioritise actions and reconcile decisions as a project develop, taking into account the use of time and costs when selecting materials, components, tools, equipment and production methods |
| 4  | a. ability to decide how to manufacture the product taking account of critical dimensions and tolerances |

**Table 5.** The Relation between Each Key Stage and Criteria of ‘Capability of Expressing and Explaining.’ This table is a modification of part of the ‘Program of Study’ in the National Curriculum for England, Design and Technology (Department for Education and Employment and Qualifications and Curriculum Authority; 1999).

<table>
<thead>
<tr>
<th>KS</th>
<th>Capability of Expressing and Explaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
1. ability to talk about their ideas

2. ability to communicate design ideas indifferent ways as these develop, bearing in mind aesthetic qualities, and the uses and purposes for which the product is intended
   b. ability to explain ideas clearly, putting together a list of what they want their design to achieve

3. a. ability to use graphic techniques and ICT, including computer-aided design (CAD), to explore, develop, model and communicate design proposals, for example, using CAD software or clip-art libraries, CD-ROM and internet-based resources, or scanners and digital cameras

4. a. ability to use CAD software to generate accurate drawings and part drawings to help with manufacturing

As a result of this study, ‘developing, planning and communicating ideas’ of PS was comprised of three types: ‘capability of designing,’ ‘capability of planning’ and ‘capability of expressing and explaining’ related to pupils' development aged 5 to 16 systematically. And, assessment criteria of the syllabus of AQA examination board as well as PS in NC were shown in accordance with pupils' performance clearly. As Custer et al (2001) pointed out that designing, involving ideation, identifying possible solutions, prototyping, and finalizing the design, has become a predominant problem solving process in the technology education laboratory-classroom, it was reasonable to suppose that three types and assessment criteria of the AQA examination board focused on problem solving as the concept of ‘designing.’

In Japan, the Japanese Society of technology education (1999) and Yamazaki (1999) studied the scopes and sequence of technology education. The scopes and sequence of technological objects is shown in Table 6 (The Japanese Society of technology education, 1999). It is very important to note that four content of objects, that is, ‘Materials and Manufacturing,’ ‘Convention Technology of Energy,’ ‘Information, System, Technology of Control’ and ‘Bio-related Technology’ have been proposed as scopes of technology education by the Japanese Society of technology education. However, there have been few studies on the scopes and sequences of technological design process. Therefore, the results of this study were suggested that inquiring scope and sequence of ‘designing’ of technology education in Japan was useful for the innovation of the Japanese national curriculum development.

Conclusion
In concluding, (1) ‘developing, planning and communicating ideas’ of ‘Program of Study’ in National Curriculum was comprised of three types of learning abilities: ‘designing,’ ‘planning’ and ‘expressing and explaining’; (2) three types were established for pupil’s development aged 5 to 16 in accordance with pupils performance systematically; (3) ‘designing’ was one of the important learning abilities for Design and Technology in U.K. and assessment criteria of the AQA examination board were related to ‘designing’ as a ‘whole processes of technological activities.’

Reference


### Grade Content of Objects

<table>
<thead>
<tr>
<th>Grade</th>
<th>Kindergarten</th>
<th>Elementary Schools</th>
<th>Lower Secondary Schools</th>
<th>Upper Secondary Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The 1, 2 grade</td>
<td>The 3, 4 grade</td>
<td>The 5, 6 grade</td>
<td>The 1 grade</td>
</tr>
</tbody>
</table>

#### 1. Materials and Manufacturing Technology

**Themes**
- making and playing (the acquisition of sensitivity)
- making creatively (the acquisition of skill)
- 'Monozukuri' to fulfill the purpose by using hands
- 'Monozukuri' to be based on a scientific ground

**Kinds of Materials**
- Soft materials (paper, clay, cloth etc.)
- a little hard materials (a piece of wood, bamboo, plastic, corrugated paper box etc.)
- hard materials (Those materials are meant as materials which have the strength for practical use, for example, wood, veneer board, plastic, metal etc.)

**Natures and Uses of Materials**
- to touch materials to cultivate a sensibility of pupil's hands
- to touch various materials
- to select materials to fulfill pupil's uses
- to put the right person of materials in the place

**Designing and Drawing included those faculty and structure**
- to draw the image of manufactured products
- image of manufactured products
- drawing and planning to take the purpose, functions and conveniences into account
- to make and investigate the models
- to think the methods of connection to fulfill purpose or make tough structure

**Manufacturing Methods and Means (tools, control etc.)**
- to play with tools
- to select tools to fulfill pupil's manufacturing purpose
- to think out tools
- to use tools
- the easy machines, for example, fret saw, electric drill, hollow chisel mortiser, drilling machine, lathe turning machine, grinder, etc.
- to think the manufacturing procedure or construction and design a process table
- the manufacturing machines (lathe turning machine, milling machine, etc.)
- hand → tool → machine → mechatronics (the historical transition of tools)

**Manufacturing Technique and Environmental Safeguard**
- the works with empty boxes etc.
- the paper which are made of carton of milk
- manufacturing products which are made of empty can or semi cylindrical board
- activity of production and environmental load
- to carry out the all processes (production → consumption → recycling)

#### 2. Conversion Technology of Energy

**Conversional Methods**
- to touch wind or water
- physical conversion (the force of wind or water etc.)
- chemical change (heat reaction or battery etc.)
- friction and heat
- operation of electromagnetic induction (from motive power to electric power)
- the effect to light and electricity of semiconductor (from light to electric power)
- joule heat of register (from electric power to heat)
- electron and the operation of fluorescent (from electric power to light)
- electricity and electron circuit, communication mechanism
- technology of electromagnetic induction
- technology of recycle
## Conversional Efficiency
- the degree of turn
- comparative of brightness or quantity
- the change of load
- conversional efficiency (Pupils are taken those contents in the exams.)
- heat efficiency
- the quantity of environmental

## Conversional Machinery
- waterway and waterwheel
- battery and electric bulb
- resell to generate fire
- wind wheel
- electromagnet
- a movable toy
- generator, electric motor, internal combustion engine
- a movable mechanism
- a photovoltaic cell (a solar battery)
- a fluorescent light, an electric heater, a movable machine
- fuel battery, generation of electricity of MHD
- laser
- a microwave oven

## Resources and Materials
- wind, water
- fuel
- heat
- light, waste
- hydrogen
| Conversion Technology and Environmental Safeguard | - combustion and global warming  
- economy, the improvement of technology  
- the production of electric power and the quantity of environmental  
- the improvement of technology (the improvement in efficiency and conversion of ways)  
- the development of recycling technology, a safety way  
- generation of electricity of waste  
- the countermeasure of global worming  
- the countermeasure of environmental problems, a machinery for welfare |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 3. Information, System, Technology of Control | - a toy block (all kinds of sensor and motor)  
- to control (sequence control) models (a car or a doll etc.)  
- to measure a light or a temperature  
- measure → the management of data → control (feedback control) |
| Measuring and Control | - drawing - word processor, a table calculation  
- data base  
- a script language  
- a program language |
| Software | - to use and make a home page for pupil’s purpose  
- meaning of information  
- structure of communication  
- structure of light communication  
- manufacturing of a sound and a portrait  
- feature of using information  
- to use a software  
- to use a multimedia  
- modeling and simulation |
| Information Communication, Network, Multimedia | - to play with computers  
- to gather an information in easy posting of an information  
- to use and make a home page for pupil’s purpose  
- structure of communication  
- information systems which have been used in the neighborhood  
- information systems which have been used in the industrial world  
- the purpose, the result or the influence to the human body of the use of computers  
- information systems which have been used in frontier technology  
- the system which have related mutually (network)  
- the progress of information-oriented and the meaning between information and daily life  
- the ethics of internet, copyright  
- the merits and demerits of the use of computers |
| Technological, Social and Environmental Meaning | - to use a software  
- to use a multimedia  
- modeling and simulation  
- information systems which have been used in the neighborhood  
- information systems which have been used in the industrial world  
- the purpose, the result or the influence to the human body of the use of computers  
- information systems which have been used in frontier technology  
- the system which have related mutually (network)  
- the progress of information-oriented and the meaning between information and daily life |
| Informational Ethics | - to play with plants in the neighborhood  
- seeding or planting  
- cultivation which stresses the observation  
- watering - weeding - harvest and easy cooks  
- harvest and appreciation  
- to make the plan of cultivation  
- cultivation, manufacturing or cooking of the staple food crops  
- the conditions for germination and cultivation technology  
- the forms of crops and cultivation technology  
- to make a flower bed  
- to make manure and compost  
- cultivation technology and the economy, society, the ethics of environment  
- the valuation of technology  
- to make the plan of cultivation to take valuation of an environmental influence into account  
- the development of farming and our life  
- to make the plan of cultivation to take technology and environment into account  
- trees planted  
- the physiology of crops and cultivation technology  
- technology of kind  
- the environment of cultivation and extermination of blight insects, for example, to make the soil and design of manuring  
- to eat and life  
- the basis of biotechnology  
- cultivation of bio crops, a microbe  
- cultivation of plant construction - biotechnology and the ethics of life |
| 4. Bio-related Technology | - to enjoy with creatures  
- to notice toward adoration of life, to love creatures  
- cultivation of mushrooms  
- to respect the life of oneself and others, the continuity of life  
- cultivation technology and the economy, society, the ethics of environment |

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Pupils Attitudes Towards Technology  Annual Conference  June 2003
<table>
<thead>
<tr>
<th>Technology for Growing up Creatures and Environmental Safeguard</th>
<th>- the interest in the place and change to grow up or the sign of growth</th>
<th>- the function of national land conservation in the forest and the farming, cultivation technology and environmental safeguard</th>
<th>- conservation of forest and resources to fisherie</th>
<th>- cultivation of environmental control, conservation of resources to creatures, and heredities</th>
</tr>
</thead>
<tbody>
<tr>
<td>- to interest to the surrounding plants</td>
<td>- the growth of cultivation plants and the change of environment</td>
<td>- the relation between cultivation plants and natural environment</td>
<td>- cultivation technology and environmental safeguard, and heredities</td>
<td>- conservation of forest and resources to fisherie</td>
</tr>
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</tbody>
</table>

Patt 13
An exploration of the role values plays in design decision-making.

Rhoda Coles, Department of Design and Technology, Loughborough University, England
Email: R.L.Coles@lboro.ac.uk,

Abstract

The paper explores design decision-making through the eyes of key authors. ‘Knowing that’ and ‘knowing how’ are reviewed and the problematic distinctions between ‘know how’ and skill noted. The effect of values on design decision-making is discussed and examples from a pilot study are presented.

Keywords: Design decision-making

Introduction

Take a young student asked to design a ladder to reach a window. They have not yet learnt that the longest side of a triangle can be calculated by taking the square root of the sum of the shorter sides squared, but they still correctly guess the length of the ladder at 10 metres. This ‘move’ could be considered by the spectator as an act of luck and therefore they may prematurely conclude that the origins of the student’s decisions were not based on any intelligent consideration. However, it is the design decision-making process rather than the outcome that is important. What appears as the young student ‘taking a guess’, may in-fact be based on something else, e.g.,

- the student has seen a ladder where the struts are about 0.5m apart and that there are 20 struts;
- their neighbour appears to know how to calculate the length of the ladder mathematically and they have got an answer of 10 metres;
- that producing any answer holds more value for the young design student than leaving a blank space.

In the same way, we are interested in what drives the designer’s decisions when their actions appear careful and well thought-out.

“Design has its own distinct ‘things to know, ways of knowing them, and ways of finding out about them’…” (RCA 1979 cited in Cross 1982,). In his book The Concept of Mind, Ryle (1948) defines knowledge as, ‘know that’ and ‘know how’. Firstly, this paper describes knowing that but acknowledges that it may not be enough and asks, “Aside from possessing knowledge, what is it that predisposes an individual to apply knowledge? (Pedgley 1999)

Pring states, “Something learnt can be “impersonally packaged” and has to become “personally significant” (ibid). Pedgley attributes knowledge becoming personally significant to acquiring know how (Ryle 1948) and the application of values in the form of value judgments (judgements made on the basis of one’s values). This paper explains the need for knowing how and its connection to skilful behaviour, it then describes the role of values and value judgements in more detail.

Knowing That

When designing products and systems, designers must employ a wide variety of knowledge (Fig 3). “The primary source of knowing that is from reading or being told (…) Knowledge so derived is, assuming it has not been forgotten, able to be communicated verbally” (op cit)
Knowing that is not only “that part that is held in an individual’s memory (…) but also knowledge about where to find such items” (*ibid*). This idea echoes Polanyi who wrote “…we are interested less in the stocks of truths that they acquire and retain than in their capacities to find out” (1962) e.g.

- We can know that recycled plastic material can be used for interior and exterior applications.
- We know that we can find the typical tensile strength of the ‘origins’ range of recycled plastics by looking on their website (www.yemmhart.com 2002).

Hicks *et al* describes knowing that as ‘technological’ knowledge and presents it in three groups: control, energy, and materials (Table 1).

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Control over the man made environment must be done with a knowledge of how systems, static or dynamic, can be created for a specific purpose.</td>
</tr>
<tr>
<td>Energy</td>
<td>Knowledge is required of the sources, costs and forms of energy; of methods for storing and transmitting energy; and of efficiency and the conversion of energy.</td>
</tr>
<tr>
<td>Materials</td>
<td>Selection and use of appropriate materials, their sources and costs, of their useful properties and limitations; and of the appropriate methods by which they may be processed, manipulated and connected.</td>
</tr>
</tbody>
</table>

But what forms of knowledge do designers require? “Designers are continually called upon to make decisions which require information from other disciplines” (*ibid*). This raises two important points; firstly, Hicks use of the term ‘information’; this can come from many sources (e.g., books or conversation) and can be valid (e.g., a theory that has been subject to scientific testing), false (e.g., an aloof verbal remark) or a partial form of either (it may be incomplete). It is not until this information has been assimilated by the designer that it can be referred to as knowledge. Secondly, the designer may not be able to use the information in its original form and may need to deconstruct and restructure it as necessary (Layton 1993) because “…in order to be used effectively it must be transferred into designerly knowledge” (Cross 1982) This ‘personalised’ way in which designers use propositional knowledge is supported by Daley who states:
“...the mind may not have a systematic way of knowing or conceiving, the schemata of which can be definitely described” (1984). This restructuring into designerly knowledge can lead to corruption of information, and it may have been misconstrued on assimilation; there are no guarantees that the knowledge the designer possesses has any direct connection to the information that was originally sought. What is important is our ability to state whether a designer’s decisions are derived from knowing that (whether that which is known is incorrect or correct is immaterial), rather than being derived from any other source.

Knowing how and skill
In designing, knowing that may be insufficient because “from all this, one does not really know the product, only of it” (Pedgley 1999) and people are more concerned with “operations than with the truths that they [people] learn” (Ryle 1948). That is to say, a knowing how can be derived only from personal experience. For example:

- I can be told that the balls of solder must not touch and that they must hold the components in place. I can be shown the right and wrong way to solder (Fig. 4), but from all this I still will not know how to solder a circuit together neatly.

![GOOD JOINT](https://www.kpsec.freeuk.com/solder.htm)

![BAD JOINT](https://www.kpsec.freeuk.com/solder.htm)

Figure 2 Things I can be told about soldering (www.kpsec.freeuk.com/solder.htm)

Introducing the concept of skills, Polanyi states “…you cannot acquire a skill merely by learning to perform its fragments, but must also discover the knack of coordinating them effectively” (1962) Hicks et al introduces four categories to identify skills (Table 2):

<table>
<thead>
<tr>
<th>Category</th>
<th>Includes the ability to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation</td>
<td>• recognise the existence of a problem which may be amenable to solution &lt;br&gt; • perceive, or identify through investigation, how far a given thing or system meets the stated need &lt;br&gt; • look for information and resources and generate information through observation and experiment &lt;br&gt; • judge how relevant, sufficient and reliable are the information and resources obtained &lt;br&gt; • employ a balance of knowledge, analytical skills and judgement in reaching conclusions in the face of ill-defined problems</td>
</tr>
<tr>
<td>Invention</td>
<td>• initiate and develop ideas and images of proposed things or systems, and to manipulate, rotate and transform those images &lt;br&gt; • think of alternative configurations for a desired thing or system and to adapt, transform and select from these to meet given needs &lt;br&gt; • express these images in various ways, such as sketching, drawing, diagram making, constructing, or through the use of notation or language, and thus communicate information about them to others &lt;br&gt; • examine the integrity and coherence of a product or system, how well it matches its requirements and how well the requirements themselves are appropriately defined</td>
</tr>
</tbody>
</table>
**Table 2** Identifying the skills used in design decision-making (1982)

Although Polanyi and Hicks *et al* are describing skills, they could arguably be describing know how. Attempting to distinguish between these two concepts has led to much discussion in the prior art for this complex area of design decision-making, but it remains an unresolved area.

Pedgley describes know how as “knowledge from acquaintance” and claims that “whereas know-how can be said to exist in one’s mind at all times (as tacit knowledge), the same cannot be said of skill, skill exists only during the performance of an activity” (1999). This contradicts Norman’s ideas as, quoting Archer and Roberts, he describes “forming images in the mind’s eye” (*ibid*) or a designers use of cognitive modelling (and especially in the sense of graphic modelling to represent ideas) as a form of skill. Polanyi describes the ‘activity’ as the “performance of a skill” (1962). For example a pianist can be described as giving a ‘skilled performance’ at a concert. However, when they have finished, we can still describe them as ‘possessing great skill’ or being a ‘skilled’ musician. Naughton and Walker suggest a distinction between know how and skill explaining that skill is a “whole business” (1981) or, in Norman’s words, the “enabling force” (*op cit*) Pedgley agrees (although he is still referring to skill as the performance). He states: “What an observer sees in an individual’s practical action is not solely know-how, but skill, of which know-how might be one element” (1999).

**Values**

Designers are concerned with “ill-defined” (Roberts, Archer and Baynes 1992) or “wicked” (Cross 1982) problems in that they “contain a complex of missing information, inexplicit requirements and conflicting demands”. Consequently designers have to apply an alternative solution strategy (than used for solving scientific problems) that relies on generating “a satisfactory solution, rather than on any prolonged analysis of the problem.” (*ibid*) This is also known as satisficing. Without scientific methods, some other ‘judgement’ is required. “Intelligently reflecting how to act is, among other things, considering what is pertinent and disregarding what is not” (Polanyi 1962). It is therefore undoubted that values must play some part in designerly behaviour, as decisions must be made as to which solution is ‘best’. Cross says of education: “Deciding what is worthwhile is obviously value-laden and problematic” (1982). He could just as easily have been discussing design decision-making. “In design decision-making, a marked effect of values is to direct and reduce the various avenues of enquiry a designer explores” (Pedgley 1999). Hicks *et al* identifies four areas within which values might be assessed (Table 3). These are examples of values that affect design decision-making.

Roberts (1993) outlines an additional area along the dimension of values (Table 4) that takes into account some of the additional examples of values within designing which may have been previously neglected.
Designers have their own personal values (Table 5, at end of paper) which will direct and control their decisions, and they must also take into account, or are influenced (either consciously or not) by the values of society. Allowing design decisions to be influenced by societal values is important, as:

…it appears that a technology becomes a successful one, in the sense of achieving widespread adoption, when values embedded in the design are congruent with those of social groups in that particular culture.” (Layton 1992)

Layton also states that “technological obsolescence or senility” ([ibid], or when a product is no longer desired by society, refers to the changing of values within social groups leading to a product becoming “dysfunctional within the culture it is placed”([ibid]).

We all intrinsically use products and our surroundings to communicate ourselves to others. This concept is important in our understanding of the influence of values on design decision-making as:

“A significant branch of designerly ways of knowing, then, is the knowledge that resides in objects. Designers are immersed in this material culture and draw upon it as the primary source of their thinking. Designers have the ability to both ‘read’ and ‘write’ in this culture…” (Cross 1982)

This brings us to the importance of ‘dispositional concepts’ (Ryle 1948) and their use by designers (however tacitly) to convey the correct message through their products. Designers are aware of how others perceive their products and of the values of the society they are designing for and use this to direct their decision-making. Ryle describes dispositional concepts as knowing how, but it is clear to see that their application is based on values.

