Technological literacy and entr(e/a)preneurial competencies

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Abstract
This article discusses the importance of developing a view on educating the intersection technology-work-economy. The Belgian 'TOLEON'-project developed for the Flemish region is used as a case-study to illustrate a more concrete vision on teaching entr(e/a)preneurial technology. The structure of the learning environment, the gendersensitive aspects of it and the used interpretation of practical work as a strategy for active and constructive learning are discussed. Finaly, a model for project- and competency-based learning based on sequencing heuristics is presented followed by a suitable assessment strategy.
Technology, economy, work and its importance

Every day, the powerful interaction of technology, science, economy and society is clearly noticeable. West-European countries try to maintain a strong economical position in a globalising world. The last decades we can notice a descent of industrial employment due to productivity increase and capital shift towards the new developing economies (China, India, Eastern Europe, …). Since the 1970's, this shift has led in Belgium towards a proportional growth of the service-economy (De Grauwe, 2006). As innovation plays an important role in maintaining economical leadership in the world, many countries and companies raise their budget for R&D. Entrepreneurship plays an important role in a creative and job-creating economy. In Belgium, the early-stage entrepreneurship has dropped in 2006 to 2.6% (Global entrepreneurship monitor, 2007). This figure represents the number of people in the active population that are busy tot start up a business. 5% is the European average. So initiatives to stimulate entrepreneurship are high on the priority-list of Belgian politics.

Not only entrepreneurship plays an important role in today's economy, also entrepreneurial competencies in organisations (**entra**preneurship) are necessary to build dynamic, flexible, innovating and learning work-environments.

It is clear that the interaction technology-economy must play a role in our technology education curricula. It is hardly imagineable to say that learners are 'technologically literated' if they have no insight at all in relations between technology, economy and people's work in this perspective.

In many industrialised countries and regions such as France (Education technologique ,2005), Flanders (Bossaerts, B. Denys, J. and Tegenbos, G ,2003), Germany (Oberliesen, R. Schudy, J., 2003), … this idea is an engine for important renewal of the technology curriculum.

For German philosopher Günther Ropohl[1] , the aspect of work is very attached to human needs. Technology plays then a material role in an attempt to satisfy these needs. A definition of technology without this dimension is incomplete.

Advocates of a strong link between economy and technology education emphasize the role of technology as a social process. For education, entrepreneurship is an important element of inspiration:

[1] Oberliesen en Schudy, 2003. Paraphrased on p. 77.

e.g. developing creative, social and emotional skills are important not only for the future entrepreneur, but also every citizan's daily life and profession.

In Belgium, typical initiatives to promote entrepreneurship in pupils are:

- bringing entrepreneurs and managers into classrooms
- virtual business games
- setting up mini-enterprises at school
- company visits for pupils and teachers
- work shadowing
- teaching entrepreneurial competencies to manage small enterprises.
-

These initiatives are mainly oriented towards studies in trade and economy in secondary and higher education. There is no real tradition in connecting technology education with economy-work and entrepreneurship.

Building a vision on entr(e/a)epreneurial technology education
The topic of building a view on technology education and industry is not new for the Pupils' Attitude Towards Technology-conference (PATT). It has been an element of study in PATT 5 and in 1995, international examples have been developed. (PATT, 2003)

The TOLEON-project
This project is a Flemisch initiative for the development of tools for teaching on the intersection of technology-work and economy. It was funded by the Flemisch community in Belgium and developed by Arteveldehogeschool, a university college of Ghent university in collaboration with 4 companies specialised in educational technology. The tools are developed for key-stage 7 to 10 and do not focus on typical entrepreneurship factors such as

- having specific ideas about the marketplace or
- taking prudent risks based on a clear (market)vision.

The project focuses more on stimulating entrepreurial learing, enriching pupils' self-concept and expanding understanding on the relationships between work-economy and technology.

Educating the intersection work-economy-technology
Following elements played a role in developing an education tool for teaching at the intersection work-economy-technology:

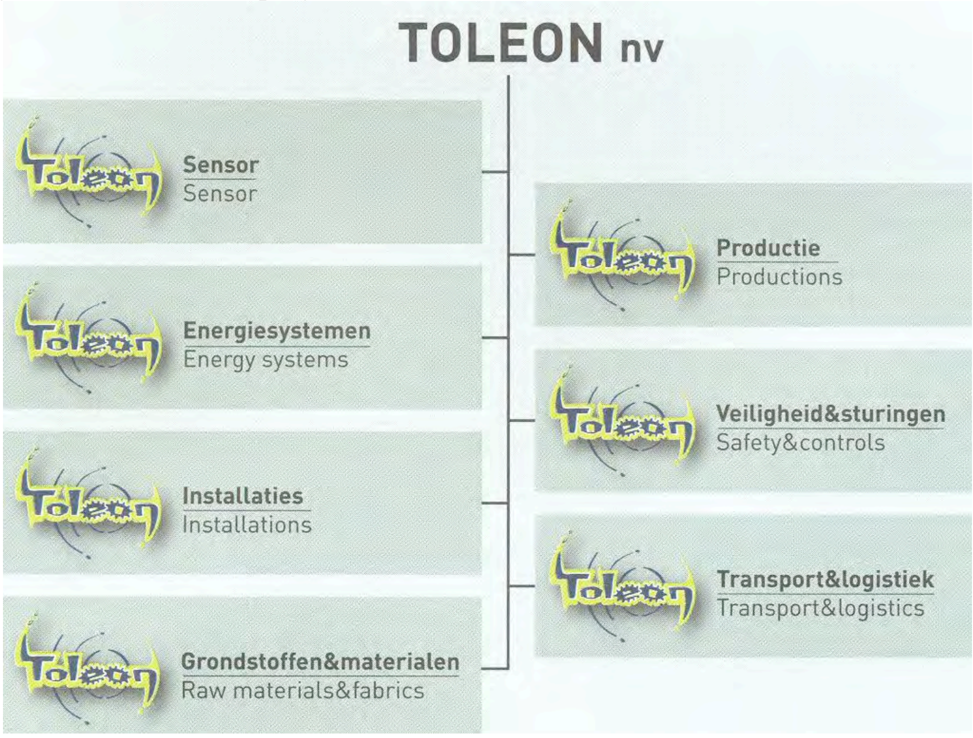
- The tension between human needs and limited resources as a common engine in economy and technology.
- Technology education as a good subject for the development of useful competencies to solve problems at home, in free time, at school, but also in simulations of the professional life. Not only the direct world of children can be addressed, also contexts derived from the world of companies and professional life can be addressed. Careful simulation of these contexts is then required. Much attention is necessary to find simplified real-life contexts that are good enough to broaden pupils horizon without risking misconceptions. As Solomon (1994), pointed out, good simulations are not simple.
- This inspiration out of the professional life can be broader than only context: making know how explicit, assessment techniques, using simple but professional materials and instruments. In France, this approach has been explored (Cliquet, J. a.o., 2002).
- Our daily interaction with technology demands several forms of problem solving: using, designing, making and analysing/researching systems, needs and phenomena; detecting errors, maintaining, … So also in authentic technology education, these competencies play an important role.
- Cooperative learning as a good setup for roleplay referring to real professions such as the operator, quality-manager, safety advisor, researcher, designer, engineer, …. Besides these more professional roles, people play specific roles in problem solving: when defining clusters of key competencies in technology such as researching/gathering knowledge, innovating, managing and executing, a link with Kolb's learning styles can be noticed (Van de Velde and Hantson, 2005).

- Learners are enriching their self-concept by obtaining information on their interests and future possibilities/abilities.
- Economic understanding based on economy as a social proces: consumers, organisations and governements making choises on the use of resources and regulation of technology (Jephcote, M. and Hendley, D. ,1994). Every choise in a design- or making-task has its economic, social and ecologic consequences. Economic and industrial understanding as an ability to make such choices and as an ability to understand how consumers, companies and governements make such choices.
- Creating learning environments where pupils are encouraged to learn in entr(a/e)preneurial way: being creative, showing leadership, taking risks, working on social and communicative abilities, learning to deal with disappointment (building a strong emotional personality). In the Flemish region of Belgium, this aspect has been modelled by Laevers and Bertrands (2003).
- Modern professional life becomes more interdisciplinary and needs a broad spectrum of competencies. The importance of key-competencies is rizing. For the TOLEON-project following clusters of key-competencies were used (De Maertelaere, S. Coulier, R. Hantson, P. en Van de Velde, D. ,2006):
  * competencies for problem solving;
  * competencies for self-regulation;
  * social and emotional competencies
  * competencies for communication
  * context- and discipline-specific competencies;

The TOLEON-project, a case study.

The learning environment in TOLEON

Toleon (Van de Velde, D. Hantson P. en Huyghe, B., 2006) consists of 6 cases with educational technology. The simulated company "TOLEON nv" has several business-units.



Every case stands for such a unit. A case contains text-books, interactive games on cd-rom, an introductery film illustrating the context, materials for practical work and gadgets for supporting role-play.

Photo 1: educational technology for learning production-competencies with the TOLEON-project.

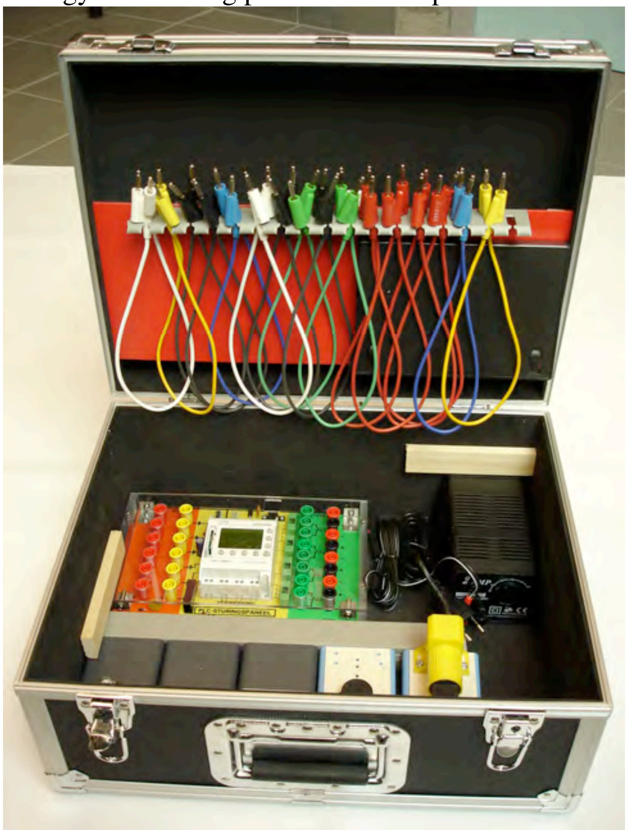


Photo 2: educational technology for learning technology with programmable controllers in ‘TOLEON-safety&control’.

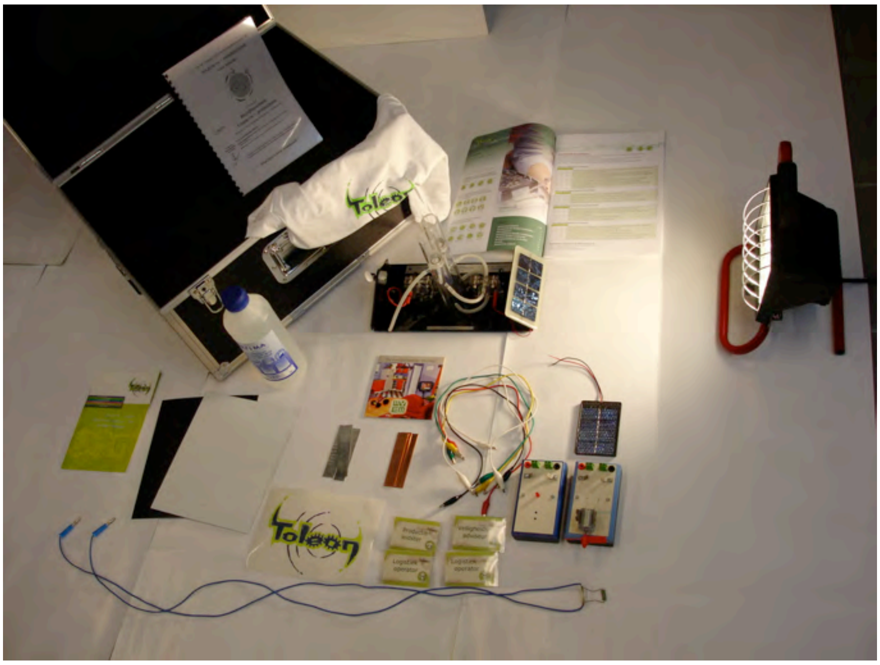


Photo 3: educational technology for learning technology in the business-unit 'TOLEON-energy-systems'.

Rich contexts for learning and the world of companies

All problem solving in TOLEON is situated by means of rich context descriptions. We've used a lot of instruments used in companies for that: e-mail prints, fax-transmission prints with order-data, checklists, simplified real-company problem discriptions, simulated company website and company visits, …

Gendersensitive approach in TOLEON

In order to address the central values of girls in technology education, the following points of attention were taken into account:

- gendersensitive graphics: use of neutral green as a colour in graphics referring to actual youth culture that are appealing for boys <u>and</u> girls
- role-pattern- confronting images and pictures with attention for the equality of females in professions.
- Learning goals for social and communicative competencies and connecting technology with creativity. Role-play as a interesting tool for developing such abilities.
- Rich contexts with attention for the interaction man-society-nature.

An innovating approach of practicum ('practical work')

Defined heuristics

In the TOLEON-project, a practicum is defined as a simulation of a real-life context-based problem-solving. Several types of problem-solving are defined and every type becomes connected with a specific heuristic structure. Special attention has been applied to avoid ritualisation. The heuristic structures are carrying the know-how for the typical competencies in technology such as designing, producing, analysing systems, ……

The structure of the heuristics are simplified and defined by 5 <u>iterative</u> steps/phases.

Each typical form of problem-solving in technology becomes structured by a profiled heuristic. For learners, these know-how structures are also indicated by a graphic icon.

Icon of the covering technological process (TP)

Steps/phases in practical work heuristics

For the covering technological process we defined 5 sub-heuristics (we use the word 'phase'):

1/need identification-2/design-3/production-4/use-5/effect.
Every ‘phase’ consist of 5 typical steps. These heuristics may not be used as algorithms forcing learners in a ritualized process. They are used as anchors respecting the learning style of pupils.

Researching practicum (RP): gathering knowledge.
A researching practicum can be linked to scientific work. In technology education, they play a role in generating usefull knowledge for further technological activities. By experimenting, either in group or individually, pupils gather knowledge and insights about natural phenomena, social and technological activities and systems.

Practicum “researching natural phenomena”
The goal is to research natural phenomena to generate knowlegde for further technological problem-solving.

Practicum “researching needs (and limitations)”
Practical research-activity to gather knowledge about needs, limitations and resources to support further technological problem solving such as designing.

Instrumental practicum (IP)

using (an instrument);

using (a manual)

Practical work as an approach to gather competencies for using technological systems. In this process of using, the manual of a technological system is an important concept. In the Flemisch region of Belgium, we can notice a lot of cognitive testing of device-specific knowledge in technology education. Therfore, for every piece of instrument or device in the set of TOLEON’s educational technology, a manual is developed. So the emphasis comes on learning the competence how to use a manual when using systems. Where the other processes are more heuristic, the process of use is more algorithmic.
For learning the use of more complex systems, e.g. a programmable controller, we used half solved using-problems. This approach makes the practicum more dynamic and is a good preparation for a ‘general problem solving practicum’ (GEPS).