<table>
<thead>
<tr>
<th>Category</th>
<th>involve the appreciation and application of:</th>
</tr>
</thead>
</table>
| Technical values | • efficiency, and the ways in which input is compared with the resultant output robustness; flexibility, and the ways in which the performance of a man-made object or system might be sensitive to change  
• precision, and the qualities of fit and of fitness to purpose, valued either for their own sakes or as a means to an end  
• confidence, and the ways in which possible reliability or unreliability of information is taken into account |
| Economic values | • the broad distinction between the ideas of use-value, intrinsic value and value-in-exchange  
• the distinction between value, price and cost  
• the marginal value of one product or product variation over another  
• the effects of variation in supply and demand on availability and price |
| Aesthetic values | • the structures, proportion and colours to be found in the natural and the man-made world  
• of the importance of aesthetic factors in all forms of human communication and self-expression  
• the inter-relationship between workmanship, tools and the aesthetic quality of the resulting environment or artefact |
| Moral values | • mankind’s impact on the natural environment and his responsibility for its and his own future survival  
• the inter-relationship between the man-made world and religious, social, economic and philosophies  
• the needs of individuals in society and ways of meeting them  
• the importance of ethical values in carrying out design activity and evaluating the effects of technology |
Table 3 Values acting on the decision-making process (Hicks et al, 1982)

<table>
<thead>
<tr>
<th>Category</th>
<th>involve the appreciation and application of:</th>
</tr>
</thead>
</table>
| Hedonic values | • the role of vision, hearing, smell, taste and touch in attaching value phenomena through their direct appeal to the senses;  
• the role of appetite, desire, pleasure, pain etc, in the evolution of products and systems;  
• the demands made on the configuration of man-made things and systems by the physiology and psychology of people;  
• the importance of hedonic factors in all forms of design activity and an ability to take them into account when designing or evaluating things in the man-made environment. |

Table 4 Hedonic values (Roberts 1993)

<table>
<thead>
<tr>
<th>Internal (Pedgley 1999, p51-52)</th>
<th>I think that shiny plastic looks terrible' An opinion which may sway the designer in this case away from the use of shiny plastic in the new product.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reaching a balance of form and harmony of materials is what designing a product is all about for me'. An implicit statement of priority to focus thoughts on the determinations of a product's form and materials rather than in some other product feature.</td>
</tr>
<tr>
<td></td>
<td>I have a passion for creating products in which materials provide people with a tactile response' An emotional state driving this designer's approach to product design.</td>
</tr>
<tr>
<td>External (Layton 1992a, p37-40)</td>
<td>The value of occupational hierarchies is preserved through the design of office furniture that differ in size from the large managerial desk to the smaller, more reserved work station for a secretary.</td>
</tr>
<tr>
<td></td>
<td>The design of mousetraps reflecting the culture in which they are used, the French version, modelled on the guillotine and an Egyptian one which entombs the hapless mouse in a pyramidal structure.</td>
</tr>
<tr>
<td></td>
<td>The success of joint ownership schemes is dependant on the value placed on collectivism rather than individualism. Therefore because of the social status of owning a personal computer, in western societies the design of a central IT service would probably fail.</td>
</tr>
<tr>
<td>Goonatilake (1984, p71)</td>
<td>The values of certain societies can also become direct drivers of design decisions, for example the post World War II competition between the American and Soviet Union military machines, in which their science and technology both vie and mirror each other. Other examples include the space race and in a modern context, the competitive nature of large transnational corporations.</td>
</tr>
</tbody>
</table>

Table 5

Examples the Sustainable Design Award (SDA)
It was decided that retrospective analysis of designer’s work would be carried out as one method of further understanding design decision-making. The first stage of this was a pilot study. Three A-level students were chosen to take part and will be referred to as SG, NN and RG. All three students were taking part in the SDA, an award scheme integrated into their normal work to “help students explore environmental,
Pupils Attitudes Towards Technology   Annual Conference   June 2003

Economic, social and moral issues in design and technology” (http://www.itdg.org/html/education/sda.htm). Each student took part in a forty-minute interview about his or her project work. The transcripts in Figure 5 provide examples of knowing that influencing students decision-making.

| **Internal**  
(Pedgley 1999, p51-52) | I think that shiny plastic looks terrible' An opinion which may sway the designer in this case away from the use of shiny plastic in the new product.  
Reaching a balance of form and harmony of materials is what designing a product is all about for me'. An implicit statement of priority to focus thoughts on the determinations of a product's form and materials rather than in some other product feature.  
I have a passion for creating products in which materials provide people with a tactile response' An emotional state driving this designer's approach to product design. |
| **External**  
(Layton 1992a, p37-40) | The value of occupational hierarchies is preserved through the design of office furniture that differ in size from the large managerial desk to the smaller, more reserved work station for a secretary.  
The design of mousetraps reflecting the culture in which they are used, the French version, modelled on the guillotine and an Egyptian one which entombs the hapless mouse in a pyramidal structure.  
The success of joint ownership schemes is dependant on the value placed on collectivism rather than individualism. Therefore because of the social status of owning a personal computer, in western societies the design of a central IT service would probably fail. |
| Goonatilake  
(1984, p71) | The values of certain societies can also become direct drivers of design decisions, for example the post World War II competition between the American and Soviet Union military machines, in which their science and technology both vie and mirror each other. Other examples include the space race and in a modern context, the competitive nature of large transnational corporations. |

**Figure 3** Examples of knowing that from personal knowledge, reading and finding out

Figure 6 shows knowing how as derived from acquaintance, or experience and practice. It also appeared that decisions regarding materials were strongly influenced by know how (NN discussion).

| RC – oh right ok, so how come you chose MDF  
NN – because I perceive it to be very strong and I’ve worked with it a few times  
RC – so is it because you’re quite used to it?  
NN – yeah, yeah, I think that’s it  
RC – This is another model…  
SG – yeah, a model for the main bag  
RC – how did this help?  
SG – well it helped me to realise how I was going to put the actual bag together |

**Figure 4** Knowing how from previous experience and gained during the project
RC – and here you’ve got the…what are these inners made out of?
SG – I was sort of thinking you could have a thick material, a thick, thick bag, but I wasn’t sure whether that would work or not
RC – So you weren’t specifying a particular material
SG – no, I think I did eventually think of foam but its not a very good material and I’m not very happy about working with it to be honest.
RC – Did you reject that idea
SG – yes

RC – is there anywhere you were thinking (reads) oh here we go you’ve got some... educate about the product, the recycled materials, what do you mean by that?
RH – cos its sustainable design, I want to use materials that can be recycled, used again in some way, maybe in another project, or product

RC – So when you were looking at these pictures were you thinking of any way you could transfer some of these ideas to your project?
NN – Yeah I’ve got sketched a lot of these and the things that I used was the whole shell, the whole raw material, how effective the materials are for manufacturing

RC – So you have dimensions here already, how come you decided on your dimensions?
NN – oh these are dimensions of existing ones.

RC – you’ve gone into price quite a lot here, is that something that you’re concerned about?
RH – money’s quite limited in underdeveloped countries, so they’re not going to want to spend a lot of money on anything they make
RC – so when you were thinking about materials that you would use, were you thinking about just the materials that are actually available to them?
RH – probably cardboard, canvas, things that are actually available to them, wood, but then you would probably use wood to burn rather than in production.

Figure 6 Social values effecting design decisions

Figure 7 Gaining a wealth of knowledge from existing products

Figure 7 shows decisions being swayed by personal agenda’s such as ease of working with a material, personal opinion and desire to do things in a certain way. We can also see that decisions are influenced by societal values, the examples below (Fig. 8) refer to the designer’s decisions being influenced by the values of the society they are designing for. We can see that thinking about the working conditions and suitable materials for the product, influence decisions. We can also see how information is gained and values are transferred through existing products (Fig. 9).
Conclusion
The uncovering and clarification of the principles within the area of design decision-making are vital concerns for research, and the fundamental reason for writing this paper. It has highlighted problematic areas, especially concerning the distinctions between knowing how and skill. The pilot study provided evidence of the literature presented and has provided foundations for further studies. It is important to continue research within this area in order to build a more concise model to aid our understanding of design decision–making.

References
Layton D. (1992) Values and Design and Technology – Design Curriculum Matters: 2, Department of Design and Technology, Loughborough University of Technology
What are the Unique and Essential Characteristics of Technology Education in the Primary School? A Study Based in the USA.

Carole J. Thomson, Faculty of Education, University of Aberdeen, Scotland
Email: c.j.thomson@abdn.ac.uk

Abstract

The purpose of this modified, rotational Delphi study was to identify the unique and appropriate characteristics of technology education for the primary curriculum in the USA. Two groups of participants in the USA, experts in technology education and primary teachers with some experience of technology education completed three rounds of the Delphi study using an electronic World Wide Web based survey. The results suggest that there are many characteristics of methodology, knowledge and understanding, and skills that both the technology experts and the primary teachers perceive as being important for primary education. However the most unique characteristics identified were those of skills and methodology, with knowledge and understanding featuring to a much lesser degree.

Overall, the participants were asked to rate 27 characteristics of methodology, 22 characteristics of knowledge and understanding and 43 skills. The survey was conducted electronically and the items were rotated around the two groups to prevent fatigue.

The findings suggest that technology education experts and primary teachers in the USA feel that technology education has many characteristics that are fundamental to the primary curriculum. They identified intellectual capabilities, practical skills, design and problem solving as unique and appropriate characteristics of primary technology education. They also identified technological concepts as unique to this field of study.
Many countries have technology education as a core component of the primary curriculum. The instrument for this study was informed and developed from theory and practice of primary technology from some of these countries. It is suggested that the findings of this study could provide a core of characteristics with which to evaluate and develop present programmes and policies in primary technology education in the USA.

There is very limited evidence from academic research which demonstrates the needs and benefits of technology education for primary aged children. However, there is considerable anecdotal evidence to support its inclusion in the primary school curriculum. This study suggests that further research is needed into children’s learning in technology education in order to provide a sound basis on which to build national and school policies and programmes.

Introduction

Technology education is a relatively new entrant to the primary education curriculum for many countries. It can be defined as:

“*That part of the curriculum concerned with helping learners to become technologically capable: to identify human needs for which technological solutions are possible, design and make appropriate products (physical products or organisational systems), and to evaluate their quality and their potential societal and environmental effects.*” (Gardner & Hill, 1999, p.104)

It is widely recognised that this adds yet another dimension to what is already, some would argue, an overcrowded curriculum (Braukmann, 1993; Knamiller, 1992). Identifying the characteristics of technology education that are unique and appropriate and to add value to the existing primary curriculum is, therefore, essential if technology education is to be accepted and recognised as an important part of young children’s learning.

The Primary School Curriculum

Few people would argue against the need for literacy or numeracy in the primary school curriculum. However, theories and arguments abound about what children should know or be able to do by a particular stage in their lives. Governments, philosophers, psychologists, educators, communities, and individuals all want to influence what children learn, and know if this is taught, during their formative years in primary education. This results in a very broad curriculum being taught in the primary school, leaving too many demands on teachers who have to juggle time and make subjective judgments about what value to place on any particular subject (Osborne & Simon, 1996). Research demonstrates that even with curricular guidance, primary teachers find it difficult to meet the time recommendations for all subjects (Harlen, 1999). Teachers, who are influenced by their competence and confidence to teach a subject (Aubusson & Webb, 1992; Harlen, Holroyd & Byrne, 1995), need to understand how the essential components of a subject can add value to children’s learning. They need professional development and guidance as to what is relevant and important for children to learn from any particular subject at an appropriate stage of their education (Mant & Summers, 1995). It also matters that the subject content reflects an ever-spiraling curriculum (Bruner, 1966; 1986).

How Children Learn

Children have their own ideas, which have been constructed because of their experiences in everyday life (Harlen, 1997, 1999, Leach & Scott, 1995). Such findings are contrary to the ‘tabula rasa’ theory (blank slate), or empty vessel theory, that necessitated teachers feeding ideas that would somehow begin to fill these empty minds. Constructivism, a theory initially developed through Piaget’s work in the 1920s, recognizes that children are “active learners who are able to set goals, organize, and revise” (Bransford, Brown & Cocking, 1999, p. 68), and by doing so, organize their own knowledge. Children therefore build on, or assimilate, new ideas into existing frameworks thus developing their own conceptual understanding of the world around them.

How children learn will depend on their individual strengths in a particular mode. Gardner (1983) developed the theory of multiple intelligences: linguistic, logical, musical, spatial, bodily kinaesthetic,
interpersonal, intrapersonal, and naturalistic, and recognised that children may have particular strengths within which they may attain optimal learning. Such a theory offers teachers a range of modes to develop concepts and provides a variety of ways of enabling children to exhibit their multiple intelligences (Gardner, 1997).

In addition to multiple intelligences, children were found to have a variety of learning strategies (Siegler, 1996), choosing those that had the greatest advantages for a particular problem. Although these strategies have been identified in young children, increasing strategic development is associated with age and experience within a domain (Lemaire & Siegler, 1995).

Knowing about how children learn, their knowledge construction, their use of multiple intelligences, and their use of a variety of learning strategies enables educators to plan for appropriate and relevant learning. It can inform development of teaching strategies, programs, and curricula that best fit the needs of their children, whatever their age, aptitude, ability, or experience.

**Characteristics of Technology Education**

The most recent major developments in technology education in England (DFE, 1995), Scotland (Scottish Executive, 2000), New South Wales, Australia, Board of Studies (1993), and USA (ITEA, 2000) suggested a variety of concepts necessary for the understanding of technology education at the elementary stages of learning.

In England the aim of technology education is:

“Pupils should be able to design and make products safely by applying knowledge and skills from the programs of study for technology and where appropriate from other subjects, particularly art, mathematics and science.” (DFE&W, 1992, p.19)

Thus, technology education was seen as integrating knowledge and skills from a variety of disciplines, including technology in order to make products. Conceptual understanding of a technological nature, specifically identified as required for technological capability, includes knowledge of mechanisms, structures, products, and applications (DFE, 1995). The knowledge is framed in general terms, as a means to an end rather than for its own worth.

In Scotland (Scottish Executive, 2000), where a similar process based approach exists, conceptual understanding is seen as a means to an end. The document stated, “the central purpose of knowledge and understanding in technology is to enable skills to be developed effectively and attitudes to be well informed” (p.67). The knowledge and understanding strands are specifically named as: needs and how they are met, resources and how they are managed, (and) processes and how they are applied. (p.66)

Within these broad strands, the more specific concepts of design, technological change, materials, energy conservation and transfer, processes, and control were identified. However, they were couched in general terms for the purpose of designing and making products to meet the needs of “groups and societies, past, present and future” (p.71).

**Reasons for the Research**

Despite the anecdotal beneficial claims being made for children’s learning from their exposure to primary technology education, Foster (1997) found that it was “virtually non existent in primary schools in the US” (p. 34). In England and Wales, where a National Curriculum has required primary schools to teach technology education since 1990, “some primary schools are actually teaching less technology than they did before the National Curriculum appeared” (Davies, 1999, p.26). Add this information to the fragmented and limited research base available for this area (Zuga, 1996; 1999), and the picture for primary technology education seems less than favourable. In spite of this, teachers who witnessed the joy of children engaged in technology education (Bottrill, 1996), the organizations, such as ITEA, who have just delivered the new standards for technology education in the US, and the governments which continue to fund changes to try to improve children’s learning experiences, all believe that there is a place for technology education in the curriculum. It is, therefore, critical at this juncture, with increasing pressure being made on the curriculum, that the characteristics of technology education that are unique and appropriate for primary children’s learning, be identified.
Purpose of the Study

The purpose of the study was to identify the characteristics of technology education that are unique and appropriate for children’s learning in the elementary school in the USA. It was designed to seek answers to the following specific research questions:

1. Which technological knowledge and understanding is unique and appropriate for children’s learning?
2. Which technological skills are unique and appropriate for children’s learning?
3. Which methods should be used in the teaching of technology education in the primary school?

In order to find answers to these questions, the study used the experience gained by two groups of educators: experts in the field of technology education in the United States of America (USA); primary teachers in the USA, with some experience of technology education.

In an effort to address the research questions, it was decided that a Delphi survey of experts in the field of technology education and primary trained teachers with some experience with technology education, would provide opinions that addressed both policy and practice. It was assumed that traditionally the experts in the field, professors in technology education, would have influenced policy decisions about what should be included in a curriculum for technology education. Primary teachers traditionally would have been expected to take these policy decisions and the ensuing curricular guidance and translate this into practice in their classrooms. The decisions to use these two groups was to see: (a) whether a consensus of opinion could be established about which characteristics of technology education are unique and appropriate for primary children; (b) whether the opinions of both groups are similar or different; and, (c) to see if either group would influence the other in the final outcomes.

The technology education experts were nominated by professors in the field known to the researcher. These experts nominated further experts and primary teachers whom they knew were active in technology education in their primary schools. All of the participants for both groups, the technology education experts and the primary teachers, came from the USA.

Research suggested that for policies to be successfully applied, practitioners and policy makers need to work together from the beginning of the decision making process (Burgess, 1993). The result of this study may suggest a way forward.

Current Available Research

Although there is limited research in technology education (Cajas, 1999; Layton, 1993), and even less research in primary technology education (Foster, 1997; Zuga, 1995; 1999), there has been a considerable amount of agreement in the academic world about what the current general education should encompass. Suggestions include “student motivation, hands-on learning, community and career awareness, (and) practical and applied academics” (Foster, 1997, p.4). As early as 1923, Bonser and Mossman (1923) were asking the question: “Is there not also a body of experience and knowledge relative to industrial arts which is of common value to all, regardless of sex or occupation?” (p.20). The research available in primary technology tends to be highly specific (Foster, 1997; Zuga, 1999) and focuses mostly on teaching methods (McCormick, Murphy & Hennesy 1994) and student attitudes (Raat & De Vries, 1985; McHaney, 1997; Thomson & Householder, 1993; Wright & Thomson, 1998), “without a strong connection to specific ideas and skills that have been identified as part of technological literacy” (Cajas, 2000, p.2). Other research on children’s conceptual and skill development in science and mathematics through design based learning (Hmelo, Holton & Kolodner, 2000) may be relevant to technology education or, at least, may suggest a way forward (Cajas, 1999).

The Delphi Technique

The Delphi technique is a systematic, rigorous, and effective methodology used by policy makers, politicians, bureaucrats, and university academics looking for making critical decisions. The technique is particularly recommended for stakeholders in education (Clayton, 1997). Critical decisions for this purpose are those involving personnel, program developers, management, and resource allocation, and require careful consideration (Rasp, 1973) since they “can positively or negatively effect the overall functioning of
an organization” (Clayton, 1997, p. 375). Such critical decision-making requires human endeavors and intellectualizing that goes beyond normal daily, routine activities (Clayton, 1997).

Delphi Background
The term ‘Delphi’ is a derivation of the ‘Delphi Oracle’ relating to the ancient Greek myth suggesting that one person, a ‘chosen one’, was able to predict the future with infallible authority. The technique was originally used to forecast the future technological developments; thus, the association with the oracle.

The Delphi technique has been used to set priorities, establish research goals, and to forecast educational needs (Finch & Crunkilton, 1993). Educational purposes for which it has been used include curriculum development (Reeves & Jauch, 1978; Harman, 1981; Blair & Uhl, 1993; Volk, 1993; Wells, 1994; Klutshkovski & Troth, 1995); institutional planning (Uhl, 1983); determining educational effectiveness (Roberts et al, 1984); forecasting expectations relating to the condition of emotional disturbance/behavior disorder (Carpenter, 1985); forecasting effects of de-institutionalization and necessary educational services (Putnam and Bruininks, 1986); identifying conditions most likely to encourage full participation in non-formal education programs (Spencer-Cooke, 1986); identifying features of effective in-service practices (Van Tulder et al, 1988); vocational education and training (McCampbell, 1989; Hakim and Weinblatt, 1993); teacher effectiveness (Stivers and McMorris, 1991); issues in interactive media education (Raker, 1992); identifying competences (Clayton, 1992; Cannon et al, 1992; Smith & Simpson, 1995; Thach & Murphy, 1995; Scarcella, 1997); distance education (Miller & Husmann, 1994); nurse education (Hartley, 1995); preparation of students for the 21st century (Garber, 1995); investigating future directions in education and inclusion for students with disabilities (Putnam et al, 1995); and the future of adult education (Leirman, 1996).

More pertinently for this study, the Delphi technique has been used to identify critical issues and problems in technology education (Wicklein, 1993); and quality characteristics for technology education (Clark, 1997).

The Delphi technique was used because the problem under investigation was appropriate for “subjective judgments on a collective basis” (Linstone and Turoff, 1975, p.4). It requires a larger number of individuals “than can effectively interact in a face to face exchange” (Linstone & Turoff, 1975, p.4), and these individuals were so widely dispersed that distance and “cost (made) frequent group meetings infeasible” (Blair & Uhl, 1993, p.109).

The modified rotational Delphi technique was engaged to reduce attrition of panel members due to fatigue. Attrition is known to have a negative effect on the reliability and validity of results (Hill & Fowles, 1975; Hakim & Weinblatt, 1993; Scarcella, 1997). All survey techniques are known to have an optimal length for the population that was nominated (Crowl, 1996) and cooperation and interest were seen to diminish with length (Christensen, 1980). Since the panelists only had to respond to a subset of the instrument in the first two rounds, this reduced the length of the survey and, thus, amount of time that was required for a response. Crowl (1996) recommended that an instrument should have a limited number of items, 30 or less, in order to reduce errors due to interpretation.

Since the field of primary technology is very comprehensive, a large number of items for knowledge and understanding, skills and methodology were necessary for this survey (Appendix 1). The rationale for using electronic communication to collect data was to increase response time and to reduce the administrative time associated with the sending, receiving and returning of surveys. It was also being used as an appropriate means of communication for contemporary society, especially for experts and teachers in the field of technology education.