Technology-specific practical work

Designing
Practical work for the creation of a product/system/service or environment dealing with needs, limitations and resources of humans, society and nature.

Producing (making)
Practical work to produce products/ systems/ environments/ services starting from a given design and criteria. There is task-analysis, work preparation and continious improvement of proces (man-means-methods-materials- workplace). The making requires strict attention for safety, quality, ergonomics, attention for the making process productivity ….

Researching effects
Practical work with the aim to research effects of technological developments on man, society and nature. The research practicum includes making suggestions for regulating the technological development or regulating the social context.

Researching/analysing technical systems

Every artefact represents a enormous amount of knowledge needed to realise it. Where mostly only the knowledge for good use of the artefact is present, this heuristic process tries to bring up futher knowledge about functions and meanings of (sub)systems and the flow of mater, energy and information.

Problem solving (GEPS)

Many technological problems do not have a specific profile in the sense of

designing/producing/researching, …. E.g. reparing a defect, maintaining an artifact, diagnosis and trouble shooting, …For this kind of problem solving we used a more vague general problem-solving heuristic (GEPS). Important aspects are diagnosis, finding subproblems, searching known solutions for these subproblems or transforming problems in controllable forms, testing and assessment of solutions and processes, ….

Model for authentic and competency-based learning

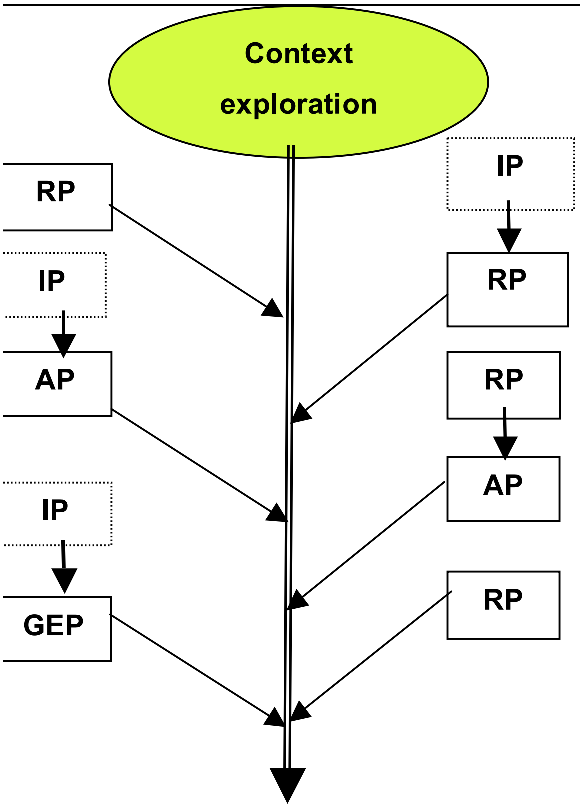
Sequencing heuristics

In order to construct a lesson-cycle of 6 to 9 weeks we have used a model where the specified types of practical work follow a logical sequence and a competence-based order.

In the connection phase pupils explore the context through their spheres of life: technology at home, in the community, at school, but also in private and public organisations.

In the analytical phase, learners gather knowledge and abilities needed for technological problem solving in the phase of synthesis. In this phase, a more complex technological problem has to be solved integrating the learnt elements. This technological problem (mostly a design- and production-task) is representative for the learning context and must be appealing for pupils. The expansion phase serves to open up again the perspective and shows the role of the aquired competencies in our technological world.

In TOLEON, this schedule is not a rigourous thing. E.g. in ‘Toleon safety&controll’ the analytical phase consists of a alternate succession of ‘instrumental practica’ (IP’s) where problem-based learning is focused on instrumental learning in order to use the programmable controller and ‘gereral problem solving’ (GEPS), in which the problem solving itself and programming-strategies become more important.



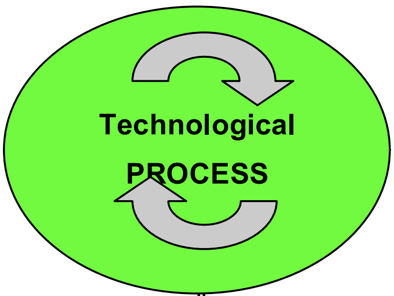
1.Connection phase
2.Analytical phase

(3-4 weeks)

RP: researching practicum

IP: instrumental practicum

AP: applied practicum: applying knolegde in an other context
GEPS: gereral problem solving

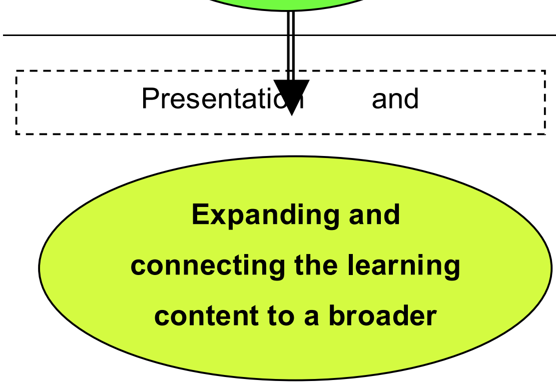


3. Phase of synthesis

(2-3 weeks)

TP: technological process
Processes:
full technological proces or process zooming (= designing, producing)

C O N V E R G E N T



4. Phase of expansion

(1 or 2 weeks)

Besides presentation and evaluation, practical work for investigating effects is useful.

D I V E R G E N T

Graphic model: program for teaching technology of a defined context over a 6-9 weeks period (Van de Velde and Hantson, 2003).

The use of general systems theory in TOLEON

- For the grades 7 to 9, simple concepts of gereral systems theory are an appealing alternative for traditional discipline-based analysis of systems (e.g. mechanic analysis, electronic analysis, hydraulic analysis, ….).

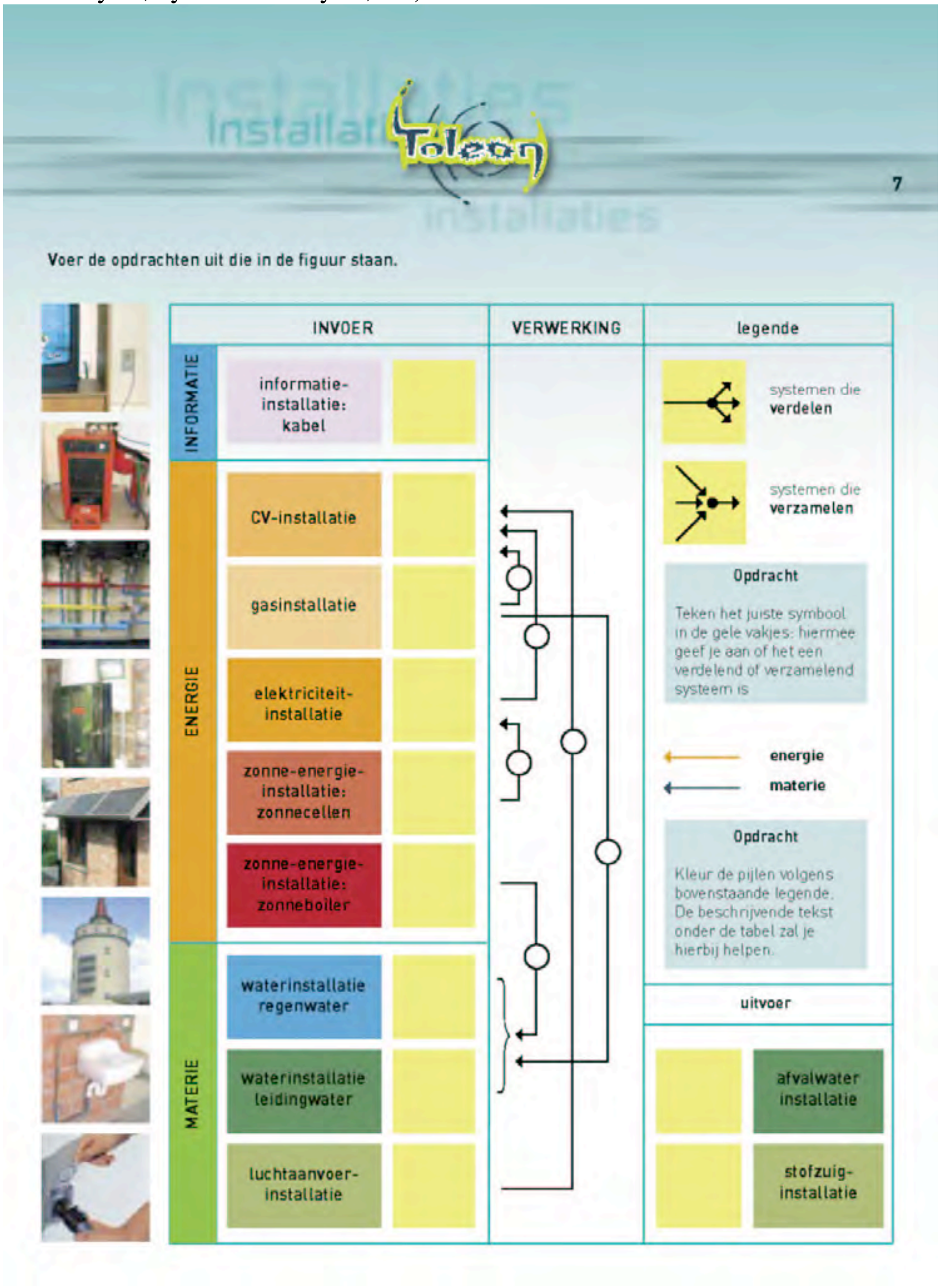


Figure: example of one of the general system-theory approaches used to analyse charasteristics of technical dynamic systems at home and relations between them in 'TOLEON-installations'.

We used following concepts:

- identity-cards[2] of (a group of) systems;

[2] Identity-cards for systems are epistemologically related to the work of 18th century-encyclopedists trying to grasp e.g. the complexity in plants and animals: trying to bring structure in our complex and diverse designed world.

- input-proces-memory-transport-output models of the information-, matter- and energyflow in technical systems;
- black boxes representing (sub-)systems;
- principles of control systems such as feedback;
- Intuitive understanding of the priciples of O- and 1-junctions and their influence on effort- and flow (as derived from Bund Graph theory).

Assessment strategy

In textbooks, besides a product-assessment, there is attention for process-assessment (‘continuous improvement-chart’ as inspired by the industry).