The Modified Rotational Delphi Technique
Three rounds of the modified rotational Delphi were conducted. Each round, consisting of an electronic survey, was presented to the participants, group (a) experts in technology education, and group (b) primary teachers, via the World Wide Web. The participants completed the surveys and returned them to the researcher via the World Wide Web. The responses were analyzed and used to design the instrument for the subsequent round and to obtain the final results.
Identified Areas of Technology Education for Survey within this Study

The literature reviewed revealed four major areas of characteristics pertinent to the area of technology education in the elementary curriculum. These four areas were knowledge and understanding, skills, attitudes and values and methodology (ITEA, 2000; SOEID, 2000). In one study (Foster, 1997) technology education is analyzed three different ways; as content, as process and as method. However, most countries, which have a recognized programme for technology education in the primary curriculum, include all of these areas to a greater or lesser degree. In parts of Australia, New South Wales, Board of Studies (1993) and England and Wales (DFE & WO, 1995), the latest document would seem to put most of the emphasis on skills, whereas in Scotland (SCCC, 1996; SOED, 1993, there is a clear balance between knowledge and understanding and skills. In the USA, the new standards (ITEA, 2000) would appear to put considerable emphasis on knowledge and understanding. Curriculum, Rationale, Benchmark and Standards documents from the USA (ITEA, 2000), England and Wales (DFEandWO, 1995), Scotland (SOEID, 2000), New South Wales, Board of Studies (1993) and South Africa (e-mail, 2000) were reviewed to identify possible knowledge and understanding, skill and methodological characteristics for this survey.

The literature on the constructivist theory suggests a way of learning but does not prescribe a way of teaching (Fosnot, 1995). Although methodology is an issue, countries with programs for elementary technology have resisted the need to prescribe methodology preferring to give teachers some ownership of this area (SOED, 1993; ITEA, 2000) However, a recent review of research literature from the USA (Bransford, Brown, Rodney, & Cocking, 1999)) and Great Britain (Harlen, 1999) suggests that how children are taught will influence how they learn. In both cases suggestions for acknowledging children’s previous learning, learning styles, assessment, classroom ethos and depth of learning, are developed. This specific literature, in addition to other literature reviewed, has been used to identify possible methodology for this survey.

Although some countries recognise the need to include attitudes and values as a major area of technology education (SCCC, 1996), assessment of these characteristics is a sensitive issue. A section on attitudes and values was not included in the research instrument since these characteristics were not included in the Standards for Technological Literacy(ITEA, 2000) in the USA. However, the section on methodology inevitably considers some of these issues in relation to learning styles and it was considered important to review the literature on children’s attitudes towards technology education in order to inform the methodology debate.

Finally, the issues raised at a recent research conference (AAAS, 1999) which reviewed research in the area of technology education and made recommendations for further research, was used to inform the survey for all three areas of the study; knowledge and understanding, skills, and methodology.

Electronic Survey
A web-based survey (Test Pilot, 2000) was used to design and construct the modified rotational Delphi survey. It was accessible to the participants through a World Wide Web address; access was controlled through the researcher by means of a personal ID and password. Only the researcher could view the participants’ responses, thus maintaining a high level of security.

The complete instrument containing all possible items (Appendix 1) was designed for piloting purposes. From this complete instrument, a subset of the instrument was designed for the technology experts and the primary teachers for Rounds 1 and 2. Round 3 was a composite round consisting of non-consensus items and the section on skills. Each instrument subset was given its own address on the World Wide Web.

Biographical Details
Distribution of participants by state is presented in Table 1. The most obvious feature is that the experts in technology education are more widely distributed than the elementary teachers. Although there would appear to be links between experts and teachers in Idaho and Virginia, no other links were particularly obvious. Two of the teachers teach in the same school.
Table 1

State Residence and Number of Participants

<table>
<thead>
<tr>
<th>Technology Education Experts</th>
<th>Frequency</th>
<th>Elementary Teachers</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georgia</td>
<td>1</td>
<td>Connecticut</td>
<td>2</td>
</tr>
<tr>
<td>Idaho</td>
<td>1</td>
<td>Idaho</td>
<td>1</td>
</tr>
<tr>
<td>Illinois</td>
<td>2</td>
<td>Kentucky</td>
<td>1</td>
</tr>
<tr>
<td>Indiana</td>
<td>1</td>
<td>Mississippi</td>
<td>2</td>
</tr>
<tr>
<td>Iowa</td>
<td>1</td>
<td>Missouri</td>
<td>3</td>
</tr>
<tr>
<td>New Jersey</td>
<td>2</td>
<td>Texas</td>
<td>3</td>
</tr>
<tr>
<td>New York</td>
<td>1</td>
<td>Virginia</td>
<td>3</td>
</tr>
<tr>
<td>Ohio</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington DC</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The most noticeable feature of this sample of participants is that while only 33.3% of the technology education experts are female, 93.3% of the elementary teachers are female (Table 2). Of the female experts, there were small numbers in comparison to the male experts, who averaged over 20 years experience. There are more female experts with experience at the 10–20 year range and there are equal numbers of females and males with experience of 5-10 years. The overall trend is a reduction in the number of male experts at the lower levels of experience. The elementary teachers were mostly female and had between 5 and 20 years of experience.

The age profile was such that 83% of the total population was over 40, with the experts in technology education having the older profile; this was expected since most of the experts had experience over a long period of time. However, the age profile of the elementary teacher is also skewed to the upper age categories, with 73% being over 40 years old.

Table 2

Age and Experience of Participants

| Years of Experience: | Experts | | Elementary Teachers | |
|----------------------|---------|-------------------------------|-----------------|
|                      | Female  | Male | Female | Male | |
| Under 5 Years        | 5       | 10   | 2      | 0    | |
| 5-10 Years           | 1       | 1    | 7      | 0    | |
| 10-20 Years          | 3       | 2    | 4      | 0    | |
| More Than 20 years   | 1       | 7    | 0      | 1    | |
| Age:                 |         |      |         |      | |
| 25 - 30 Years        | 0       | 0    | 1      | 0    | |
| 30 - 40 Years        | 1       | 0    | 3      | 0    | |
| 40 - 50 Years        | 2       | 3    | 5      | 0    | |
| Over 50 Years        | 2       | 7    | 4      | 1    | |

Results of the Survey
The panel, made up of technology education experts and primary teachers with some experience with technology education, reached consensus on 97.8% of the items representing the characteristics of technology education. Analysis and interpretation of the results demonstrated progression towards consensus over the three rounds.
In analysing for unique characteristics of technology education, it was decided that items which reached complete consensus (interquartile = 0) and which were rated at the very high level, would form these unique characteristics. The unique characteristics were found to consist of 7 items for methodology, 1 item for knowledge and understanding, and 12 items for skills. Of the other items, 69 reached consensus at the high rating and were, therefore, perceived as important by the participants. One item received a medium rating and was not perceived as important. Two items did not reach consensus by the end of the three rounds. Since this was a policy Delphi, these non-consensus items were used to inform the debate (Clayton, 1997).

**Technological skills which are unique and appropriate for children’s learning.**

The balance of characteristics is skewed towards the skills, which is ironic since countries which have had a core curriculum for the last 5-10 years have moved to this process led approach (DFE, 1995; SOEID, 2000). There were proportionately more skill characteristics (27.9% skills, 25.9% methods and 4.5% knowledge and understanding) meeting complete consensus at the very high rating than any other characteristics. The constructivist theory would favor this approach to learning since it would see children constructing their own knowledge from a variety of experiences (Fosnot, 1995).

The primary education teachers reached consensus at a very high rating on more skills’ characteristics than any other characteristics, which suggested that they would expect to see a technology curriculum that was skill based. Technology education experts’ results showed consensus for only 1 skill characteristic item. This item, #1090, is in line with the primary teachers’ results and read, “Technology education should enable children to work as part of a team to design and make a product to solve a problem or need”. Such teamwork encourages children to share their ideas with their peers and their teachers thus enabling the scaffolding that Vygotsky (Van de Veer and Valsinger, 1994) sees as essential to children’s learning.

**Technological knowledge and understanding which is unique and appropriate for children’s learning.**

Only one of the characteristic items for knowledge and understanding reached complete consensus at the very high rating. This item, #450, “Technology education provides a unique opportunity for children to gain knowledge and understanding of the technological concepts”, is directly in line with the ITEA (2000) initiative for technological literacy. However, the results would suggest that the emphasis should not be on knowledge and understanding that is in contrast to the same standards. This raises the debate about what will happen with the new standards ITEA (2000). Teachers who believe in methodology and skills as most important are going to find it difficult to deliver all the knowledge and understanding stated as necessary in the document.

**Technology methodology characteristics which are unique and appropriate for children’s learning.**

The results of the rotational Delphi identified 7 methodology characteristic items as being unique. All except one of these items is “unique” to both the experts in technology education and the primary teachers. Although the results of the primary teachers identified more methodology characteristics than the technology education experts at complete consensus and at the very high level, the experts had 7 of 8 of their “unique” items as methodology characteristics. This suggested awareness by both groups of the need to provide appropriate methodology for primary children. It is interesting to see that the items chosen were perceived by the panel as being unique to technology education, especially when the first one reads, “Technology education should be taught to develop children’s intellectual capabilities”, which, presumably, is the main reason for teaching any subject.

The characteristic items which achieved the “unique” results included developing children’s intellectual capabilities, enhancing children’s general education, helping children to gain access to their own problem solving strategies, bringing authenticity into the classroom through real world objects, involving children with hands-on tasks, and providing a reassuring and supportive atmosphere. The study confirmed as important, these items identified by Harlen (1999). It is also worth asking the question about whether technology education is unique to one or more of Howard Gardner’s multiple intelligences (Gardner, 1983).
Discussion
This small scale study demonstrates that technology education experts and primary teachers in the USA believe that skills and methodology are more important than knowledge and understanding at the primary school level. Whereas national trends tend toward the more academic side of the curriculum in technology education (ITEA, 2000), this study demonstrates the need to place greater emphasis on the methodology and skills. Since methodology and skills were seen by both groups as very important, the characteristics may also be useful in the critically evaluation of current national and school policies and practice.

There appears to have been limited consideration given to the need to consider the uniqueness of technology education within the overall primary curriculum. The final results suggested that the technology education experts were more analytical in their survey responses than the primary teachers. This resulted in fewer items being described as “unique” by the experts (8) than for the primary teachers (35). One possible explanation is that the experts have had more opportunity to study the outcomes of technology education nationally and internationally, leading them to think more critically about the problems of an overcrowded curriculum. Alternatively, the primary teachers may see more of the characteristics of technology education as an opportunity to integrate some of the primary curriculum. This alternative possibility is borne out by some of the teachers’ comments. In both cases, however, when considering the “uniqueness” of items, the emphasis was on methodology (experts 88.9%, teachers 31.4%) and skills (experts 25% teachers 57.1%), with knowledge and understanding items being designated “unique” in a proportionately few cases (experts 0 %, teachers 11.4%).

Creating the Delphi survey on a web-based package made for an efficient system. It was efficient in the sense that the data for this survey was collected over two months. This was a shorter time than if a traditional mailing system had been used (Scarcella, 1997). During this time, five different surveys were designed and completed by the participants; one common survey and two different surveys were used for each of the groups. The majority of returns were made within a week of the survey being sent out, although reminders, which were easy to send because of the medium, were sent out for all three rounds. High percentage returns and comments from the participants provided evidence of the efficiency of the method. Comments from the participants also demonstrated that they were of the opinion that the medium was effective with one or two reservations.

The results form this study could provide a starting point for policy makers, local authorities, or individual schools in the USA to begin developing primary technology education programs (Thomson, 2000). The “unique” characteristics could provide the core characteristics for any program or at least spark a debate about a way forward.

It is recognised that this survey was based in one country, the USA, and as such the results should not be generalised to include other countries. Consideration should now be given to a larger scale survey of the unique and essential characteristics of primary technology in a several countries. The results of such a survey would provide valuable information for policy makers and practitioners and perhaps lead to improved practice for teachers and more worthwhile experiences for pupils.

Primary technology education will only be successful if it is sustainable and focusing on fewer core characteristics for the technology education curriculum could have this desired effect. This study has begun a process which may lead to the identification and better understanding of the unique and essential characteristics for technology in the primary curriculum.

References
A full and comprehensive set of references, including an appendix, is available from the author.
Development of Teaching Materials on Design-Production-Performance Test in Industrial Technology Education

Sumiyoshi MITA, OYAMA National College of Technology, Japan
Toshiki MATSUDA, Tokyo Institute of Technology, Japan
Email: mita@oyama-ct.ac.jp

Abstract
For promoting learners’ understanding, we developed teaching matter for manufacturing that can be used for introductory courses of industrial technology education. This teaching material is an exercise in designing, producing and performance testing mechanical models. We introduced this material into classroom teaching at a technical high school and a college of technology. Practical education results clarified that a teaching method using this teaching material is effective.

Introduction
Lesson contents of industrial technology education for various industrial technology fields consist of knowledge, theory and skills relating to a design-production-performance test. The industrial technology education curriculum is produced with this idea as a basis.

Two styles of teaching methods in industrial technology education are introduced mainly. One is classroom teaching, through which students learn knowledge and theory. The other is experiment and practice through students’ knowledge, theory and skill in laboratories and practice rooms.

Herein, we review aims of education, teaching methods and educational systems in technology education, industrial technology education and engineering education. These all address a common issue: we must foster students’ problem solving ability.
To the present, the dominant paradigm has been inculcation of knowledge and skill; students themselves systematize and understand them well later. However, students practice knowledge and theory through classroom teaching in experiment and practice. They will understand learning contents more deeply through confirming practical results in technology education. Also, it is expected that the goal, the subject should possess problem solving ability to finish the final grade, can be achieved more effectively through repeating such instruction in the fundamental subject.

Next, we focus on the problem of inconsistency posed by the aim of classroom teaching by one method engendering experimentation and practice on teaching contents and the teaching methods used presently in industrial technology education. For resolving this inconsistency, one plan is to introduce learning that is equivalent to the experiment and incorporate practice into classroom teaching without changing the school education outline greatly.

Students are presented a suitable subject with experiment and practice corresponding to the learning content and students’ achievement. They will use knowledge and theory and solve a problem. It is necessary to develop a teaching method that allows for these activities. This is especially important in technology education for teaching creativity and problem solving ability and producing a curriculum aimed at teaching these abilities.

Aim of this study
The aim of this study is the following. Students grapple with a technological subject based on fundamental knowledge and theory; they then confirm results by themselves and finally master the basis.

We take up a strategy of introducing learning with experimentation and practice into a classroom teaching to accomplish this aim.

Basic policy to develop “MONODUKURI”
Teaching materials to introduce learning with experimentation and practice into a classroom teaching is not only production; the materials are developed based on the process of the design-production-performance test. Teaching materials that include three activities of the design-production-performance test are called “MONODUKURI”.

We focus on teaching materials of mechanical industrial technology education. Because we intend that students master basic abilities, “production” is placed on materialization of the learner’s motivation and the goal for learning; we presuppose that students can use hand tools easily in manufacturing activity. Therefore, “skill” in manufacturing activity isn’t made an evaluation criterion. Instead, the knowledge that relates to “design” and “performance test” is made an evaluation criterion.

In design, production and performance test of mechanical models, students will understand basic knowledge and theories and apply them to practice. Students will find an optimum solution based on practice results. Through these activities, students will acquire ability through understanding and practical experience.

How to develop “MONODUKURI”
When we develop “MONODUKURI” teaching materials, we consider the following.

(a) Students are interested in materials.
(b) Teaching materials consist of fundamental knowledge and theories of science and technology.
(c) Teaching materials are provided that students can engage and use without expensive and large-scale equipment.
(d) One teacher can teach about 40 students at one time.
(e) Teaching materials should enable students to use materials with knowledge through repeating the cycle of the design-production-performance test.

(f) Students with no high-level skills can solve a problem in about 5 hours.

“MONODUKURI” teaching materials are developed based on the method of task analysis and knowledge structure analysis. They are developed concretely in accordance with the following procedure.

(1) Learning contents that students have already learned and students will learn in the future are selected carefully in fundamental contents.

(2) Knowledge of teaching materials concerning “MONODUKURI” is classified into science (physics and chemistry) and technology (mechanical technology); they are listed in accordance with keywords on teaching contents of a lecture subject.

(3) Listed key words about teaching materials of “MONODUKURI” are structuralized.

**Development of “MONODUKURI” in mechanical technology education**

The following teaching materials of “MONODUKURI” concerning dynamics were developed:

1. Motor-driven winch model: The winch can wind up a load of 600 g.
2. Model car: The car can pull up a load of 200 g.
3. Model car: The car, whose mass is 1 kg, can run up a slope of 30°.

These teaching materials involve fundamental concepts of physics, applied dynamics and design engineering. Learning elements of these teaching materials are shown in Tables 1 and 2 based on the procedure (1) and (2) mentioned above; ‘X’ shown in these tables indicates the relation between teaching materials and learning contents. Table 1 shows the relation between teaching materials and knowledge of science; Table 2 shows the relation between teaching materials and knowledge of technology. In addition, learning elements are structuralized in Figs. 1 and 2 based on the procedure (3).

<table>
<thead>
<tr>
<th>Work</th>
<th>Motor-driven winch</th>
<th>Model car</th>
<th>Model car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Movement distance</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Unit of work</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Principle of work</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Unit of power</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Energy</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Unit of energy</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Kinetic energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential energy</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical energy conservation law</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frictional force</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1. The relation between basic knowledge and the developed teaching material— "Work in dynamics"**

<table>
<thead>
<tr>
<th>Learning element</th>
<th>Teaching material a</th>
<th>Teaching material b</th>
<th>Teaching material c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor-driven winch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model car</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model car</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2. The relation between basic knowledge and the developed teaching material-- "Mechanism"

<table>
<thead>
<tr>
<th>Gear: Number of teeth</th>
<th>Module</th>
<th>Pitch diameter</th>
<th>Addendum diameter</th>
<th>Gear train</th>
<th>Transmission ratio</th>
<th>Center distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Chain: Chain, Sprocket</td>
<td></td>
<td>Pitch diameter</td>
<td></td>
<td></td>
<td>Length of chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Mechanical efficiency</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Effective work</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lost work</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Effective power</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lost power</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Fig. 1 Structural analysis of basic knowledge related to teaching materials**

---

**Motor performance**

\[
\text{Motor efficiency} = \frac{P_m}{P_e} \times 100
\]

\[
P_m = 2\pi N_m T_m / 60
\]

\[
\eta_e = 1.5 \times I
\]

---

**Winch: Torque for winding a load**

\[
\text{Torque for winding a load} = N_m [N \cdot m]
\]
mgD/2
Preliminary decision of drum diameter

<table>
<thead>
<tr>
<th>Drum diameter D [m]</th>
<th>Gravity acting on a load mg [N]</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg</td>
<td>Mass of a load m[kg]</td>
</tr>
<tr>
<td></td>
<td>Gravity acceleration g[m/s²]</td>
</tr>
</tbody>
</table>

Fig. 2•Structural analysis of basic knowledge related to teaching materials

**Teaching using “MONODUKURI” and students’ activities**

“Motor-driven winch model” was taken up as a teaching material. Students design and produce the motor-driven winch that can wind up a 600 g load. Finally, students test performance of the winch that students have made.

This teaching material comprises the following elements. Students select the best element based on their judgment.

(a) Power source: Motor RE-140 for driving a model (Mabuchi Motor Corp.)
(b) Winding drum: Aluminum rods of 20 mm, 30 mm and 40 mm diameter
(c) Reduction gear using spur gears: The gearbox transmission ratio 68 and spur gears of module 0.5 mm
(d) Bearing
(e) Base and machine screw for fixing parts

The required time for winding a load and motor current are measured to test performance of the finished motor-driven winch. A simple measuring apparatus of a stopwatch and tape measure is used to measure performance.

**Teaching method**

The following two teaching methods are compared.

Students themselves learn knowledge and theory with manufacturing.

(This is called the “MONODUKURI Method”)

A teacher introduces a desktop experiment into a class and instructs knowledge and theory to students.

(This method is called the “Traditional Method”)

To verify the effect of each teaching method, students who had learned the basis of science and technology were selected as subjects. Subjects are 46 students of the fourth form who learn mechanical engineering at a college of technology. Subjects are divided into two groups of the experimental group and the control group. The experimental group learns through “MONODUKURI Method”, while the control group learns through “Traditional Method”. Each group comprises 23 students.

**Teaching Program**

Since the effects of two teaching methods (“MONODUKURI Method” and “Traditional Method”) are compared in this study, students learn based on the teaching program shown in Fig. 3.

---

Presentation and design of the design subject

Students design the design subject with deciding their design procedure. (100 minutes)

Pre-test and pre-concept map (100 minutes)
Feedback of pre-test results
Design of a motor-driven winch when efficiency of a gear train is set at 100%
Students design the design subject based on a design procedure which a teacher decided.
(100 minutes)

Assembling motor-driven winch based on students' design sheets and demonstration of
the performance test by a teacher.
Students learn the design method of the motor-driven winch in consideration of
the efficiency of a gear train. (100 minutes)

<table>
<thead>
<tr>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning through &quot;MONODUKURI Method&quot; (100 minutes)</td>
<td>Learning through &quot;Traditional Method&quot; (100 minutes)</td>
</tr>
</tbody>
</table>

Post-test and post-concept map (100 minutes)

**Fig. 3 Teaching program**
**Evaluation of the teaching method and consideration**
Effects of teaching through the two teaching methods ("MONODUKURI Method" and "Traditional Method") are evaluated by test and concept map.