Learners get 360° feedback on their contribution to the learning process. There is attention for self-assessment and peer-assessment in the assessment table (see figure).

The assessed roles were developed combining input from assessment research in education (Dochy, Schelfhout and Jansens, 2003) and project management (Wijnen, Renes and Storm, 2001).

As a result, pupils can get feedback on their assignment-contributions. Ass well, they get to know something about their talents (profile-score): are they inspirators, thinkers, entrepreneurs, supporters, operators of conservators?

Teachers can attach additional observable learning goals. In the Flemish region of Belgium, a team of employers, teachers and assement-specialists have developed a rubric-scale (Union of Christian employers, 2006) with observable basic attitudes relevant for professional- and school-life.

Assessment stategy

……………………………………………
……………………………………………
pers:
……………………………………

score	Give and receive appreciation scores.
1	No contribution to beter team-results
2	Low effort
3	Good effort
4	Excellent contribution to team result

Conclusion

	Appreciaton- score:					
t-chart: learn to know your talents.	Self assess-ment	Assessment of team member 1 ……………..	Assessment of team member 2 ………………	Assessment of team member 3 ………………	Assessm ent by teacher	
ave good ideas and you think about future ems. You are an **inspirator**.						Profile-score
work very orderly following excact ctions. You are a **conservator**.						
an explain a given situation very good, you **thinker**.						
ike the hands-on work, you are an **ator**.						
ake the lead and try to get things done, you n **entrepreneur**.						
ry to help where possible and you are erned to keep everyone motivated. You are **porter**.						
………………………………………………. rvable competencies, added by the er.)						
rvable competencies, added by the er.)						
score: the appreciation of your work						

This article illustrates the importance of teaching on the intersection technology-work-economy. It describes a concrete development of an education concept and its supporting educational technology for teaching entrepreneurial technology for grades 7 to 10. The project pays attention for gender aspects, situates the learning content in contexts, uses several approaches for simulation and authentic learning. For competence-based learning and the development of meta-cognition, a concept of sequencing heuristics was developed. Also a suitable assessment strategy was defined. We can conclude that educating on the intersection technology-work-economy is not contradictory with modern views on eduction. The project TOLEON shows us a clear link with technological literacy as defined in the USA-standards, far beyond the influence of vocational technology on gerenal technology education.

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"Why can't I design as well as other people? I thought I understood the process and what was required."

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Introduction
This small-scale research study arose from a desire to help students improve their design activity whilst training to become design and technology teachers. The study was informed by an in-depth review of literature concerning designing (e.g. Lawson, 1990; Baynes, 1992; Hennessy & McCormick, 1994; Taylor, 2000) and the complex integration of processes, concepts, knowledge and skills required to carry out such activity (e.g. Eggleston, 2001; HMI, 2003), plus the findings from several relevant research projects that had been carried out by the author during the past fifteen years.

Over the years there have been many students on the Design and Technology Initial Teacher Training (D&T ITT) programme referred to in this study, whose design projects have displayed evidence of an excellent level of design activity. These students were usually intrinsically motivated, innovative, creative and highly skilled.

However, evidence from design activity produced by other students, plus numerous conversations held between students (represented by the quote used as a title for this paper) and the academic team, indicated that there were students who struggled to produce the level of design activity necessary to support successful product development, even though: such activities were carried out several times throughout their degree programme; they received the same inputs as successful students; the students themselves wished to improve their understanding and performance and they were enthusiastic about becoming teachers of design and technology.

Over the years many strategies have been developed by the academic team to help students improve their understanding and use of design skills. These have included lectures, seminars, individual tutorials, handouts, a criteria based matrix for formative feedback, the use of examples of good practice, and discussion pairing of students on a number of occasions throughout a design project. Unfortunately, there still remain students for whom these strategies are insufficient. In order to develop new teaching strategies and materials the team believed they needed a better understanding of the differences between the design activity of successful students and those who struggled - hence this small-scale study.

The Sample
The sample was made up of twenty-seven (13 male, 14 female) undergraduate D&T ITT students at a University in the North East of England.

Data collected
1. The design activity used for analysis purposes was completed during a Core Design and Communication module where students were asked to design a first aid or emergency kit for a dedicated sport, which they had to identify. The design activity was in the form of a folio with evidence of an analysis of the problem, identification of constraints, both two-dimensional drawings and photographs of three-dimensional (3D) design activity, evaluative annotation, plus additional evidence of research collected in a file and in some cases, physical 3D modelling. The students did not have to make their chosen product, although they were expected to provide evidence of planning for its manufacture.

Each folio of design activity was scrutinised page-by-page to determine the following:

- What type of activity was taking place on each page? Codes were used which had been devised during a pilot using a sample of six folios from a previous year's cohort studying the same module.
- Whether the activity on a page was all images; all words; more images than words; more words than images or an equal amount of images and words.
- Whether the annotations on a page were descriptive or provided perceptive, reflective thinking, or whether both appeared on a page
- Whether there was evidence of creative thinking on a page
- Whether there was evidence of copying existing ideas on a page
- Whether designs were presented on a page as whole ideas, or parts of an idea or whether both types of activity were used on a page

Table 1. Criteria used to determine the type of design activity that appeared on a page of a folio

Each folio of design activity was scrutinised page-by-page to determine what type of activity had occurred (see Table 1 for details). The design folios were then assessed for the type of evidence that appears throughout a folio rather than on a single page (see Table 2 for details). This latter data were converted into a percentage score for good design activity for each member of the sample.