**Test**
Students answered problems concerning the Motor, Gear, Winch Model, and Efficiency. Table 3 shows test results. Pre-test results did not differ significantly and two learning groups show similar quality. Post-test results differ significantly at a 5% confidence level.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>All problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>55</td>
<td>19</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>51</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>46</td>
<td>22</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>47</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Gear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>75</td>
<td>27</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>72</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Winch model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>61</td>
<td>25</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>56</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>45</td>
<td>31</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>35</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>All problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>88</td>
<td>10</td>
<td>p&lt;5%</td>
</tr>
<tr>
<td>Control group</td>
<td>77</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>87</td>
<td>18</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>79</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Gear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>98</td>
<td>6</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>94</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Winch model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>81</td>
<td>25</td>
<td>n. s.</td>
</tr>
<tr>
<td>Control group</td>
<td>72</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>84</td>
<td>24</td>
<td>p&lt;1%</td>
</tr>
</tbody>
</table>
Table 3. Results of the evaluation test

Concept map
Students produce a concept map of power for winding a load shown in Fig. 4. In the concept map shown in Fig. 4, well-known learning elements are arranged in the lowest rank; the learning elements that become a final goal are arranged at the highest rank. Furthermore, lower elements are arranged between these elements. Students draw a line between elements to construct the concept map.
The total number of lines shown in Fig. 4 divides the number of lines, which a learner quoted between learning elements; the concept map is evaluated as the rate of correct line.
The rate of correct line=(Number of correct lines)/(Total number of lines) [%]

Fig. 4•The concept map of power for winding a load

Table 4 shows the concept map results. These results imply that the instruction method through which the experimental group learns is effective.
### Table 4. Evaluation results of the concept map

<table>
<thead>
<tr>
<th></th>
<th>Experimental group</th>
<th>Control group</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-lesson concept</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>map • •</td>
<td>45</td>
<td>44</td>
<td>n. s.</td>
</tr>
<tr>
<td><strong>Post-lesson concept</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>map • •</td>
<td>67</td>
<td>56</td>
<td>p&lt;5%</td>
</tr>
</tbody>
</table>

n.s.: non-significant

**Mean**

**S.D.**

**t-test**

Students’ response

Students completed a questionnaire. Survey items and results of students’ answers are shown in Table 5.

#### Table 5. Questionnaire results

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you have interest and could you address the subject?</td>
<td>27%</td>
<td>56%</td>
<td>11%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Did the exercise introducing “MONODUKURI” help you to understand more than an exercise comprising only calculation?</td>
<td>48%</td>
<td>31%</td>
<td>11%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Could you understand learning contents better through producing something by yourself than through teaching by a desktop experiment done by a teacher?</td>
<td>56%</td>
<td>18%</td>
<td>20%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Do you hope that “MONODUKURI” and experiments are introduced into class teaching?</td>
<td>68%</td>
<td>23%</td>
<td>6%</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>

5: Very understandable / Strongly agree 4: Understandable / Agree 3: No particular opinion 2: Difficult to understand / Disagree 1: Very difficult to understand / Strongly disagree

**Summary**

We described a method for developing teaching material of “MONODUKURI” which can be introduced into a classroom teaching and developed the teaching material concretely. Fundamental knowledge related to “MONODUKURI” teaching material was structured. Teaching material with the following characteristics was developed.

1. The teaching material places special emphasis on more fundamental content than conventional teaching materials.
2. A single teacher can introduce the teaching material in a classroom setting and teach it in 2-4 hours.
3. The teaching material can be produced easily with hand tools without the high-level skill; its performance can be tested with a simple measuring apparatus.

The effect of the two teaching methods was verified using teaching material of a design-production-performance test of a motor-driven winch that can wind up a load of 600 g: one teaching method is that by which students themselves grapple with “MONODUKURI”; the other is one whereby teachers instruct...
students through a desktop experiment. We evaluated teaching effects by test and concept map. The teaching method introducing “MONODUKURI” was more effective than the traditional teaching method. Moreover, students favorably received the class into which “MONODUKURI” was introduced and learned eagerly.

Challenging More Able Pupils in Technology Education in the secondary school

Chris Smith, Department of Educational Studies, University of Glasgow
John Dakers, Department of Educational Studies, University of Glasgow
Email: csmith@educ.gla.ac.uk
Email: jdakers@educ.gla.ac.uk

Abstract

In Scotland More Able Pupils are generally educated in mainstream schools with their age related peer group. Teachers are therefore expected to cater for a wide range of abilities within one class. The current national initiatives related to inclusive education would suggest that this situation is likely to continue.

In gifted education, generally, little attention has been given to subject specific concerns about the identification and appropriate challenge of able pupils. In technology education this is particularly true as, in Scotland, it has long been perceived as a subject for those regarded as ‘less able’.

This paper explores the range and nature of intelligent behaviours in technology education suggested by the literature. It then offers a model of reflection for teachers to
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help them think through the issues relating to the appropriate challenge of their most able pupils in technological education.

Introduction

The study of 90 empirical studies of giftedness published between 1997 and 1998 in five scholarly journals important to the field provided several important findings. To begin with, a not unexpected, but nevertheless significant, result was that no consistent and uniform criteria for the identification of gifted individuals could be isolated (Zeigler and Raul, 2000, p.128).

According to the review by Zeigler and Paul there is a lack of agreement about what constitutes an able individual and there is an inherent narrowness in the identifying criteria used in most research. This links with a positivist and empirical tradition in the identification of able pupils through the assessment of a narrow range of measurable qualities historically associated with the IQ (Intelligent Quotient) test. However, more recent developments in the study of giftedness (Gardner, 1993; Sternberg, 19??; Renzuilli, 19??) would indicate that such measures do not account for the highly valued traits that are associated with successful gifted individuals.

Almost from the beginning, modern research has demonstrated that although students with high IQs usually obtain good grades both at school and university, they are consistently outstripped by those with not only a high IQ but also high creativity. (Cropley and Cropley, 2000, p.207)

In terms of Design and Technology Education, creativity plays a central role. Indeed, Barlex (2003) argues the “creativity is now explicitly acknowledged as an essential feature of design and technology”. (p.5)

There is a shifting paradigm in gifted education from IQ – dominated explanations to a broader, multi-faceted conceptualisation (Vialle, 1999). This reflects a broader shift in learning theory from reductionism (Poplin, 1988a) to holism, social constructivism and structuralism (Poplin, 1988b).

While the new paradigm is evident in recent policies (SEED, 2003); reports (HMIE, 2003) and legislation (SE, 2003 draft bill) on inclusion, the concomitant shift in pedagogy has not yet taken place. Thus a tension is created whereby the reductionist paradigm remains firmly embedded within the educational system at the same time as new understandings about learning and assessment suggest that a very different approach is required. Kimbell (1997) identifies the paradigm shift as creating a tension between a criterion and holistic approach in the assessment of “what is good” (p.31) in technological education.

What is ‘good’ in technological education?

There is a lot of agreement that IQ scores are too narrow for the accurate identification of all gifted and talented individuals (Gardner, 1993; Goleman, 1996; Drewelow, 1998) and that creativity, especially in the field of technology education, is an important feature of giftedness (Cropley and Cropley, 2000). Facaaaru (1985, cited by Cropley and Cropley, 2000) showed that engineers rated most highly by colleagues displayed: factual knowledge; rapid recall; logical thinking as well as the ability to provide unusual ideas, tolerate the unconventional and see unexpected implications.

In class discussions with a group of students in a Scottish University, undertaking the Batchelor of Technological Education degree, it was agreed that logical and creative thinking as well as problem solving was crucial to the identification of gifted individuals in technology education. This group also added that inter personal abilities were important because so much related to technology education, in the wider world of industry, depended on team-work and collaboration. Thus, as Kimbell (1997) suggested, it would appear that “asessing pupils’ capability in the process of design and development is a far more complex matter than simply assessing their knowledge and skills” (p.XX) (introduction). However, according to Cropley and Cropley (2000), it is perhaps a combination of knowledge and skills as well as the consideration of a wider range of abilities that is required.
“Engineering requires high levels of expertise: mastery of basic knowledge, skills and techniques. The public wants machines to work and bridges to continue standing. Mastery of what already exists then has high value for students, and production of novelty runs directly counter to this tradition. Paradoxically, however, it is highly prized.” (Cropley and Cropley, 2000, p217)

The provision of opportunities in the curriculum becomes essential: “To achieve a creative act, the potential for creativity must exist.” (Davies, 2002, p99). More specifically there is a challenge in assessing what Kimball identifies as the uniqueness of technological education: “thought in action” (1997, p30). It is the combination of the traditional (knowledge and understanding) with the more holistic approach (creativity, social skills and innovation), contextualised in real settings, which produces this “interaction of mind and hand – inside and outside the head” (Kimball, 1997, p29). The aim of creating innovative solutions to practical problems brings together the old and the new paradigms in the technological classroom. Reconciling the two is not easy. To concentrate on one at the expense of the other is potentially damaging.

The Scottish Consultative Council on the Curriculum (SCCC) endorses the view that technology is a unique form of creative activity where “human beings interact with their environment to bring about change in response to needs, wants and opportunities” (SCCC, 1996, p3). The purpose of technological education, as outlined by SCCC, is to develop technological capability in young people. This capability is translated by SCCC into four key areas of technological ability that should be developed in children and young people: Technological perspective; confidence; sensitivity and creativity.

Davies (2002, p97) suggests some possible qualities of gifted and talented learners in design and technology that include innovative use of knowledge and skills; being able to think in ways that allows the transfer of ideas from familiar to unfamiliar contexts and create elegant problems or solutions from complex, disorganised information. He also includes the ability to reflect on one’s own thinking and to be self critical and, as with the students on the BtechEd course, he suggests that effectively working within a group as a leader and/or team leader is essential.

General features, then, of what is ‘good’ begin to emerge that include:
- Imaginative and enterprising application of knowledge and skills
- Ways of thinking such as systems thinking and a variety of processes
- Social processes such as working in teams or organisations and
- Coping creatively with complexity

If, then, it is abilities in these broad areas that are key to developing technological capability it would follow that teachers, in mediating the curriculum for children and young people, would design tasks that allow them to teach in a way that develops these abilities in learners. However, teaching alone is not sufficient and may fail to take account of pupils who can already demonstrate these abilities. Opportunities become key to the identification of learners who can already demonstrate these abilities to a high level. Finally, identification is pointless if further challenge and support to develop these abilities even further does not exist.

The problem has been that the embeddedness of the reductionist paradigm in the current educational system has led to inherent dangers in current teaching and assessment procedures such that the identification of gifted and talented individuals becomes difficult. Kimbell (1997) refers to six specific problems that can arise.

The danger of exclusivity as the process becomes a set of rituals prescribed by examiners.
The associated tendency to transform creative processes into pre-specified products.
Real images (real pupils) become splintered into digits of meaningless detail.
A proliferation in assessment is brought about by the splintering process.
It brings uncertainty in knowing when a tiny bit of detail is a no or a yes.
This creates confusion by the inevitable interaction of the bits of detail
(adapted from Kimbell, 1997, p25/6 original emphasis)
The problem with producing a set of criteria or attainment targets that might or might not identify an able pupil lies then with the reductionist nature of the approach. In identifying a set of criteria or learning outcomes the assessment is reduced to a series of, often unrelated, ticks on a sheet. It can also raise the tension between teaching one thing and assessing another (Kimbell, 1997, p51). While the criteria may identify knowledge and skills that can be taught and learned, the assessment of what is ‘good’ relates not to the individual features but to the pupil’s capability in putting it to use in a real task (Kimbell, 1997, p51).

Identification and Provision for more able pupils in technological education

If checklists or sets of criteria are not the answer then how is it that teachers can be supported to more reliably identify and provide for more able pupils in the classroom? If, as Kimbell et al (1990) suggest, that it is the inter-relationship between modelling ideas in the mind, and modelling ideas in reality that is the cornerstone of capability in design and technology (p21) then as Davies (2002, p93) states this implies learners holistically engaging with the processes of designing (ideas generation and selection, evaluation and investigation) and making (planning, mock-up generation, refining and detailing) but with embedded opportunities for creativity at any stage.

The essence of this move towards contextualising tasks is that ‘real’ tasks do not and cannot exist in a vacuum, and the setting of the task is a major determinant of the meaning of that task (Kimbell, 1997, p55). Renzulli (2000) suggests that ‘real’ problems only real if they have:

- A personal frame of reference;
- No existing or unique solutions;
- A possibility of creating new products or information and
- A real audience.

Clapham (1997 cited by Cropley and Cropley, 2000) suggested that training for students of technology at university may help them to become more creative. Cropley and Cropley (2000) went on to undertake research and found that students could be encouraged to be more creative by simply making them aware of what creativity was and what it involved. Clear feedback on how to behave more creatively was also beneficial. If this is beneficial to students at university then there may be application and usefulness for learners of school age. Whether or not teachers have the confidence and abilities to do this is questionable. This is especially true if the educational system of which they are a product has not encouraged them to be creative. In this way maximising the potential of the gifted child in the regular classroom becomes a professional development issue (Moltzen, 1998).

Moltzen (1998) goes on to identify a tension between the uninformed and rampant egalitarianism of the regular classrooms and those who perceive the regular classroom as an educational wasteland for our best and brightest (p36). One reason for this difficulty is a legacy from the IQ movement that implies a fixed membership of a gifted group (p40) based on a single criterion (Zeigler and Raul, 2000). A key area for staff development and reflection then would be opportunities to think through some of the tensions identified in this paper. Although perhaps compromises might be the best one can hope for, by reflecting on the tensions identified in this paper, local and individual solutions that nurture creative and innovative approaches from teachers, and in turn learners, might be encouraged.

A model for reflection

Kennard (1998) suggests four strands that should exist within a model of identification of more able pupils: the interpretative framework, selection of appropriately challenging materials; consideration of appropriate forms of interaction between teachers and pupils and the continuous provision of opportunities for able children to respond to challenging materials.
Smith and Docherty (2000) also suggest four points for reflection but further suggest that the process should be cyclical rather than linear (diagram one).

Diagram one

In this model it is suggested that all educators would do well to clarify their beliefs about what constitutes an able learner (definition). Only having discussed the relevant issues can provision be examined critically for opportunity (provision). These opportunities need to exist not only to teach those abilities deemed key to gifted learners in technological education but to acknowledge those who are already able to display them in abundance – given the appropriate opportunity to do so (identification). It is imperative, however, that we do not stop there. Further challenge for those who already display these abilities to a high level is required (provision). This process may well make us redefine what we believe intelligent behaviours in technology education to be (definition).

It is proposed here that in light of these previous considerations a new model emerges that is perhaps more sophisticated and offers a more helpful framework for local reflection (diagram two).

Diagram two

If Pedagogy is determined by the relationship in teachers’ understanding of the nature of learners and learning and of knowledge (Murphy, ????, p9) then maximising the potential of the gifted child in the regular classroom is becomes a professional development issue (Moltzen, 1998, p36). The dominant pedagogy in technological education currently gives value to particular types of knowledge represented in national tests and examinations (Murphy, ????, p9). Teacher beliefs about the nature of technological education – either as static or as dynamic and creative becomes crucial. Opportunities, therefore, for teachers to consider their own beliefs about the nature of their subject and of how giftedness may manifest itself within this become essential.
The nature of these beliefs give rise to particular frameworks for interpreting particular behaviours in class and whether these are classified as intelligent or not. It is only in the light of this that provision can be examined for opportunities for learners to demonstrate their abilities. However, mere opportunity is not enough. How teachers organise pupils in their class for learning and how they interact and respond to pupil work becomes crucial. It is only when all these elements converge positively that identification of gifted individuals can occur. This very process of identification may lead to a reexamination of beliefs about what intelligent behaviours in technological education might be and who it is in a class that might be able to demonstrate them.

**Conclusion**

A key tension exists in education at present that represents a major shift in thinking related to learning and teaching. This is reflected in issues related to the education of gifted and talented learners in the technological classroom. Educators find themselves in a transition phase where the assessment methods associated with reductionist approach maintain dominance yet new understandings associated with a more holistic and social constructivist paradigm offer the way forward for more accurate and appropriate methods of identification and challenge of gifted individuals. While professional development for teachers themselves offers one strand in the way forward there is a need for endorsement of creative, critical design thinking at policy level (Murphy, ????, p9) which is only beginning to emerge.

References
Pupils’ Values and Perceptions of Design and Technology

Peter Grover, Centre for D&T Education, Sheffield Hallam University  
Andy Mitchell, Centre for D&T Education, Sheffield Hallam University  
Liz Fuller, Centre for D&T Education, Sheffield Hallam University  
Email: A.F.Mitchell@shu.ac.uk

Abstract

The holistic approach to design and technology (D&T) has been widely advocated during the period of the national curriculum and it is recognised that this approach represents the ‘ideal’ in terms of pupils engaging with designing and making. However this approach has not been universally adopted by all schools in England.

During the process of the development and refinement of the national curriculum order for D&T the need for updating and ‘modernisation’ has been repeatedly identified. This modernisation refers to the nature of designing and making tasks, the resources used and processes employed. Taking into account the radical nature of a national curriculum that set out to define a new and modern subject it is perhaps surprising that in many respects, the nature of the teaching and pupil activity has changed little in some schools.

Central to good design and technology (D&T) teaching and learning is practical designing and making activity resulting in functioning products. It is the authors’ contention that it is the creation of ‘real’ products of quality that defines the true value and worth of D&T. Sheffield Hallam University (SHU) has been involved with the development of innovative teaching resources for D&T to enable this to happen. The Technology Enhancement Programme (TEP) is known for its provision of new and innovative physical resources to support D&T teaching and learning in the areas of systems and control and resistant materials. As part of a project to evaluate the use and effectiveness of these combined resources, TEP supported by Sheffield Hallam University, has established the Millennium Schools Project. This project involves a study of approximately 11,000 pupils in 22 schools. 11 schools have been provided with extensive physical resources, curriculum teaching materials and associated training. Between 2001 and 2003, the results of pupils’ activity are being observed and surveys of pupils and teachers are being
conducted by The National Centre for Social Research (NCSR). During the autumn term of 2001, a baseline survey examining pupils’ attitudes was conducted through the use of a questionnaire completed by all pupils in year 8, 9 and 10 in the 22 sample schools. This required them to reflect on their experience of D&T.

This paper describes the nature of the intervention that has taken place in 11 of the 22 schools. It examines the rationale behind the project and reports some of the findings at this interim stage of the project resulting from the baseline survey. Using this data it explores attitudes expressed by pupils.

It is hoped that through analysing the data, a better understanding of how pupils perceive and value D&T activity will be gained enabling teachers to use this information to inform the design and delivery of their individual schemes of work.

Key Words: Pupil’s values, perceptions, designing, making.

Introduction and Background
A particular strength of the national curriculum is the freedom schools have to develop a model for delivery incorporating project work unique to the school. Such freedom provides teachers with the opportunity for innovation, creativity and allows for individual responses to initiatives and the development of processes and resources as they become available. This has been the basis for curriculum development in design and technology (D&T) and is seen by the authors to represent an essential element in the development of the subject. The national curriculum has provided a framework of minimum entitlement for all pupils. It is however, the skill and professionalism of the teacher that translates this entitlement into a meaningful experience. Curriculum leaders have had the responsibility for ensuring and maintaining a balanced and relevant D&T curriculum with a content that ensures coverage of the national curriculum programmes of study and provides opportunity for the development and application of originality, creativity and innovation by pupils. What is the attitude of pupils to this scenario?

In 2001 the Technology Enhancement Programme (TEP) in association with Sheffield Hallam University (SHU) and the National Centre for Social Research (NCSR) embarked on a study to examine the attitudes of pupils to current design and technology curriculum provision. A curriculum development project, The Millennium Schools Project was initiated to introduce new curriculum material and examine their effect on pupils’ responses and attitudes toward D&T.

SHU has considerable experience of curriculum development and the provision of professional in-service training activity (INSET) nationally. Over the past seven years the university has worked closely with the Technology Enhancement Programme (TEP). This is a national initiative whose mission is to enhance and enrich technology education and training. TEP has developed curriculum resources including consumable materials, physical hardware/software and teaching materials in the form of multi media and text based publications.

The national curriculum order for D&T and the Qualifications and Curriculum Authority (QCA) scheme of work for KS3 have provided valuable guidance for schools. Discussions with teachers might suggest that although useful, in isolation these documents have not necessarily produced the desired curriculum ‘modernisation’. The Millennium Schools Project was interested in maintaining and modernising approaches to the D&T curriculum, by making the student experience central to the curriculum. It also aimed to maintain the professional responsibility of the design and technology teacher to initiate and implement local, innovative curriculum matter. Previous D&T curriculum initiatives have been welcomed by the profession although their impact has often been tempered by practical constraints.

Such constraints include:

- lack of time in schools for innovative project development incorporating new resources;
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- time to locate resources;
- inadequate funding;
- a system that impedes creativity, risk taking and innovation;
- limited knowledge of new and innovative resources available;
- training provision;
- perceived limitation of teaching environments.

Description of the Millennium Schools Project, its implementation and rationale
The Millennium Schools Project began with the premise that although pupils generally appear to enjoy D&T activity, they relate more purposefully to some aspects than they do others. It also believed those pupils’ attitudes and subsequently their level of performance is intrinsically linked to the nature of design and making tasks they are set. The Millennium Schools project provided a model for curriculum intervention and development. SHU in association with NCSR aims to measure the change in pupil attitudes to D&T resulting from schools participating in the project.

The project involves 22 schools of which 11 are for control purposes. The other 11 are pilot schools are subject to intervention. During the period from July 2001 to July 2003, these schools have been provided with project ideas, methodology, physical resources and training to enable them to teach new D&T curriculum material to entire cohorts of year 7, 8 and 9 pupils. Schools were required to develop their own schemes of work incorporating a minimum of 3 projects for each entire year group.

The Millennium Schools project involved curriculum intervention and development comprising 3 strands:

Materials and publications
Pilot schools were provided with a comprehensive set of publications containing ideas, resource descriptions and methodology, produced by SHU. TEP is specifically concerned with the development of systems and control and resistant materials D&T fields of knowledge and the projects were selected to reflect this. The university’s D&T initial teacher training programme and INSET courses for teachers were used to trial these resources in advance of them being used in the pilot schools.

Central to the philosophy of the initiative is the concept of a ‘project’ as a mechanism for developing pupils’ capability to design and make. Ten design and make projects were devised:

- Post-it note organiser: Organiser for packs of self adhesive notes
- CAD Flash: LED powered flash light manufactured using CAD/CAM
- Flat flash and battery tester: Two 'graphic products' making use of electro-luminescent and thermochromic film
- Aroma fan: Mood changing controllable fan to disperse aromas
- Message in a box: PIC controlled messaging system
- Jitterbug: Interactive programmable bug using a PIC controller
- Bubble blower: Electro mechanical device for blowing bubbles at parties
Each individual project is based around the development of an innovative focused practical project that has been designed to function in the following ways:

a. It recognises that the concept and quality of the project ‘idea’ introduced through the design brief is of crucial importance for the completion of successful practical outcomes. The intention was to provide project ideas that were different, imaginative and had rich opportunities for children to be creative. This provides a ‘wow factor’ for pupils, creating a desire to engage with designing and making. The aesthetic quality of products is accepted as an important factor influencing children’s feelings toward them and the project attributes included careful consideration of aspects such as tactility and colour.

b. The ideas and methodology make specific reference to the use of modern materials, emerging technologies and manufacturing techniques. For example peripheral interface controller chips (PICs) in electronic circuits, pre-finished materials and use of innovative fabrication methods. This replicates industrial models of production, building in quality and speeding up manufacture.

c. A method of delivery was also recommended acknowledging individual pupil pathways to an outcome. Each project was initiated with a number of highly structured focused practical tasks, introducing technical knowledge of materials and processes. Pupils were encouraged to design through making a series of prototypes, working their way through to a final solution, in the iterative fashion described by SEAC/EMU (1991).

Each project is supported by a written publication to provide teachers with the means to rapidly initiate the projects.

Training
Projects and materials were introduced to participating schools through training courses provided by SHU, concentrating on giving teachers the knowledge, skills and confidence to make creative use of the recommended resources, project ideas and pedagogy. Emphasis was placed on providing opportunities for design and making activity enabling pupils to produce unique, quality practical responses.

Resourcing
Participating pilot schools were required to introduce a minimum of 3 projects per whole year cohort. TEP provided them with all the necessary resources and materials, unique to the project, to implement the new projects within their Key Stage 3 programmes. They were, however, expected to provide the normal range of manufacturing equipment and consumables.

Methodology
The evaluation of the TEP Millennium Project is being carried out by NCSR using data collected over three years from over 10,000 students in more than 20 schools. The research is using an experimental design to measure the impact of the Millennium Project resources on Key Stage 3 students.

The original sample of 24 schools around Sheffield and Warwick was recruited by the project team in 2001. These schools were matched into pairs by size and exam performance and assigned randomly to either the control or the experimental group. The baseline study (from which these data are drawn) was carried out during the autumn term of 2001, completed in the classroom by pupils in Years 8, 9 and 10 using self-completion questionnaires. Two schools’ output was subsequently excluded on grounds of quality, leaving a sample of 11,592 pupils from 22 schools.
The questionnaires cover attitudes to school in general and D&T in particular, and interest in different aspects of D&T topics and skills. It includes data on sex, ethnicity and indicators of family economic status.

Follow-up studies are taking place in autumn 2004 (Years 8 and 9) and autumn 2003 (Years 9 and 10).

**Findings from the baseline survey and comment**

The ongoing research is collecting quantitative evidence from all pupils in the schools partaking in the project. In addition qualitative data is also being collected from teachers engaged in using the teaching resources and methodologies developed. The project has yet to reach the stage where conclusions may be drawn as to the extent to which pupils’ attitudes to design and technology have been changed as a result of intervention from the Millennium Schools Project. It is however interesting to consider the evidence from the baseline study as an indicative study of pupils attitudes prior to the intervention of the Millennium Schools Project. Subsequent data collected during the project and at its completion will then be used for purposes of comparison. The cohort of 11592 pupils possessed the following characteristics:

<table>
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<tr>
<th></th>
<th>%</th>
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<tbody>
<tr>
<td>White</td>
<td>91.7</td>
</tr>
<tr>
<td>Non white</td>
<td>7.8</td>
</tr>
<tr>
<td>No response to ethnicity question</td>
<td>0.5</td>
</tr>
<tr>
<td>Boy</td>
<td>53.0</td>
</tr>
<tr>
<td>Girl</td>
<td>47.0</td>
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</table>

Pupils were asked to complete a 35 question questionnaire, responding by ticking boxes giving answers that were most true for them. For the purposes of this initial examination of the baseline survey, only a small number of questions are made use of and referred to in this analysis below. More sophisticated use will be made of the data when similar questionnaires are completed and analysed later in 2003 and 2004.

Pupils were asked to respond to the question:

Q16. ‘*First, do you enjoy designing things in Design and Technology*…’

and:

Q17. *Do you enjoy making things in Design and Technology*…’

36.3% of pupils indicated they liked designing and making, but 39.9% liked making only. 8.0% liked designing only. Generally they enjoyed making more than designing. This trend is maintained across year groups within the Key Stage, general ability range, D&T ability range and gender. Irrespective of how they viewed their own ability, 66% of pupils responded that they enjoyed making a lot.

Pupils were asked about their feeling towards D&T as a subject and were also required to rate their own ability in the subject.

Q13. *Thinking about how well you do at Design and Technology, do you think you are*…

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>…better than most people in your year group</td>
<td></td>
</tr>
<tr>
<td>…about average for your year group,</td>
<td></td>
</tr>
<tr>
<td>…not as good as most people in your year group?</td>
<td></td>
</tr>
<tr>
<td>Can’t choose</td>
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84.3% of pupils indicated that they were either better than most or at least average.
They were also asked:

Q14. Thinking about Design and Technology lessons and projects over the past year, how interesting or otherwise did you find them? Were they...

<table>
<thead>
<tr>
<th>...very interesting</th>
<th>...fairly interesting</th>
<th>...not very interesting</th>
<th>...not at all interesting</th>
<th>Can’t choose</th>
</tr>
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</table>

78% of pupils found the subject very or fairly interesting. Both boys and girls found it equally interesting. The results from these two questions indicate that the majority of pupils in the cohort were responding positively to D&T as a subject in their schools as it existed prior to the Millennium Schools Project intervention. Findings indicate that they enjoy lessons.

The researchers were interested in gaining an insight into pupil’s perceptions of D&T’s standing and status against other school subjects. They were asked to respond to the statement:

Q28. “Most people think that Design and Technology is not a proper school subject, like maths or science are.” Do you...

<table>
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<th>...strongly agree</th>
<th>...agree</th>
<th>...neither agree nor disagree</th>
<th>...disagree</th>
<th>...strongly disagree</th>
<th>Can’t choose</th>
</tr>
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</table>

51.8% responded that they disagreed or strongly disagreed with the statement. When asked to select the 3 subjects they liked best, D&T featured alongside Art and Design and Physical Education (PE). The least popular were Geography and Modern Foreign Languages (MFL).

The results would indicate that the majority of pupils see the subject as worthwhile, interesting and something they are good at. They value the subject with 60.3% believing that it is important to get a qualification in D&T. This leads to questioning how difficult they perceive the subject to be. A further question asked them to:

Q15. Read the statements below and tick the one which best describes what you have felt about Design and Technology over the past year?

<table>
<thead>
<tr>
<th>Most of what we did was easy for me</th>
<th>I found some things easy and other things hard</th>
<th>Most of what we did was hard for me</th>
<th>Can’t choose</th>
</tr>
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21.1% responded that they found most of what they did was easy and 94% that some was easy and some was hard. Only 3.8% reported that most of what they did was hard.
53% of pupils agreed with the statement:

Q30. You do not have to be clever to do well at Design and Technology

This might suggest that current D&T work is perceived by pupils as being less challenging than it could be.

Overall the findings resulting from the baseline study indicate that pupils generally regard the subject positively as it is taught in the 22 schools surveyed. Whereas this may not be surprising, the evidence does quantify the extent to which pupils value the subject. The fact that pupils also view themselves as ‘capable’ practitioners is also positive and leads one to consider the potential for providing additional challenge in the work and in particular the tasks they are set. The fact that they value the making experience is supported by the Craft Council research Learning Through Making project (1998).

‘It saw an urgent need to examine the central role played by making – not only in learning the skills to overcome the well-documented famine of competent makers, but also in learning life skills […] the contribution was only incompletely recognised and its potential even more rarely appreciated.’ Eggleston (2000,135)

**Conclusions**

The early findings of the Millennium Schools Project baseline study and observations of pupil and teacher responses have encouraged the project team. In particular these initial outcomes would appear to support the authors contention that making ought to remain central to D&T activity. The designing and making of ‘desirable products’, what the Craft Council referred to as ‘intelligent making’, provides excellent educational opportunities for D&T and can also develop a wide range of personal attributes.

‘Secondary school pupils enjoy ‘practical making’ provided it engages realistically with their motivation and aspirations. They do not appreciate what they see as ‘irrelevant theory’ and ‘paperwork’, regarding neither as being necessary in the ‘practical learning’ of ‘practical subjects’.’ Eggleston (2000,139)

The baseline questionnaire might lead the profession toward complacency as it suggests that pupils enjoy and value what they are currently experiencing within D&T. Arguably this may not provide the motivation necessary amongst D&T professionals for curriculum innovation and modernisation. However the need to provide modern opportunities for designing and making quality products that further excite and challenge the imagination, creativity and manufacturing skills of pupils remains paramount. It remains to be seen if the Millennium schools project will have any impact on pupils’ attitude to design and technology.

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The effect of alternative approaches to design instruction (structural or functional) on the quality of technological problem solving processes

Osnat Dagan, Ort Israel, Moshinsky Pedagogical Center
David Mioduser, Tel Aviv University, School of Education
Email: odagan@ort.org.il

Abstract

The study reported here is part of a larger research project aimed to examine the relationship between alternative approaches towards design teaching (structural or functional), and the quality of the design process. The structural approach emphasizes the need for an ordered learning of the stages of the design process, while the functional approach emphasizes the teaching and study of design functions (rather than stages). 80 seventh graders, divided in two groups, were taught a unit on technological problem solving by either approach for 14 classes (21 hours). The results were analyzed looking for: 1. the quality of the design functions that was described and presented in the student’s portfolios 2. the students’ perceptions of the design process.

Key Words: Problem Solving, Design, Quality of Design process, Design Functions, Technology Education, Junior-High-School.

Significant changes have taken place in technology education in the last decade. Educators and educational policy makers have become aware of the importance of technological concepts and skills as part of the today’s citizen education. The contents, skills, and methods of technology education are being re-examined, regarding both technological literacy and specialization studies.

One of the major goals of technological literacy is to provide students with tools for solving technological problems. The main methodological resource for this purpose is the design process, as used by
technologists to create solutions in response to human needs and enhance the quality of life. There is a conflict regarding the nature and qualities of the design process: in one hand, it is conceived as a creative, branching, and cyclical process based on multi-disciplinary knowledge, while in the other hand it has to meet the requirements of products-production processes, e.g., to be structured, to proceed in stages, to meet schedules, to be clearly product oriented.

Signs of this conflict can be found amongst researchers and educators dealing with technological literacy. Two main methodological approaches for teaching the problem solving process can be found in the literature (Polya 1957; Newell and Simon 1972; Schon 1983; Charles and Lester 1984; Philpot and Sellwood 1987; Todd 1990, Hegarty 1991; Hutchinson and Karanitz 1994; Kimbell, Stables, and Green, 1996): (a) The structural (stage-by-stage) approach, and (b) the functional approach.

The structural approach emphasizes the need for an ordered learning of the stages of the design process (Hutchinson 1994, Todd 1990, Waetjen 1989). Different models (differing from each other mainly by the number of stages into which the process is divided) were developed all over the world for teaching design as an organized and methodical tool (e.g., DES in UK 1989, in the US, Australia, Argentina, the Netherlands). The learning process proceeds as the gradual implementation of the different stages.

The functional approach emphasizes the teaching and study of design functions (rather than stages): problem identification and definition, investigation, decision making, planning, making, evaluation. At every stage of the process the problem solver may use more than one of the design functions (e.g., investigation and evaluation). According to this approach the process of problem solving is expected to be more flexible and cyclical. The instructional plan is based on the teaching of the different design functions (Chidgey 1994; McCormick 1994; Mioduser 1998), so that the students will use them in the way that best matches the problem, the situation, and their own personal style.

The structural approach is more commonly implemented in curricular materials, and many studies have focused on it. The studies’ results raised doubts about the capability of the students to achieve a holistic view of the process by this instructional approach (Hennesy & McCormick 1994, Johnson 1994, de-Vries 1997). In contrast, for the functional approach very few attempts for the orderly development of instructional materials have been made, (Jhohnsey 1998) and just few studies have been conducted.

A central goal in design-process instruction is to facilitate the construction of appropriate mental models of the technological problem solving process, in the form of internal representations of the real world situation and its solution (Barker et al, 1998). By mental design models we refer to systematic structural/functional/causal internal models of the design process (Mioduser 1998). In our current work we have obtained preliminary results on mental models construction by students while learning design in both of the above approaches to design instruction (Mioduser & Dagan, 2002).

The study reported in this paper is part of a larger research project aiming to identify the relationship between the instructional approaches, the mental models constructed by the students, and the problem solving processes actually taking place. Our overall question focused on the examination of the connection between learning design in either of the two instructional approaches (structural and functional) and: (1) The students’ mental models of the technological problem solving process; (2) The scope and quality of use of the various design functions by the students while designing a solution; (3) The students’ conceptions of the process; and (4) The components and quality of solutions for different problems as generated by the students.

From amongst these questions, we report in this paper on preliminary results related to the second research issue: The connection between the instructional approach (structural or functional) and the scope and quality of use of the various design functions by the students while designing a solution.

Method
The research population comprised 80 seventh grade students (Junior-high School), from Ort School in Akko (northern Israel), learning design as part of the compulsory science and technology curriculum. The
students learn in heterogeneous classes in which there are equal number of boys and girls. The participant students pertain to four classes, which for this study were divided in two groups:

- Two classes in which the design process was taught using the structural approach.
- Two classes in which the design process was taught using the functional approach.

In both instructional approaches the students had to identify a problematic situation, and define the problem, the needs, and the requirements for the solution. In the structural approach the students learned the design process stage by stage. At each stage they studied what they have to do and applied it to the problem they had chosen. In the functional approach, the students defined the problem, the needs and requirements and then learned all the design functions (tools). We emphasized the fact that it was possible to make use of different functions in different places in the process, and more than once. After solving their problem (during the process of learning), all students in both groups were given a new problem that they were asked to solve - to design and model it.

The participant teacher was selected on the basis of his ample experience in teaching problem solving in junior high school for several years. The instruction lasted 14 meetings, 90 minutes each.

The research tools
In this research we used two groups of research tools, qualitative as well as quantitative tools. Qualitative/interpretative tools, were used in order to identify and examine processes as they were taking place.

We examined students’ portfolios: 1) which were developed during the problem solving process; and 2) which were developed while solving a new problem (in the study’s post-test).

The collected data were organized and analyzed in order to construct profiles of the quality of the process. The criteria for analyzing the design functions were defined on the basis of the attainment targets of the Israelly syllabus for Science and Technology, the teacher’s targets, and relevant research literature (e.g., Custer et al., 2001; Hill 1997; Allan 1995; Burghardt 1999). The validation of the analysis criteria was made by experts evaluation. The experts’ scores overlayed with researchers’ in more than 80% of the cases. In addition, quantitative tools were used to examine statistically significant differences within and between the groups as regards to several variables of the learning process.

Results
Qualitative analysis of the students’ models
We analyzed two kinds of portfolios:

1. The portfolios that the students developed on their own problem solved during the instructional process (13 meetings).
2. The portfolios that the students generated on a new given problem (post-test session) and which they had to solve in limited time (one meeting - 90 minutes).

From the portfolios created by the students during the problem solving (instructional) process, and for the solution of a new problem, we created a set of parameters or criteria to depict the quality of the problem solving processes for each student, and to compare between the performance of both groups (the stages and the functional groups). The analysis of the data focused on the following issues (every issue or criterion was scored in a 1-4 scale):

1. Qualities of the description of a problematic situation.
2. Problem definition.
4. Specifications.
5. Investigation – when?
6. Investigation – how many times?
7. Review/survey.
8. Connection between the investigated issues and the features of the problem to be solved.
9. The contribution of the investigation to the solution of the problem.
10. Generation of ideas.
11. Choosing a solution (decision making).
12. Argument supporting the decision made.
13. Level of the drawings and graphical representations.
14. Drawing as thinking process.
15. Planning.
16. Documentation of the products-making process.
17. Evaluation.

Quantitative analysis of the student models
The above criteria were used for the qualitative analysis of both groups’ performance (stages and functional groups), during and at the end of the instructional process.

I. The analysis of the students’ portfolios created during the instructional process

Table 1 and Figure 1 refer to the quality of design functions in both groups. We can see that the mean score of the functions group is higher than that of the stages group for most criteria. For most of the high level thinking skills the mean score of the functions group was higher than the stages group.

The mean score of the stages group was higher only in two of the design functions: problem definition and information review/survey.

Table 1: Comparison between the two groups in the quality of the design functions as they are in the students’ portfolios – during the instructional process

<table>
<thead>
<tr>
<th>Criteria of the process’ quality</th>
<th>Stages group (mean)</th>
<th>Functions group (mean)</th>
<th>Difference (mean)</th>
<th>t - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The story</td>
<td>3.59</td>
<td>3.97</td>
<td>0.38</td>
<td>1.85</td>
</tr>
<tr>
<td>Problem definition</td>
<td>3.90</td>
<td>3.50</td>
<td>0.40</td>
<td>2.26*</td>
</tr>
<tr>
<td>Needs identification specifications</td>
<td>3.65</td>
<td>4.00</td>
<td>0.35</td>
<td>1.68</td>
</tr>
<tr>
<td>Investigations – when?</td>
<td>1.32</td>
<td>1.37</td>
<td>0.56</td>
<td>0.24</td>
</tr>
<tr>
<td>Investigations – how many times?</td>
<td>1.47</td>
<td>2.00</td>
<td>0.53</td>
<td>2.14*</td>
</tr>
<tr>
<td>review/survey</td>
<td>1.90</td>
<td>1.09</td>
<td>0.82</td>
<td>5.67 **</td>
</tr>
<tr>
<td>Connections between the investigation and the problem</td>
<td>2.35</td>
<td>3.21</td>
<td>0.86</td>
<td>2.51*</td>
</tr>
<tr>
<td>contribution of the investigation to the solution</td>
<td>1.18</td>
<td>1.33</td>
<td>0.15</td>
<td>0.73</td>
</tr>
<tr>
<td>gathering ideas</td>
<td>2.50</td>
<td>3.72</td>
<td>1.22</td>
<td>3.46**</td>
</tr>
<tr>
<td>choosing a solution</td>
<td>2.46</td>
<td>3.11</td>
<td>0.65</td>
<td>1.73</td>
</tr>
<tr>
<td>argument to the decision</td>
<td>1.93</td>
<td>2.79</td>
<td>0.86</td>
<td>2.43*</td>
</tr>
</tbody>
</table>
From a close examination of the portfolios’ contents we could conclude that most students did not make significant investigations or gather information. Most students in the stages group, who were explicitly taught to make information surveys, wrote at least the questions for the survey. But in most portfolios of this group we couldn’t find evidence for actual data collection completing the survey. In the functions group the students could choose if they need a survey, and most of them preferred not to use the survey tool.

**Figure 1:** Comparison between the groups in the quality of the design functions as manifested in the students’ portfolios during the instructional process

For most criteria the functions group’s mean scores were higher.

2 **The analysis of students’ portfolios made after the instructional process – as a post test**

In this case we gave the students a new story describing a novel problematic situation to be solved. We gave the students only blank paper for their portfolios. They had to complete the task in limited time and in the classroom, without gathering additional information nor actually making the solutions. However, we asked the student to write down what information they needed and that they would like to search for, and how they would build their solutions.

We compared their new portfolios, by the relevant criteria, with the previous ones (Table 2, Figure 2).