The design folios were assessed as a whole using a Likert-type scale of: very good evidence, good evidence, some evidence, poor evidence or no evidence, looking for the following activities associated with designing:

- Was the brief well defined and understood
- Was appropriate research collected
- Was research well analysed
- Was there evidence of research being used during the design process
- Was there a good range of constraints/considerations identified
- Was there evidence of the development of a Product Design Specification by the end of the process
- Were the principles of the function clarified
- Was there a good range of early ideas
- Was there evidence of an appropriate amount of 2-D modelling at an early stage of the process
- Was there evidence of an appropriate use of 3-D modelling at an early stage of the process
- Was there evidence of the development and detailing of the chosen idea
- Was there an appropriate amount of 3-D modelling at the chosen idea stage
- Was there evidence of planning for manufacture in terms of: materials, construction process, plans/patterns etc
- Was the chosen idea workable
- Was the chosen idea creative/innovative in function
- Was the chosen idea creative/innovative in form

Table 2. Criteria used to assess the design folios globally

2. All students also carried out Riding's computer presented Cognitive Style Analysis (CSA) to determine their Preferred Information Processing Style (PIP Style) (Riding & Rayner, 1998). The CSA provided data on a person's position on two independent dimensions: a Wholist-Analytic Cognitive Style dimension; and a Verbaliser-Imager Cognitive Style dimension. It is suggested that the 'Wholist-Analytic style' indicates a tendency for individuals to process information in wholes or in parts, while the 'Verbaliser-Imager style' indicates the tendency for individuals to represent information during thinking in words or images. These definitions were deemed

appropriate for use in conjunction with design activity (see Atkinson, 2000 for a more detailed explanation).

Results
PIP Style
The PIP Style data for the total sample indicated that in comparison to the standardisation sample (Riding, 2000) this sample did not have students at the extremes of either dimension, particularly the Imager end of the Verbaliser-Imager dimension (see Table 3).

Sample	Wholist-Analytic	Verbaliser-Imager
CSA standardisation Sample (*n*= 999)	0.370 – 4.050	0.400 – 5.610
Sample under discussion (*n* = 27)	0.680 – 2.740	0.820 – 1.590

Table 3. A comparison between the ratios on the two CSA dimensions found Riding's standardisation sample and the sample under discussion

When the CSA data were divided into the three divisions normally associated with each dimension, there was a fairly even spread on the Verbaliser-Imagery dimension with ten Verbalisers, eleven Bimodal in the central category of that dimension and six Imagers. On the Wholist-Analytic dimension the spread was uneven, there were seven Wholists; two Intermediate in the central category and a significantly large cohort of eighteen Analytics (Chi Square Test: Variance 67.000; df 2; Chi square 134.00, p-value <0.0001). The small number of Intermediates in this study made this group too small for analysis purposes. It was therefore decided that, in line with other studies using Wholist-Analytic data (e.g. Borg & Riding, 1993; Evans, 2003) that the Wholist-Analytic dimension would be divided into two groups only, Analytics (19) and Wholists (8).

The relationship between Design Activity and PIP Style
The importance of imaging as a means "…by which we make externally available our thoughts" (Doyle, 2004, p.67) and as a way of presenting evidence of creative idea generation, has been well researched (e.g. Kamii 1980; Lawson, 1990; Doyle, 2004; Hope, 2005). Therefore in the first instance the collected data was scrutinised to find out how many of the sample had produced a larger number of design sheets using images rather than words, and how many students had produced a larger number of sheets using more words than images. This was then amalgamated with the PIP Style data from the Verbaliser-Imager dimension to see how many students designed in a manner that matched or mismatched their PIP style (see Table 4).

PIP Style	Higher percentage of sheets using more words than images	Higher percentage of sheets using more images than words
Verbaliser	6	4
Bimodal	5	6
Imager	0	6

Table 4. The number of the sample on the Verbaliser/Imager dimension that preferred to use more images or more words in their design activity

This analysis indicated that the Designing Style of all Imagers matched their PIP Style on the Verbaliser-Imager dimension. It also indicated that a large proportion of Verbalisers Designing Style matched their PIP Style even though this meant the use of more words than images, which did not sit comfortably with the type of activity involved. Bimodals who could process information equally well in images or words were evenly split between those who used more images and those who used more words during their designing. The design activity data were then scrutinised to find out how many of the sample had produced a larger number of sheets illustrating complete solutions in single drawings in comparison to those who had paid more attention to detailing parts of ideas in their drawings. This data was then amalgamated with PIP Style data from the Wholist-Analytic dimension in order to see who designed in a manner that matched their PIP Style on that dimension and who did not (See Table 5).

PIP Style	Higher percentage of sheets illustrating parts of a design idea than whole ideas	Higher percentage of sheets illustrating wholes ideas in single drawings rather than parts of ideas	Equal amount of sheets illustrating whole ideas and parts of ideas
Analytic	11	5	3
Wholist	5	3	0

Table 5. The number of the sample on the Analytic/Wholist dimension that preferred to design illustrating parts of an idea rather than whole ideas in a single drawing and visa versa

The importance of working out the details of ideas appears to have had an effect upon the design activity of most of the sample, in that even those students who preferred to see the whole picture rather than individual parts tended to provide more evidence of detailing parts of a design than whole ideas. As anticipated, because of the importance of working out details of ideas there were a highly significant number of Analytics whose Designing Style matched their PIP style.