**Table 2:** Comparison between the two groups in the quality of the design functions as they are in the students’ portfolios after the instructional process – post test

<table>
<thead>
<tr>
<th>Criteria of the process’ quality</th>
<th>Stages group (mean)</th>
<th>Functions group (mean)</th>
<th>Difference (mean)</th>
<th>t - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem definition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>review survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gathering ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>drawings’ detailing</td>
<td>2.80</td>
<td>3.66</td>
<td>0.86</td>
<td>2.58</td>
</tr>
<tr>
<td>drawing as a thinking process</td>
<td>2.4</td>
<td>3.14</td>
<td>0.74</td>
<td>2.20</td>
</tr>
<tr>
<td>details planning</td>
<td>1.29</td>
<td>2.5</td>
<td>1.21</td>
<td>4.19</td>
</tr>
<tr>
<td>documentation of making the products</td>
<td>1.54</td>
<td>1.86</td>
<td>0.32</td>
<td>0.78</td>
</tr>
<tr>
<td>evaluation</td>
<td>1.08</td>
<td>1.12</td>
<td>0.04</td>
<td>0.37</td>
</tr>
</tbody>
</table>

* Significant p<0.05  ** Significant p<0.01
In most criteria (except for problem definition and detailed planning) the functions group’s means scores were higher than those of the stages group. Significant difference was found in the functions for which high level thinking skills are required, such as choosing a solution, argument for decision making (choosing the solution) etc.

**Figure 2**: Comparison between the two groups in the quality of the design functions in the students’ portfolios after the instructional process – post test
3. **Comparison between groups by the frequencies of the design functions usage**

In order to compare the quality of the process we examine the frequencies of the functions used by the students (Table 3, Figure 3).

**Table 3:** Comparing the two groups by the frequencies of use of the design functions during the instructional process (percentage)

<table>
<thead>
<tr>
<th>No. of functions</th>
<th>Stages group</th>
<th>Functions group</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>6</td>
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<tr>
<td>7</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

**Figure 3:** Comparing the two groups by the frequencies of the functions implemented during the instructional process (percentage)
In the stages group 65% of the students used 2-6 functions and 35% used 7-8 functions while in the functions group 78% from the students used 7-10 functions (some of the students used some functions more than once).

**Discussion**

The study reported here is part of a larger research project aimed to examine the relationship between alternative approaches towards design teaching (structural or functional), and the students’ mental modeling of the design process, the quality of their design process, the students’ perceptions of the design process and the quality of their solutions to design tasks. In this report we present preliminary results focusing on the quality of students’ design process along several points in time during and after the learning process. Based on this preliminary analysis of the results, we have identified the following trends:

1. There were differences between the two groups in the quality of the process during the instruction and when they had to solve a new problem in the post-test.
2. The functions group had higher mean scores in most of the criteria examined, especially in those related to high thinking skills both during the instructional process and in new assignment.
3. The Function group had higher scores in criteria: Investigations – how many times? connections between the investigation and the problem; gathering ideas; argument for decision-making; drawings’ detail; choosing a solution; drawing as a thinking process; and details planning.
4. The functions group used more functions while solving the problems than the stages group.
5. In every lesson, while choosing the functions they want to focus on, the functions group students appeared to hold the whole picture of the design process.

The results of the whole study are currently being analyzed. At its end, we expect to unveil the underlying cognitive processes characterizing the generation of design solutions in both groups, as well as the way these solutions were affected by the alternative approaches towards design instruction.

Note: The reported work is part of the first author’s PhD dissertation in Tel-Aviv University’s School of Education, under the second author’s supervision.

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PATT 13

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Art and Science of Design and Technology Education: The University of Botswana experience

Dr R. D. Dingalo, Industrial Design and Technology Department, University of Botswana, Botswana
Mr R. Moalosi, Industrial Design and Technology Department, University of Botswana, Botswana
Email: dingalor@mopipi.ub.bw
Email: moalosi@mopipi.ub.bw
Abstract

Design and Technology is a multi-disciplinary and multi-dimensional subject. Its main goal is to impart skills, knowledge as well as creation of artifacts. In pursuit of these, Design and Technology draws from other subjects in the curriculum. This paper analyses the contribution other subjects add value to Design and Technology, most notably art, science and technology. The paper will be supported from material covering a General Education Course (GEC 258) entitled Art and Science of Design. Our thesis is that Art, Science and Technology play a meaningful role in enhancing Design and Technology. We will then discuss how the new University of Botswana admissions procedures brought about by semesterisation will impact on Design and Technology students basing on the secondary school curriculum.

Key words: Art, Science and Technology Education

Introduction

In 2002, the University of Botswana (UB) adopted a new semesterised system, moving from year long to semester-based courses. The Department of Industrial Design and Technology, which offered the degree of Bachelor of Education (Design and Technology) undertook a review of their programme, and came up with a Bachelor of Design (Design and Technology Education) degree. The latter is more science and technology based. Semesterisation has further brought flexibility in the curriculum whereby students can now, apart from core courses, choose from a pool such as electives, general education and optional courses. These array of options are meant to broaden students understanding of broader issues not necessarily tied to their area of specialisation. One of the courses which we encourage Design and Technology students to opt for is General Education Course (GEC) 258 entitled Art and Science of Design. The course attempts to locate and broaden Design and Technology thinking within the context of Art and Science of Design.

Programme Review

In reviewing the Design and Technology programme, stakeholders were consulted and some of the shortcomings identified included the following as alluded to by Moalosi (2001) that the B.Ed. (Design and Technology) programme was too practical and craft-orientated, lacking in technological depth. It did not develop a strong technology knowledge or competence. This in turn negatively affected the confidence of teachers in teaching technology in schools to any depth. It was more of training doers than thinkers, which was an unhealthy situation especially for people who would be teachers.

Students enrolling into UB especially for science, engineering and technology had a problem of applying the science they learnt from ‘O’level. This meant that students who intended studying for such courses would first enrol with the Faculty of Science to do Bachelor of Science year 1 to upgrade them to ‘A’ level standard before they can opt for any of these careers. This arrangement is going to disadvantage those students who intend studying Design and Technology, as this would be elaborated further in this presentation.

It is anticipated that the new programme (Bachelor of Design – Design & Technology Education) should be able to integrate science, engineering, design, technology and education of which the old programme failed to do. Graduates from this programme are going to be teachers and they need to be conversant in all these areas as they will in turn guide students in some of the career options available in these areas. This is in line with the national vision 2016 which states that, ‘Botswana will need to develop a system of education that is able to adapt to the changing needs of the country as the world around us changes. If Botswana is to transform itself into an industrial and information led society, then it is essential that it must set the highest possible standards for vocational and technical training as well as academic excellence’. (1996:28)

Furthermore, vision 2016 advocates that, ‘all Batswana must have the opportunity for a continued and universal education, with option after O’level to take up vocational and technical training as an alternative to purely academic study’. (Opicit)

Design & Technology is the best-suited subject in the secondary curriculum, which can make this national vision objective a reality, and it is important that the revised programme take these objectives on board.
The relationship between Art, Science, and Design and Technology

Design and Technology’s main goal is to impart skills, knowledge as well as creation of physical artefacts. On the other hand, art focuses on looking at pictures rather than reading. Art schools have not been centres of reading or theory building. It is important to note that design comes from the art and craft tradition. Reading and research has not been prized in the art and craft tradition. The tradition of research, writing and professional dialogue on which scientific progress depends on has been for the most part absent. Some artist’s claim that real artists do not use words, rather they use their hands to make things that will speak for themselves and for their makers.

Outstanding artefacts do speak for themselves and for their makers. Nevertheless, artefacts do not articulate or clarify the design process. This is where the distinction between Art and Design and Technology is found. The key difference between Design and Technology and Art is not in the crafting of the beauty or the aesthetic quality of the artefact; these might be the same and it is a question of the process. The design process begins above all with inquiry. Bernsen (1986) described design as translating a purpose into a physical form or tool. According to the Britannica Online, Art is “the use of skill and imagination in the creation of aesthetic objects, environments, or experiences that can be shared with others”, which also forms the basis of design.

Design underpins both visual and graphic thinking in that it is first organised by thinking of solving a problem. In itself, and from a humanistic point of view, design is made up of elements of everyday activity which we do either knowingly or unknowingly. In solving everyday practical problems, we discriminate and make choices and decisions about what we encounter. This discrimination of choice is what we might term low level, because in most cases people are not aware that they are making design choices. High-level design then is when people consciously make choices, are ‘head on’ in design, that is the professional designer, whom we want to produce through our B. Des (Design and Technology) degree. The conscious making of choice employs Art, as defined above, and Science and Technology. In defining ‘technology’ I will adopt the definition by Pass (1986) who maintains that technology is the process by which man adapts his environment to his own ends and the establishment of available techniques and procedures. The establishment of available techniques and procedures calls for the application of science.

In Design and Technology, the problem comes first but in the artistic approach, it is often a solution looking for a problem waiting to be settled on an unsuspecting client. Bernsen (1986) argues that unless the process is a conscious problem solving process, it is not design.

A good design process must embrace the aesthetic especially graphical communication (drawn from art) as well as the scientific. In Design and Technology, the central difference is that one does not start with the look and feel, but rather with the parameters of the problem. The look, feel, tone and flavour (artistic qualities) emerge in the solution phase once the parameters of the problem establish the basic requirements of a solution. Currently, some Design and Technology curriculum are too craft oriented e.g. the phased out B.Ed. (Design and Technology) programme which was offered by the UB. Students need to use scientific methods and an articulated problem solving process. Friedman (1997) laments that, science and scientific methods involve a rich relation between theory and practice, between conceptualisation of the world and the world itself, between tacit understanding and the ability to articulate tacit understanding as conscious knowledge. This conscious knowledge is science, i.e. the understanding of how things are and how they work based on fundamental principles.

To understand how things are and how they work in a scientific way requires a foundation in the act of critical inquiry. The scientific enterprise begins when students move beyond the act of transmitting what others have said and explore for themselves what is true and what is not. This, in fact, is how science began. Design and Technology, which has inclination to science, require the art of doing and knowing. This would enable students to move from the rule of thumb based on trial and error to instruction based on scientific method. Obviously, this imparts skills ranging from critical thinking, research and planning at one end of the process to physical manufacture, assembly, packing and presentations at the other. Now, students are facing a transition from an education in crafting things to an education in understanding things. Students are now faced with the distinction between doing things right and doing the right things. Doing the right things requires a decision on what to do and this requires a design decision prior to technical
facilitation. The B.Des programme goal is to have a marriage between scientific method and practical outcomes.

The relationship between design and technology is invisible that is, it cannot be drawn. Technology helps us in transforming what has been designed in paper into practical outcomes. Technological developments have improved outputs and productivity. E.g. rather than one setting a drawing board, paper etc. all these can now be done in CAD within a few minutes. When students design, they need to know the technology, which is available, which can help them realise their design. For example, rather than cutting sheet metal using tin snipes, why not use a guillotine, which would cut the sheet much faster and more accurately.

Contrary, technology is associated with certain problems and it must not be seen as a panacea to all our problems. The use of technology requires student designers to be responsible for their actions. Early measures need to be put in place to control and manage it to get the best from it. Proper control and responsible attitudes could be the hope for the future and a way of life for the coming generation.

In all, Friedman (1997) said, the more comprehensively designers understand fundamental principles, the more effectively they will further the competitive goals for which they are responsible. A scientific approach to design is more likely to be successful than any other approach. If student’s designers are to approach their work as design science, art and technology, they require the background that permits them to understand complexity. This means a broad education based on problem solving and pattern building rather than a narrow education based on repetition, exercise and imitative patterning.

The newly established and enrolment procedures adopted for the B.Des (Design and Technology Education) degree is however hampered by secondary school’s grouping of curriculum subjects. In the local Botswana General Certificate of Secondary Education, there are three core subjects [Setswana, English and Mathematics], and 4 optional subject groups: Humanities and Social Sciences, Sciences, Creative, Technical and Vocational, and Enrichment subjects (see Table 1.1). Students’ minimum of 8 subjects has to include at least one from each of the first three of these groups.
Table 1.1  Grouping of curriculum subjects

<table>
<thead>
<tr>
<th>CORE GROUP</th>
<th>OPTIONAL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities and Social Sciences</td>
<td>Sciences</td>
</tr>
<tr>
<td>English</td>
<td>History</td>
</tr>
<tr>
<td>Setswana</td>
<td>Geography</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Social Studies</td>
</tr>
<tr>
<td>Development Studies</td>
<td></td>
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<tr>
<td>Literature in English</td>
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</table>

Triple science students take Physics, Chemistry and Biology as single full subjects, one subject from the Humanities/Social Science group, and at least one from the Creative, Technical and Vocational. Additional Mathematics is an option for this group. Double science students take somewhat reduced courses in Physics, Chemistry and Biology, one subject from the Humanities/Social Science group and a minimum of two from the Creative, Technical and Vocational group. The single science group take science as a single subject and choose one subject from the Humanities/Social science group and two subjects from the Creative, Technical and Vocational group. The Creative, Technical and Vocational option bracket is interesting for us because it is likely to constrain triple science students who generally can choose only one subject in this category. Indeed, in senior secondary schools, most students who are studying Design and Technology are those who are in the Combined Sciences bracket.

Moalosi (1999) laments that in schools, practical subjects were generally aimed at those students who were intellectually not performing well. The Education for Kagisano (1977) also acknowledged that, ‘practical subjects were relegated to a position of least choice’. Some school heads still hold this misconception that if a student is academically weak, he/she may perform well in practical subjects. The grouping of classes is done in such a way that all students doing the single sciences would opt for Additional Mathematics as their practical subject while those doing combined sciences can either opt for Design and Technology, Art, Home Economics or Agriculture.

This means that UB would end up absorbing students who have no Design & Technology grounding into BSC year 1 and ultimately who would end up studying Design & Technology for the first time at degree level. The majority of students who have studied Design and Technology at secondary school level have no
chance at pursuing Design and Technology as a career option. This is an abnormal situation, which need to be addressed as soon as possible. The message this department is sending out to students in secondary schools right now is that studying Design & Technology is not necessary if one intend enrolling into UB to study the same. This translates that Science is more important than Design & Technology to gain entrance into UB. The question remains, why study Design and Technology at secondary school level?

Conclusion
The Industrial Design and Technology Department need to seriously revisit its admission criteria. This should be reflective of the importance of Art, Science and Technology in enhancing Design and Technology. Whilst it would, to some extent, be advantageous to recruit students with a high degree of scientific knowledge, the Department should also take into cognisance that Art, Design and Technology and other Technology subjects are as equally important. Rather than first year students going through BSc year 1 in the Faculty of Science, why can they not be taught the relevant science within the department in year 1? This would bring those who did the triple sciences and combined sciences on the same platform. Obviously, this would be a carrot for those studying Design & Technology at secondary schools level to be motivated in pursuing design related careers.

References
Technical Education within Scotland’s Technology Curriculum: A Review of Structure, Policy and Stakeholder Perceptions

Brian Canavan, University of Glasgow, Scotland
Robert Doherty, University of Glasgow, Scotland
Email: b.canavan@elec.gla.ac.uk
Email rdoherty@educ.gla.ac.uk

Abstract

The rapidly changing technological environment in which we live necessitates a constant review and development of Technology Education curricula worldwide. This paper intends to explore the sometimes-reactionary approach to technology curriculum development within the context of the Scottish education system. We discuss aspects of the evolution of the Scottish curriculum towards its present structure and identify influences on this process. Through a stakeholder analysis of Technical Education in Scotland, we engage in a mapping exercise of perceptions against influence/role, with data gained from a survey of stakeholder perceptions of the current technical education curriculum. We conclude by attempting to identify key issues facing technical education at this present juncture.

Introduction

Technology education is firmly established across all stages of Scotland’s curriculum. All technology courses located within the guidance of the national curricular frameworks are linked together conceptually through the overarching concept of, ‘technological capability.’ Technological capability is defined as, ‘…understanding appropriate concepts and processes; the ability to apply knowledge and skills by thinking and acting confidently, imaginatively, creatively and with sensitivity; the ability to evaluate technological activities, artefacts and systems critically and constructively’ (SCCC, 1996).

Technical education within the structure of the Scottish secondary school curriculum provides the majority of courses that allow pupils to develop technological capability. It should however be noted that the secondary curriculum makes explicit recognition of the contribution of other courses to technological capability, and allows pupils a progression route out with Technical education. This paper will focus primarily on the contribution to Technology education made by the Technical education stable of courses.

Within official curriculum texts and inside organisations such as the Scottish Qualifications Authority (SQA) and Learning and Teaching Scotland (LTS), there is a more or less consistent use of ‘Technical education’ in referring to the courses taught within Technical departments. The term, ‘Technology education’ is reserved for the development of technological capability across all sectors and stages of the curriculum. Departments within secondary schools that offer Technical education, however, present themselves under a range of titles including; Technical education department, Technology department, Design and Technology department, Design engineering and Technology department. Historically teachers of Technical education qualified with a diploma in Technical education; when such programmes converted to degree status, they were given such names as Bachelor of Technology Education, Bachelor of Education (Technology) and Bachelor of Education (Design and Technology).
The late 70s and 80s witnessed an important period of curriculum modernisation for Technical education. In common with other education systems, there was a move beyond traditionally craft focused courses to a more contemporary curriculum under the new banner of Technology. Discrete study of metalworking and woodworking merged and evolved into working with combined materials (Integrated Craft). The efforts of a movement of individuals and organisations advocating Design education (Design Council, 1980) led ultimately to integrated craft developing into Craft and Design. Antecedent courses in Engineering and Building Drawing developed into Graphic Communication and included the introduction of CAD, CAG, illustration and presentation. Arguably the most radical curricular reform to Technical education can be seen in the introduction of Technological Studies. This modernising turn produced a new course distinctive from its forerunners Applied Mechanics and Engineering Science, both historically being marginal courses within Technical education. An emphasis on project work, resource based learning and use of technology in problem solving, all combined to characterise the contemporary nature of this development. The embracing of this new curriculum was seen as an important factor by sections of the field of practice, and other supporters of technical education, in the process of raising the status and esteem of both teachers and the standing of technical education within the wider curriculum.

The form of Technology education present in Scotland’s official and observable curricula is a result of its historical evolution through the national processes of educational policy development. In attempting to chart its present form it would seem appropriate to turn our attention to the policy making processes surrounding Technical education. Within the scope of this paper we endeavour to outline something of the structures and the stakeholders who exercise control, influence and hold legal authority within the Scottish system and offer some initial comment on present arrangements. In conceptualising the policy process we make use of the insightful framework developed by Bowe, Ball and Gold (1992). Bowe and his colleagues suggest three contexts for policy production, organising the contexts in terms of:

- The context of influence,
- The context of policy publication,
- The context of practice.

The mapping of national policy to stakeholders is important in understanding the present form of Technical education. More importantly it also serves to locate sources of new thinking, innovation and change as well as the sites of conflict and a whole array of priorities and vested interests belonging to established stakeholder groups. It is important to note that each context can, and does, communicate, exert influence and gain access to others, but each level represents a distinctive set of activities within the policy process with differentiated influence deriving from legal authority and structural position. Our initial research into the policy making process of Technical education highlighted a number of factors that emerged as significant in the process.

Awareness raising among, and gaining the attention of, politicians and key civil servants at governmental level throughout the Scottish Executive Education Department (SEED), is an important component of influence in attempting to highlight issues for reform or change. The channels of access both formal, and perhaps more importantly informal, are key dimensions of this context. The extent to which individuals, advisors and favoured organisations and networks have the opportunity to exert influence, set agendas or climate build is an important facet in understanding policy initiation and formation at this level. There are a number of NGOs and government agencies that dominate the context of policy publication and crucially, span the boundaries into the contexts of influence and practice. Significant here are the SQA, LTS and Her Majesties Inspectorate of Education (HMIE).

By virtue of its structural position rather than design, the SQA casts a long shadow through its management and control of national assessment. It has become a key player in developing and reviewing courses in Technical education and exerts a very significant influence on curriculum reform through its officers, working groups, panels and network of advisors and practitioners who work for it on a part-time basis. The role of practitioners is another interesting aspect of this context. Individual teachers can make representations to sites within the context of influence and production, as can their professional body the Technology Teacher Association (TTA). Key sets of practitioners could be described as ‘gatekeepers’. Gatekeepers may work for the SQA or TLS and sometimes both organisations; they are able to exert...
influence because of this position and also have the opportunity to influence other practitioners through the perception of their role as an ‘insider’ within the process.

In supporting implementation, attainment and teaching within national curricula guidelines and national courses, LTS is another organisation well positioned to influence reform, as well as current practice. The role of HMIE in the Scottish system was changed by national government in 2000. Until then this arm of government had provided both policy advice and quality assurance functions within education, after 2000 its policy function was officially removed. HMIEs are still, however, important players in policy reform. Through their role as ‘observers’ on any significant committees and working groups within SQA or LTS, and as advisors to government departments, positions them to exert significant influence. It has emerged during interviews with representatives from SQA, LTS and HMIE that each regarded government (the Scottish Executive) as being more accessible in Scotland’s post-devolutionary environment than previously when working with the Scottish Office as a department of the London based Westminster Government.

**Stakeholder Perceptions**
The methodological approach to the research was intended to ensure that as many stakeholder groups as possible provided an input to the study. The following stakeholder groups were identified as key contributors to the setting of policy as well as curriculum development:

1. HMIE – Her Majesty’s Inspectorate of Education
2. LTS – Learning and Teaching Scotland
3. Local authority subject advisers
4. Technology Teachers Association
5. Practising Technical teachers

Since a key area of investigation was to be teachers’ perceptions, an on-line questionnaire was developed. This enabled a flexible approach to the completion of the questionnaire and assisted in promotion of the questionnaire through groups such as the Technology Teachers Association and local authority advisers. All responses to the survey were anonymous.

In addition to the main survey, a number of stakeholder interviews were carried out with representatives from HMIE, SQA, LTS and a local authority subject adviser. The subsequent data were analysed through quantitative and qualitative means in order to explore any relationships within the data.

**Practitioner Perceptions**
In order to investigate the perceptions of teachers, a questionnaire survey was carried out. The questionnaire was intended to elicit perception data on the present position of Technical education and its constituent subjects as well as their future. The sample for the survey consisted of 30 practising teachers of Technical education from 14 different individual teaching authorities in Scotland. The sample also included teachers at a variety of stages in their careers.

The significant correlation (0.008) between teachers preferred choice of subject title and length of service in the profession indicates an uneasy relationship with the term Technology among longer-serving practitioners (Table 1).
**Bi-variate Analysis of Length of Service in Teaching and Subject Title Preference**

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>How long have you been teaching?</th>
<th>Correlation Coefficient</th>
<th>I prefer the term 'Technical' teacher to 'Technology' teacher.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>1.000</td>
<td>.476**</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>30</td>
<td>.008</td>
</tr>
<tr>
<td>I prefer the term 'Technical' teacher to 'Technology' teacher.</td>
<td>Correlation Coefficient</td>
<td>0.476**</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.008</td>
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<td>N</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

**Correlation is significant at the .01 level (2-tailed).**

**Table 1**

The redirection of the curriculum from craft-orientated subjects such as woodwork and metalwork towards a technology and design-based curriculum is exemplified in the development of Craft and Design. The restructuring towards a subject which offered a more diverse learning experience over its skills-based predecessors may however have failed to gain acceptance among many practising teachers. Tables 2 and 3 highlight the disparity of perception with regards to teachers’ confidence and enjoyment in teaching the design component of Craft and Design and their length of service. Under bivariate analysis, it can be seen that there is a highly significant (0.003 and 0.011 respectively) negative correlation between teachers’ length in service and their level of confidence and enjoyment in teaching design. This may indicate disaffection with the direction of the curriculum among long serving staff members. It may also indicate a lack of support on the design element of the course offered to teachers who trained under the craft-based curriculum of the 1960s and 70s.

**Bi-variate Analysis of Length of Service in Teaching and Confidence in Teaching Design**

<table>
<thead>
<tr>
<th>Spearman’s rho</th>
<th>How long have you been teaching?</th>
<th>Correlation Coefficient</th>
<th>I am confident in my ability to teach design effectively.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>1.000</td>
<td>-.528**</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>30</td>
<td>.003</td>
</tr>
<tr>
<td>I am confident in my ability to teach design effectively.</td>
<td>Correlation Coefficient</td>
<td>-.528**</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.003</td>
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<td></td>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

**Correlation is significant at the .01 level (2-tailed).**

**Table 2**
Bi-variate Analysis of Length of Service in Teaching and Enjoyment in Teaching Design

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>How long have you been teaching?</th>
<th>Correlation Coefficient</th>
<th>How long have you been teaching?</th>
<th>I enjoy teaching design.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>How long have you been teaching?</td>
<td>Correlation Coefficient</td>
<td>How long have you been teaching?</td>
<td>I enjoy teaching design.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.1000</td>
<td>-.459*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Correlation Coefficient</td>
<td>-.459*</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.011</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

* Correlation is significant at the .05 level (2-tailed).

Table 3

A further analysis of length of service and teachers’ perceptions of the changes made to the curriculum through the introduction of Higher Still, demonstrates the consistent unease, with which longer-serving members of staff view the direction of curriculum change. The data shows a significant negative correlation (0.017) between respondents’ length in service and their perceptions of Craft and Design under Higher Still. The disparity of perception is equally translated to Technological Studies. Whilst some individual schools and local authorities still offer this subject, many have opted to drop Technological Studies through a stated lack of uptake or as a means of rationalising the curriculum offered by Technical departments.

Reasons for the Decline in Technological Studies (Sample size – 28)

Table 4

From Table 4, it can be seen that respondents perceive subject esteem and status issues as being predominant factors in the decline of the subject. Direct competition with Physics (29%), which is often regarded as a more suitable qualification for entrance to higher education (Canavan & Doughty, 1998, Barlex, 2002), coupled with low status among school management teams and guidance staff (29%) are cited are major contributors to this decline. Significantly, 25% of respondents highlighted a lack of ability on the part of pupils as the predominant factor in the decline of the subject. Again, from the data it emerged that there is a conflict in perception between longer-serving teachers and their colleagues a significant correlation was detected between length in service and the perception of Technological Studies being too difficult for pupils.

The survey also sought to explore teachers’ perceptions of the discrete, subject-based nature of the Scottish Technical education curriculum. When asked whether they would prefer to teach a more integrated curriculum, similar to the National Curriculum (England, Wales and Northern Ireland), a majority of
respondents indicate a preference for the discrete approach to Technical subjects offered at present in Scotland, a significant percentage would like to see a change towards a more integrated curriculum. A bivariate analysis of this response, against length in service, indicated a significant correlation between the two (0.013).

The picture of long-serving teachers who wish to turn the curriculum clock back is however less apparent when considering the return to more vocational courses, which are aimed at modern apprenticeships, an idea in vogue among some policy makers. The data set clearly indicates a strong reluctance among long-serving staff to undertake a restructuring of Technical Education along purely vocational lines.

Finally, respondents were asked to consider the best and worst aspects of teaching Technical subjects. Interestingly, when we consider the negative perception of change indicated within the earlier discussion in this paper, respondents highlighted the changing nature of technology alongside subject variety as important to them in teaching Technical education. Low subject esteem was again strongly highlighted as being the worst aspect of teaching Technical education.

Discussion
The flexible use of the notion of technology within educational thinking to describe an array of concepts and subject areas can manifest itself through instances of practitioner confidence or disillusionment with change. The constantly changing skills and knowledge set required to be able to deliver courses effectively, against a backdrop of changing technological demands, and the impact of ideological projects on the curriculum, creates an educational environment where burn-out would appear to be common place. This is clearly evidenced in teachers’ perceptions of Technology education in its present form and their concerns regarding its future direction.

Since the longest serving members of staff are often departmental heads, this could raise concern in some instances over the potential for departmental stagnation. The survey of practitioners also highlights the potential role of new teachers in driving departmental policy with regards to the curriculum in tandem with more experienced members of staff.

The question of identity with respect to the Technical/Technology relationship in the self-understanding of practitioners and the relationship between the Technical and Technology curriculum is a source of tension within the Scottish system. This is an issue that suggests the need for further work to resolve such tensions and promote coherence, and balance across the technology curriculum.

Growth of options within the middle school curriculum as an unintended outcome of reforms to the post-16 curriculum has resulted in an increase in the range of courses (from 3 to 7) from which schools can construct their curriculum. This has brought into focus arguments over diversity, balance and entitlement. One area, for example, that could be threatened by this situation is design education.

The content and quality of Technical education in the first two years of secondary is varied and disparate, and has been identified as an area of development by LTS in order to conform more appropriately with the 5-14 Environmental Studies guidelines.

What we could call technical or technology champions was an issue that emerged form our interview data. By this we mean the presence or absence of officers in key policymaking and coordination positions that have a deep understanding and supportive disposition towards this curricular area. Such officers can see opportunities within the politics of curriculum development and additional streams of financial support that can be harnessed. Policy officers and curricular managers come from a variety of backgrounds, not necessarily being subject specialists, and understandably when responsible for a portfolio of curricular areas can be oriented to solving the problems that are attracting the most attention. Such officers can also be dependent on the quality of advice they receive.

Our interest in the policy processes of technology education in Scotland was driven in the main by a desire to understand something of the sources of influence and the main contributors to the intellectual climate...
that informs curricular change. This initial mapping of the policy process and policy actors would suggest that there is a lack of space or a locus within the policy-making process for foresight, strategic or blue sky thinking. As Scotland enters the 21st century we conclude that there is much to be done to progress technology education to a position from which our young people will drive the fullest benefit, the issues above would seem to serve well in starting to mark-out a future research agenda.

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Introduction
This paper results from a Doctoral thesis, realised in the Production Engineering Post Graduate Program of UFSC - Universidade Federal de Santa Catarina – Brazil, in 2002. It investigated the pedagogical potential of design activities to teach and to learn in our primary schools. International experiences were studied, among them, D&T in England and Wales and Environmental Studies in Scotland. The main aim of the work was to create and to develop a Brazilian educational model, in which design activities would be used to teach children. The emphasis of work was on Design and its activities in the classroom.

The proposal was called ‘EdaDe – Educação através do Design’ [Education through Design]. Any model developed should consider the Brazilian educational reality. It should respect our social and cultural characters, our educational tradition and laws, and finally, our social context.

Studying international experiences, it was possible to understand that EdaDe can be put in practice, formally in curricula, as a subject, as a cross curricular theme or as an area of knowledge. Non formally, it can be put into practice as a complementary program or as a group of extra curricular activities. Further still it can be undertaken informally, as isolated events.

The models
We tried to identify and to build a taxonomy of experiences in the primary design and technology education. In a first approach we identified three basic types of experiences that we denominated: formal experiences, non formal experiences and informal experiences. Below we outline some formal and non formal ways to insert the EdaDe in education:

Illustration 01 – The possible ways to insert EdaDe in education.
In model A, EdaDe is presented as a ‘subject’ among others in the curriculum. This model represents an educational organisation based on disciplines. Each one has very well defined and delimited educational content. In this case, EdaDe should have specific programme content for each key stage, well defined aims and objectives and an evaluation system established. In this way, Design and its activities will be part of a traditional system of teaching. In our research, we could not find any pure example of this model put in practice. We found some examples in which Technology – normally associated with Science – appears as a curricular subject – e.g. in Chile, Argentina and Portugal.

In a different way than Technology, it seems there is always an interdisciplinary connotation behind design activities. Perhaps this is due to the nature of design. We agreed with Bruce Archer (Archer et al., 1992) and understand design as ‘thinking’ (envisaging what) and technology as ‘doing’ (knowing how). Design and technology are two sides of a single problem. Unfortunately, sometimes design appears as a simple element of technology education, or as content in programs like this.

In model B, EdaDe appears as a curricular subject, but in this case the curriculum is conceived as an interdisciplinary structure in which subjects interact with each other. We think the English NC is a good example. D&T and Art and Design are formal subjects in the curriculum. At several points, intentional connections are promoted among knowledge of each curricular subjects (links to other subjects).

In model C, EdaDe appears as a cross curricular theme. It integrates some of the content from curricular subjects or areas of knowledge. The use of areas of knowledge is recommended by some educational systems – e.g. Spanish National Curriculum - as well as the new Brazilian educational guidelines. These guidelines are called PCNs – Parâmetros Curriculares Nacionais [National Curricular Parameters].

The cross curricular themes, defined by PCNs, attempt to promote and to prioritise integration of social issues and are oriented to increase citizenship and democracy. The suggested themes are Ethics, Environment, Cultural Plurality, Health and Sexual Education. The criteria adopted to choose those themes were ‘social urgency’, the ‘promotion of national inclusion’, the ‘possibility of application in primary schools’, and the ‘facilitation of the understanding about reality and of the social participation’. We must
remember that the Brazilian Curriculum still has a disciplinary structure complemented by those cross curricular themes. The interdisciplinary attitude is just recommended. In this conception the traditional subjects and theirs content are organised in a longitudinal axis. Around this axis, there are themes linked to the day-to-day society.

A second way to work with cross curricular themes, much more radical, was proposed by Moreno (Busquets et al., 2000). From this viewpoint, the old obligatory subjects, aren’t more ‘ends’. They are considered ‘ways’ to reach other ‘ends’. If applying cross curricular themes was already a challenge to educators, this second way, is an even greater challenge. It demands an institutional pedagogic reform and a specific teacher training.

In model D, EdaDe appears as a knowledge area integrated to the other areas of curriculum. In this case, we don’t know where a subject begins and where another ends. The idea of subject disappears and the contents integrate an holistic viewpoint. Although utopian, it seems the ideal way to promote a significant education. The practice of this proposal is almost impossible because it demands an educational training that few teachers have and an extremely flexible administrative structure that few schools have.

In our primary schools, from grades 1 through 4, the pupils have only one teacher in the classroom. In these initial stage, the approach to the model D is a little bit easier. Such ‘interdisciplinarity’ is much more an educational attitude than something imposed by the system. The interdisciplinary awareness and training of teachers is really critical for EdaDe.

In model E, EdaDe appears as a complementary program made by a series of extra-curricular activities, systematised, created and developed so that it allows the integration of content of every subjects or knowledge areas in the curriculum. We think this is the case with some good programs organised by museums – e.g. Why Design? of the National Build Museum in Washington, the programs organised by Design Museum in London –, by entities like the Nuffield Foundation and others by professional associations like the British Design Council.

There is a further possibility. We can develop complementary design activities – model F – out of curricular limits. Those activities don’t directly interact with the contents or with subject programs. This is the case of some projects such as ‘Thinking things through things’ of the London Science Museum. These projects are very interesting for EdaDe because they develop skills and collaboration to understand material culture, design, technology, science, art and manifestations of them. However, they are casual and sporadic. In them, children and young people are involved and motivated through interactive and oriented activities. Projects like these can be used and explored by teachers as auxiliary resources to active teaching, but they will be always complementary. We called these informal experiences.

The more viable models
The most promising models, under the pedagogic conception and criteria adopted in our research, are B, C, D, E and F.

Model A, in spite of its viability, goes against everything that we believe and it opposes our pedagogic positioning. We believe that the rigid structure of subjects should be reviewed in our schools. A more unified vision should prevail in our children's education.

If Design or EdaDe were adopted as a simple subject, it can be reduced to a group of contents and procedures that, instead of integrating, could fragment still more the knowledge in school. We know that this depends on the teacher’s attitudes but, many other things depend on the curriculum structure and on the philosophy and polices adopted by the educational system and the school.

Our National Educational Law, called LDB – Lei de Diretrizes e Bases da Educação, determines that we must have a National Common Basis, but this basis must be complemented with a Diversified Part. The Diversified Part must be established and administrated by the State and Municipal Governments. And then, EdaDe can be a subject in it and it must respect, besides the determinations of LDB, the State and
Municipal educational legislation. In this case, it will be a little bit easier to implant EdaDe, but it’s inclusion would be more restricted.

EdaDe could also be a new ‘curricular area’ – or ‘knowledge area’ – in the National Common Basis but, in this case it would demand a change in LDB. To do this, we would need: a great national political mobilisation; a deep debate in the educational field; the involvement of a great number of teachers and educators committed to the theme; the planning and creation of a lot of teacher training programs among other essential and necessary actions. It seems possible and viable but only in long or medium term.

Actually, EdaDe as a ‘curricular area’ would be a large field of knowledge and it would demand a very good teacher training. During our research we could identify the educational training as essential in this process. It must be remembered that EdaDe requires specific knowledge and educational competence. It demands the teacher's dedication and time for planning its activities. It is destined to everybody, independent of the gender, culture, race, religion, and social class. It is a dynamic knowledge area. It maintains connections with other subjects and curricular areas. It requires time for its practices. It results in constructions of three-dimensional objects and then, it needs appropriate spaces for storing and exhibiting it’s results. It involves safety and teacher’s supervision during its practices. It requires frequent interventions by the teacher, interactions, demonstrations and inquiry. Finally, it demands resources – money, investments etc.

Certainly, EdaDe would complement and it would be complemented by knowledge and skills developed in other subjects or curricular areas.

Another possibility is to integrate EdaDe as a part, a topic or an issue in the role of content of other subject. So, we believe that there will be a reduction, still larger, of the pedagogic potential of EdaDe.

EdaDe and it’s activities could contribute to apply the Cross Curricular Themes – model C – because, among it’s aims is citizenship education. When it works with material culture, it prepares children for critical and conscious consuming. EdaDe isn’t vocational but establishes relations with professional activities and indirectly it prepares the young citizen to world of work.

On the other hand, EdaDe should be another Cross Curricular Theme in Brazilian schools Paying attention to the criteria established by the PCNs. In other words, it prepares the young citizen to work with our material culture, to preserve it and to make it better. As designers, we know that every intervention in material culture, promotes direct impacts in people’s quality of life. ‘Design is one of the basic characteristics of what it is to be human, and an essential determinant of the quality of human life’ (HESKETT, 2002, p.4). Then, EdaDe, while it uses the design tools and values, represents an issue of ‘social urgency’ – the first enunciated condition to be a Cross Curricular Theme.

Material culture isn’t a regional theme, all Brazilians must have conditions – economic, social and cultural conditions – to access the essential material goods. Everyone should know how to form values and establish criteria to use the services and to consume these material goods. We think EdaDe should “promote the national inclusion” – the second condition.

EdaDe’s practices could be appropriate to teach and learn in primary schools as well in secondary schools. It creates favourable conditions to teach, to learn and to integrate contents of several curricular areas – the third condition.

EdaDe facilitates the understanding of reality and promotes the social participation – fourth condition – because when children and young people are involved with design activities, they can understand the implications and can measure the impacts of technology and design in society, environment and their material culture.

Model D, as already mentioned, is quite promising and also viable but, it’s implementation would be only possible in medium term. It demands the inclusion of subjects about EdaDe in the curricula of education undergraduate courses, the promotion of emergency training courses for teachers, INSET courses and
courses of specialisation for teachers – this is a modality of academic graduate in Brazil. It must be remembered that many teachers still don’t have high education diploma and a lot of times, they don’t have time and conditions to get a professional update. These facts represent difficulties to improve any program of pedagogic innovation.

Our option, it is really an option, because there are several potentially good choices that deserve deepening, was to work with complementary and non formal programs, particularly, with the model E. We understood that this option is a initial step viable in a short term. We believe that this choice will establish a theoretical basis that will allow, in the future, to make possible the necessary teaching training and the progressive inclusion of EdaDe in our primary schools.

It must be mentioned that model F is viable too. It can promote the EdaDe without commitments, plans of contents or specific subjects. The EdaDe out of curricular limits does not depend on systematised actions and it should not be linked with schools or any educational system. But, as an informal program, it can be a very good coadjutant resource for formal and non formal EdaDe programs.

Besides these inclusion possibilities, the EdaDe can be used as a didactic resource or a method to teach. This way, the EdaDe isn’t conceived as a model and it has more likeness with proposals that use projects as a method – e.g. the project method of William H. Kilpatrick. This alternative is also valid but in truth, it would be a simplification of the main aims of EdaDe.

EdaDe as a complementary program

The EdaDe as a complementary program is characterised by a group of actions and organised activities, conceived to be accomplished outside the official Curriculum. It can be classified as a non formal experience. This program yearns:

- the integration of contents of several knowledge areas of the the National Common Basis and Diversified Part of the curriculum;
- the promotion of opportunities for the children, to construct their own knowledge and understanding and the development of design abilities and making skills;
- the enlargement of children’s universe of experience through the execution of tasks and design activities;
- the necessary orientation of teachers, so that they can organise and plan design and technology activities in the school;
- the educational training for the practice of EdaDe in the school;
- the preparation, of the school staff for the full use of the EdaDe resources in the school and in the classroom;
- the offer of theoretical and practical references of EdaDe for the schools, teachers and children;
- the creation, development and offer of materials and didactic resources of EdaDe;
- the identification, selection and the planning of more appropriate design activities for the children's age groups and that are executable in the school context; and
- the approach of designers and primary schools, of teachers and children of the world of technology, art and design.

To conclude, some strategies

To make possible these objectives, the first things that we must do are to consolidate a body of theoretical and practical knowledge; establish a basis of information about EdaDe; create an academic infrastructure to promote new researches and new developments in this field; and to training teachers. It is also necessary to grow a work of public explanation about EdaDe, its aims and benefits.

We must develop some guides to the elaboration of politics for the implementation of complementary programs of EdaDe in our primary schools and we must identify some tools that facilitate the organisation and the planning of EdaDe in the school.

Under our viewpoint, the alternative more executable in a short or medium term, seems to be the establishment of a Centre that can congregate educators, teachers, designers and researchers, interested in
the promotion and in the application of EdaDe. We think this Centre must be linked with a University or a College, that maintain the offer of undergraduate courses in design and education fields.

Our work allowed us to enlarge our knowledge about children education thought design and technology. The active learning, the constructivism and the ‘interdisciplinarity’ were our educational basis.

We believed that this way, we will be contributing to the improvement of our educational system, reducing our social and cultural differences and creating opportunities for our children to interact more and more with the contemporary world.

References
Vocationalism and accountability: two threats to Design and Technology education

Professor G. Shield, Sunderland University, England.
Email: george.shield@sunderland.ac.uk

Those of us who are professionally engaged in Technology Education are frequently too closely involved in our day to day work to be able to see the broader pictures that emerge from time to time. How does 'technology' fit into the wider scene of education at the current time – how is it being viewed by other professionals and stakeholders and who are the drivers who influence our work and how?

Some time ago I published an article (Shield, 1996) in which I argued that the technology curriculum was the result of a compromise between politics, philosophy and pragmatism with the result frequently not satisfying any one constituency. Here I intend to elaborate on this and indicate how our current obsession with ‘data’ and ‘targets’ has been fuelled by the emerging trends that increasingly focus upon ‘accountability’ and ‘vocationalism’ consequently leading us away from those elements that are deemed not only to be the most valuable but possibly the only true unique component of this aspect of the school curriculum.

Views on education however are idiosyncratic can I at this stage therefore, clarify how I see the subject within general education from my English perspective and from my personal stand point. These of course, are coloured by my education, professional training and experience.

The subject as I see it has its basis in the creative act. A subject that is fashioned through, knowledge, skills, craftsmanship and the intellectual cognitive faculties that allow us to realise our vision, generally in a tangible form.

This understanding of the activity encompasses a number of valuable side products that are frequently exaggerated to meet expectations that are often driven by expediency or a political agenda. Here I include aspects such as ‘team building’, and ‘vocational training’.

The danger however is that we begin to believe our own rhetoric by emphasising these to too satisfy key agencies and in consequence fail to focus upon that which may be the most educationally beneficial about this unique experience.

Education in England, as in many other countries I imagine, is currently the focus of considerable attention by the press and politicians, being seen mainly as the key to national prosperity and to personal fulfilment through being the foundation of a successful career as well as being the answer to most of our social problems. On the down side it is thought to be highly expensive, a drain on all our pockets and inefficient, being run by a group of people who have escaped from the ‘real’ world. (Despite the well known saying ‘If you think education is expensive try ignorance’)

For example the White Paper on Higher Education published in England recently encompassed these popular perceptions with its opening statement:-
“Higher education is a great national asset. Its contribution to the economic and social well being of the nation is of vital importance” (DFES, 2003, p.10)

This increasing emphasis on the utilitarian value of Higher Education is echoed in a range of other proclamations and initiatives from our leaders. The Government of the United Kingdom is driving forward (at least in England) the establishment of a new qualification. This qualification, described as a Foundation Degree, is of two years duration, has a vocational bias and is generally taught to students who are in
employment. The programme is also often delivered by Further Education colleges who’s work is quality assured by a university on a franchise basis. This approach is thought to take the work away from the ‘ivory towers’ of the university and give it a far more vocationally worthwhile bias, by closely involving practitioners in its delivery. As well as the ‘official’ documents that emerge from our leadership current thinking is often clearer from the unofficial utterances of ministers of state and their officials. Recently our Secretary of State for Education and Skills is reported as saying (since vigorously denied) that he can see no use for the study of subjects such as Mediaeval History and we could only possibly afford to have such activities confined to one university as a form of decorative adornment of the institution. Whilst the facts of this incident may be open to dispute there is no doubt that the concept of education as being a worthwhile activity in itself no longer features in the thinking of those in authority.

As a partner to this utilitarian philosophy there is a major thrust on what counts as ‘accountability’. As a recipient of funds from the public purse, and more importantly as a contributor, I understand this need, however when the methods used result in performance indicators that are gained through what can only be deemed ‘flawed’ techniques with no form of appeal against the highly influential results it causes great disquiet. As well as often using flawed techniques the sort of data that is collected is often of the lowest level. Research output is counted in papers published, teaching quality is assessed through scrutiny of documentation, the socio economic background of your student intake is surveyed and all of this results in your financial settlement you can begin to understand the current climate within education.

There is evidence that this thinking is driving much of the work in higher education, it is also however forming the basis of current thinking within the compulsory stage. England is said to have schoolchildren who are the most tested in the world. They have national tests that result in league tables for their schools that are published, both locally and nationally, at ages 7, 11, 14, 16, 17 and 18. This can reduce schools, teachers and pupils to a state of paranoia as they await the consequences of a poor performance. There is a major groundswell emanating from the profession that this concentration on teaching to the test and only in those areas that are tested is causing serious harm to the broader education of our children.

As well as the performance of schools and universities even the Local Education Authorities receive frequent inspections and have their performance judged and the results published.

How is the second part of my thesis, i.e. that of vocationalism, applied within this compulsory sector. In the latest curriculum document to emerge from the DFES (2003), 14-19 opportunity and excellence, this utilitarian view is illustrated through the statement, that :

“……a broad and balanced education should include some work-related learning, so that young people are fully prepared for an adult life in which they will contribute to the country’s economic well-being.” (p.5)

The green paper of 2001 (DFEE, 2001) on school education talks about

“……….much greater choice of vocational based routes (p. 42) and is elaborated into:

“to test new ways of collaboration with schools, colleges, training providers and employers to provide a more coherent phase of education and to develop new programmes of vocational opportunities at key stage 4” (DFES, 2003, p.27)

I understand that elsewhere in Europe this debate may be considered eccentric and vocational education is embedded in school provision for many children (Biggar,2003), although not without question in for example Germany, (Boreham, 2002) whereas in England, in particular, it can be the source of much debate often based upon class divisions and prejudices embedded over many generations.

All of this discussion is very important to the subject of Design and Technology. We in England, and I know in many other parts of the world, are engaged in a subject that grew out of vocational training, in a large measure, and yet was always justified in schools from the earliest times as a general non-vocational activity. Generations of teachers fought over the years to gain recognition of this fact and were successful in this aim in that the subject did achieve such recognition in the early days of the national curriculum through this argument. (DFES, 1990 p.A1.)
“Design and Technology describes a way of working in which pupils investigate a need or respond to an opportunity to make or modify something. They use their knowledge and understanding to devise a method or solution, realise it practically and evaluate the product and decisions taken during the process.”

If we compare this statement that has no mention of the world of work with:-

We are committed to a modernised design and technology curriculum, which will provide pupils with skills that contribute to adult and working life, but ……………do not consider that design and technology should be a required study for all pupils” (DFES, 2003, pp.7-8)

we can see evidence of the trend mentioned earlier.

In this concern I am not alone, Kimbell voices his concern with these trends in this article written just before the curriculum guidance was published,

……………..these proposals would cement design and technology firmly into the ‘vocational’ arena of the curriculum - where some have been trying to pigeon-hole it for years. (2003 pp.3-4)

There are indications that what is being asked for is an approach to vocational education that has at its core what is perceived as a creative and problem solving approach. This understanding is fine and one with which I cannot fail to agree. Most subjects, particularly at their highest level, aim at acquiring this high level of understanding. Experts in science, the classics, philosophy or archaeology are all adept at putting their expertise to use and solving problems that are within (and sometimes outside) their experience and could therefore be deemed vocational within the terms broader definition.

A similar scenario exists within the vocational curriculum. The master builder can sometimes construct a unique building after following a skills based curriculum as could an automotive mechanic within their trade and are none the worse for it.

These subjects at lower levels have at their core, however, the predominant aim of fostering vocational, often craft, skills with other techniques appended if the opportunity arises. I have no argument with this. Such skills are valuable and are essential to our well being. They provide a vital service for our communities and should be fostered and encouraged.

The issue however is one of understanding what is important about the study of Design and Technology that is not evident in other subjects. It is a struggle that has been engaged with for at least the last forty years (and I would maintain longer under different titles). The struggle is one that has resulted in only a partial victory and requires constant vigilance. Certainly the title of design and technology is now recognised as something that is thought to be important, it is worthy of mention in the curriculum and both professionals in the education service and parents use the term. Another indicator of its effectiveness and recognition is that teachers of the subject have begun to emerge as prominent in the profession and not just within their subject area and are assuming the broader roles of leaders within the education sector.

Where we have failed however is to get across the message about what is at its core, what is its raison d’etre. If I heard the secretary of state for education equating the value of studying Design and Technology alongside Latin, or mathematics instead of alongside vocational subjects I would feel happier. We have failed to get across the message that where the subject differs from others is that process is at the core and the knowledge and skills that are used are important, but subsidiary to the creative act.

This latest trend, of removing the subject from the compulsory curriculum and introducing vocational subjects, may however be to our advantage. We may begin to engage both students and teachers in our subject who fully understand at least what we are about. I am not sufficiently arrogant to suggest that everyone should be captivated by D&T as likewise I realise that not everyone is fascinated by science or even great literature. This doesn’t detract from the virtues of such subjects but merely point out that we are all different. Perhaps we will flourish again when the subject is promoted and engaged in by enthusiasts and not by pressed pupils and staff who enter the workshops/studio /laboratory with reluctance.

The difficulty of defining the ‘usefulness’ of a subject in terms of its value to the individual is complex particularly when it is often sold as an activity that is valuable only in terms of its vocational relevance,
particularly in the old trades or when granted some recognition in new economies. It is often said that our society requires ‘creativity’ in the world of work and consequently it should be a core activity on these grounds alone. If we look at the implications of this we can see how the conflicts can arise in a centrally controlled curriculum when the topic of concern is the enhancement of creativity through the curriculum. Craft, (2003) explores this whole conflict fully discussing how the whole concept is still open to question when it is viewed in cultural and philosophical terms.

If we start examining the further statement that has recently emerged:-

“We will commission the QCA to carry out a research and development project to explore a new model of assessment that would reward good practice in design and technology and encourage creativity” (DFES, 2003, pp.7-8)

we could when in an optimistic mood see this as encouraging. For too long we have struggled to assess a high level creative act by low level criteria simply because they can have numbers readily attached or we are persuaded to try to place the various factors within criteria statements that are so open to debate that they are to all intents and purposes worthless. Unfortunately we are so obsessed by this notion of putting numbers to everything we do that the process is getting in the way of the reason for the activity. This is an obsession that we have begun to accept as normal and yet it is not an activity that we do in the normal course of life. When I go to a restaurant I don’t mark it out of ten and then grade it, likewise when I go to a concert or theatre. I don’t even assess the papers I hear at this conference. I see many different things in the offerings, some are well argued, others are technically innovative, one may draw upon such a wide range of literature that it provokes you to think differently about a topic and others may be so provocative that they force you to confront prejudices. I can understand and appreciate all of these qualities and would find it impossible to separate them out and try to classify them out of some misguided exercise at number crunching. All are of value in their own right and it is this understanding that we should be recognising.

We are therefore facing these two threats of accountability and forcing our subject along a vocational route. These however can be turned to our advantage if they allow us to focus more meaningfully upon the truly educational aspects of our work we may still turn these trends to our advantage and once more move into a new golden age of design and technology education.

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After Noise and Smoky Breath: technological change and the voices of machines

James McGonigal, Faculty of Education, University of Glasgow
Email: J.McGonigal@educ.gla.ac.uk

This paper is about the voices of machines, their sounds and rhythms in the air, and what human beings can make of these in a creative and poetic way. It also considers how teachers can use local poetries, focused in time and place, to enable young readers to overcome simplistic divisions between technology, history and literature. Through listening and responding to the voices of machines, and encountering new voices within a ‘post-industrial’ world, teenage children can reach a more mature sense of the interdependence of human and machine in the contemporary world, while not losing the almost anthropomorphic engagement that is part of their play with toys and implements from their earliest years.

These are large claims and issues, so I’d better nail them down in a rough and ready way to one place (Glasgow) and one century (say, 1860s to 1960s) and one local language (Glaswegian – a complex local dialect bearing influences of Scottish and Irish Gaelic as well as Western Lowland Scots and Scottish English). And I’ll mainly consider the huge social and industrial change that took place over that century through the vision and sounds of one poet in particular, Edwin Morgan (b. 1920), the present poet laureate of Glasgow.

The title of my talk glances at the title of an influential anthology of Glasgow poetry: Noise and Smoky Breath 1983, edited by Hamish Whyte, though I’ll quote from its second expanded edition of 1993, entitled Mungo’s Tongues: Glasgow Poems 1630-1990. Mungo is the patron saint of the city, and his tongues include the voices of the machinery that through the industrial revolution of the 19th century so changed the size, appearance, function and atmosphere, as well as the sounds, of the city, as we can hear in this poem of 1857 by Alexander Thomson:

The wild Train plunges in the hills,
He shrieks across the midnight rills;
Streams through the shifting glare,
The roar and flap of foundry fires,
That shake with light the sleeping shires;
And on the moorlands bare,
He sees afar a crown of light
Hang o’er thee in the hollow night.

[‘Glasgow’]

We notice here the animation of the steam train in animal terms, perhaps an iron horse that ‘plunges’ and ‘shrieks’; yet there is also a quasi-human dimension to its disoriented perception of the shires being shaken awake by the light from midnight furnaces, (in addition to the phantasmagoric play of lurid light and shade across the scene) and of the ‘crown of light’ which gains a gloomy connotation of empty victory from its collocation with ‘hang’ and ‘hollow’. The ‘roar and flap of foundry fires’ seems realistic enough, however, and reminds us of the sheer power of sound that accompanied the production processes sustaining Britain’s imperial growth.

The sharp contrast and interpenetration here of Scottish countryside (‘hills’, ‘rills’, ‘shires’, ‘moorlands’) and unsleeping industrial townscape reminds us of the surprising way in which much of this radical industrial change in Scottish culture was ignored in the mainstream literary output of the time. Most of the early poems I refer to here come from local writers, publishing in newspapers or journals: ‘Glasgow’ appeared in the Glasgow University Album for 1854, for example. For the most part, as Tom Nairn puts it in The Break-up of Britain: Crisis and Neo-Nationalism (1981), established Scottish writers ‘did not ponder
mightily and movingly upon the reality of 19th century Scotland – on the great Glasgow bourgeoisie of mid-century and onwards, the new class conflicts, the continuing tragedy of the Highlands’.

Instead there was a sense in which a fraudulent romanticisation of Scotland in the early 19th century had served to ensure a flawed, evasive and often sentimental literary response that was mainly rural in outlook and erased from the sight of cultured readers the technological advances of the time. In prose, this literature has become known as ‘Kailyard’ writing, meaning backyard or vegetable patch productions: small scale in scope and small-town in outlook. This was, in Cairns Craig’s terms in *The Modern Scottish Novel: Narrative and the National Imagination* (1999), symptomatic of Scotland as ‘a country under erasure’. Since Victorian Scotland, which was becoming increasingly subsumed into the imperial enterprise of Great Britain (largely for reasons of free trade and political stability) had no past that it could relate to, it became ‘unrelatable’ and thus incapable of sustaining the sort of coherent narrative demanded by a truly national novel, such as might have been written by a Scottish Charles Dickens or a George Eliot.

But this was possibly less true of poetry, certainly at the local level, which was at once more radical and more responsive to the sights and sounds of the new technologies. For instance, in 1842 ‘Tennant’s Stalk’ was built, the highest chimney in Europe at about 450 feet, to carry away the noxious fumes from St Rollox chemical work. We immediately find in the Glasgow Liberal newspaper, the *Argus*, this poem from John Mitchell, a Paisley shoemaker and political pamphleteer, in which he takes on the persona of the chimney, which is of course looking down on its neighbour chimneys, or ‘lums’:

My troth! Your makers little knew  
About stalk vents when they made you,  
Or they wad ne’er ha’e made a crew  
Sae void o’ graces,  
As day by day black reek to spew  
In ladies’ faces.  
[‘St Rollox Lum’s Address to its Brethren’]

The challenge of the new technology to Calvinist Christianity in Scotland is also nicely caught, and the way in which its progressivist and moralising vision, often considered to be helpful to the rise of capitalism, was nonplussed by the combination of new wealth and human squalor in the rapidly industrialising towns:

The steeples that aroun’ you rise  
Nae doubt, ance boasted o’ their size,  
But feint a ane o’ them now tries  
To lift an e’e,  
Or speak ae word about the skies  
Since they saw me.

It is perhaps only in a post-industrial age that the story of that momentous industrial change can be truly told, and the voices recreated that urged on such technological advance in Central Scotland. Edwin Morgan, writing for a new century, gives voice in *Cathures* (2002) not to the chimney but to its creator, the industrialist John Tennant, as radical and irreligious in his own way as the Paisley pamphleteer:

Thick smoke, acrid, highest anywhere,  
Four hundred and thirty blessed feet  
Above my empire, my chemical empire,  
My blessed St Rollox, biggest anywhere,  
My eighty acres of evenhandedly  
Distributing industry and desolation!  
Chief of all chimneys, carry your noxiousness  
Into the clouds and away from my employees,  
Settling if it must where I cannot see it!  
[‘John Tennant’]
Now in his eighties, Morgan grew up in the depression years of the 1920s and 1930s. The complex impact of international economic changes on an unresponsive Scottish industrial base during those years is summed up in T. M. Devine’s *The Scottish Nation 1700-2000*, (2000) pp. 266-72. Perhaps because its force was diminishing, the power of industrial machinery and the engineering process was more emotively present to that generation of Scots, and the attraction of the mechanical and the humanly constructed has remained with him as a feature of his poetry. As he recalls in *About Edwin Morgan* (R. Crawford and H. Whyte eds, 1990, pp. 2-3):

 [...] when we went on a Clyde steamer [my father] would make a bee-line for the engine-room, dragging me with him: to me, as a boy, the engines would have only a sort of hypnotic functional beauty, the sleek well-oiled movements, the various parts that always miraculously avoided hitting each other, but my father knew how the parts were made, how they fitted together, he could tell me how the boat actually moved, and somehow the whole industrial process remained human, despite all its problems, and I was ever able to become a Luddite.

His own poetry came into its full confidence in the 1960s, a decade of great cultural change in Britain, and of much slum clearance and motorway building in Glasgow, with urban redevelopment, smoke clearance regulation and support for the establishment of newer lighter and electronic industries to replace the moribund heavy industry based around shipbuilding and steel production. A new Britain was being formed, in the ringing phrase of the Labour politician, ‘in the white heat of technology’. Far above, the rockets and satellites of the space race generated their own considerable force field for technological advance.

All of this renewal is reflected in Morgan’s work of the time. In *The Second Life* (1968) we find celebration of authentic, busy, gritty urban life and characters, (as it had been in the industrial poetry of a century earlier) in such poems as ‘Good Friday’, ‘The Starlings in George Square’, ‘Glasgow Green’, ‘King Billy’, ‘In the Snack Bar’ – poems which are still widely taught in Scottish schools, particularly in the West of Scotland. But we also find a more radically experimental poetry, working within avant-garde international movements of Concrete and Sound Poetry, and often matched thematically to the changing technologies which so excited Morgan at this time: ‘Construction for I. K. Brunel’, ‘O Pioneers’, or ‘Spacepoem I’. I’ll include these as an appendix to this presentation (one poem with the poet’s own emendations to the printed version) since they resist easy description. It is as if the normal multiple factors in the poetic production process (sound, image, metaphor, shape and so forth) have suddenly specialised, speeded up and intensified in effect. Skilled reading aloud can demonstrate that, like the steamship’s engine, the various parts ‘always miraculously avoid hitting each other’.

Or almost always. For part of the charm of these experimental pieces lies in their exploration of the limits of communication in the service of construction. This can apply to semi-literate navvies in ‘O Pioneers’, but also to the early experiments in exploiting computer language and information technology in that decade. The computer’s first attempt at generating a Christmas card is laid out like the narrow printouts of those early machines, but also constructed in a binary off-on coding of what the computer clearly views as seasonal fare and behaviour:

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jollymerry
hollyberry
jollyberry
merryholly
happyjolly
jollyjelly
jellybelly
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and so on until the final triumphant error of the conclusion:

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MERRYCHR
YSANTHEMUM
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In the ‘Computer’s Second Christmas Card’, too, the primitive and error-prone machine makes heavy wintry weather of the Wenceslas carol.

Morgan is clearly interested in where technology can take us. In the title of his 1973 collection, it may be *From Glasgow to Saturn*. Or to Mercury, as in ‘The First Men on Mercury’ where the inadequacies of the space-scientist’s language to cope with the gradually invasive sound and syntax of Mercurian is amusing, and yet at the same time humbling. In ‘The Moons of Jupiter’ we find Morgan speculating on the establishment of industries beyond our earth’s exhausted resources, with some of the same industrial problems as of old, and also some new ones to be coped with:

The sulphur mines on Io were on strike when we arrived. I can’t say I’m surprised. Seventy-five men had just been killed in the fiercest eruption ever seen there. [...] Meanwhile the landscape burned, not that it never burned before, but this was roaring, sheeted, cruel.

At the subatomic level, ‘Particle Poems’ of 1979 gives a voice to the speeding and indeterminate world of experimental physics.

It is this experience of overhearing the voices of basic elements of the technological and electronic world that gives Morgan’s poetry its charm, and also its ability to interest young people whose scientific studies seem to take them away from literature, and especially perhaps from poetry. But just as the radical shoemakers and weavers of Victorian Glasgow wrote their verses in defiance and celebration of the darkest energies of their city, so Morgan as their successor in our time refuses to become deaf to the more subtle and varied sounds of the new technologies, or to turn from their potential to transform. At the classroom level, this positive and open approach can be celebrated in performance, through taping, choral versions of the text, musical or visual accompaniment, or writing in imitation of these models. Such co-creative approaches to poems offer a way of reading the world as well as reading the text.

For the Russian literary theorist Mikhail Bakhtin, heteroglossia and dialogism was at the heart not only of the literary world of the novel but of all social communication. Morgan’s example suggests that it can be at the centre of poetic and cybernetic relationships too. Our interface with machines can include strongly residual oral/aural and poetic elements. In poetic terms, anything can be given a voice – a snake, an apple, or a cloud, if we are dealing with folktale – or an escalator, a skateboard, or an email, if we are dealing with the real and virtual spaces that we now inhabit. In creating the voice for their machine, children can be tuning into the pulse of a world that is theirs for the reshaping. New technology needs its inventors and its exploiters, and that means not only technicians, but also visionaries, careful listeners and poets too.