Relationship between PIP Style, Designing Style and successful Design Activity

When the total sample was scrutinised to see if there were any differences in the success rate of the design activity of those whose PIP Style matched their Designing Style and those where there was a mismatch. It was evident that those with their PIP Style matching their Designing Style were the most successful (see Table 6). The difference was less acute for those students who only achieved an average level of design activity, whilst for those whose design activity was unsatisfactory there was a reverse of the trend, in this case when PIP Style matched Designing Style the results were worse than when there was a mismatch.

Relationship between PIP and Designing Style	Mean percentage for those assessed as having produced 'Good' design activity (≥60%)	*n*=	Mean percentage for those assessed as having produced 'Average' design activity (40 – 59%)	*n*=	Mean percentage for those assessed as having produced 'Poor' Design activity (≤39%)	*n*=
Matched	88%	4	47%	2	11%	13
Mismatched	69%	1	44%	1	15%	6

Table 6. Illustrates the relationship between PIP Style, Designing Style and successful design activity

As the intention of this study was to try to help these less successful students it was deemed important to dig deeper into this finding in order to ascertain whether there were any informative relationships between certain PIP Styles, Designing Styles or combinations of the two.

In the first instance the data were scrutinised in terms of the Verbaliser-Imagery dimension. It had been anticipated that students from the Bimodal PIP Style group might achieve a high mean score for their design activity, as they were able to manipulate ideas using a mixture of images or words more easily than a student who was an Imager or Verbaliser. However this proved not to be the case (see Table 7). Bimodals achieved the lowest mean score for their design activity whether they used more images or more words whilst designing.

PIP Style on Verbal Imager dimension	Results for Total Sample	Mean percentage for good design activity for those with a larger number of sheets using more words than images	Mean percentage for good design activity for those with a larger number of sheets using more images than words

	n=		*n=*		*n=*	
Verbaliser	10	31%	6	32%	4	27%
Bimodal	11	21%	5	19%	6	24%
Imager	6	42%	0	-	6	42%

Table 7. Mean Percentage for design activity for Verbaliser, Bimodal and Imager PIP Style

Verbalisers whose design activity matched their PIP Style did achieve a higher mean score than those whose design activity mismatched their PIP Style. Although poor imaging skills may well have caused the poor results for Verbalisers who chose to use more images than words in their design activity. It was also surprising that Verbalisers whose design activity matched their PIP Style achieved better results than Bimodal students bearing in mind the nature of the activity where imaging is considered so important in the manipulation and development of creative design solutions. However, their level of good design activity was still much lower than that achieved by students categorised as Imagers (see Table 5). These students, none of whom worked in a mismatched mode, achieved the highest mean score of any of the PIP Style groupings in this analysis. In terms of the Wholist-Analytic dimension and successful design activity the results for the total sample were as the academic team anticipated (see Table 8). Analytics were more successful than Wholists. This supported the team's belief that designers need to spend a considerable time detailing ideas at various stages of the process.

However, when the sample was broken down further using the data from the Wholist-Analytic dimension, into those whose Designing Style matched or mismatched their PIP Style it was students who produced more sheets of whole ideas than details of ideas, whether they were classified as Wholist or Analytic, who achieved the highest mean design activity scores (see Table 8). In fact Analytics working in a mismatched Designing Style achieved the highest mean score of any PIP Style grouping on either dimension, whilst Wholists who paid more attention to details than whole ideas, and their Designing Style was therefore a mismatch to their PIP Style, achieved the lowest mean percentage of any PIP Style group and this was significantly so (see Table 7 and 8).

PIP Style on Wholist-Analytic dimension	Results for Total Sample		Mean percentage for good design activity for those with a larger number of sheets illustrating more details of an idea than whole ideas		Mean percentage for good design activity for those with a larger number of sheets illustrating more whole ideas than parts of an idea		Mean percentage for good design activity for those with an equal number of sheets that illustrate parts of ideas and whole ideas	
	n=		*n=*		*n=*		*n=*	
Analytic	19	31%	11	21%	5	46%	3	44%
Wholist	8	23%	5	13%	3	42%		

Table 8. Mean percentages for design activity for the Analytic and Wholist PIP Style dimension

Discussion and future research

It was the intention of this study to unpick the design activity of a typical cohort of students training to become design and technology teachers, to help the academic team develop teaching materials and strategies to assist those students who struggle with this important aspect of the design and technology curriculum. The results in three separate analyses supported the well-held belief (e.g. Gray, 1979; Garner, 1989; Nicholl, 2004) that imaging is central to successful design activity. It is therefore considered important for the team to continue to develop new and more effective ways of improving drawing and imaging skills especially for those whose preferred information processing style indicates a preference for using words rather than images. It is hoped that by doing so such skills will become 'tacit habits' and enable students to concentrate on idea generation rather than having to think about how to draw.

Cognitive Psychologists would have us believe that Wholists are the divergent, creative thinkers (Kolb, 1976; Honey & Mumford 1992; Riding & Rayner, 1989; Cassidy 2003) and therefore likely to be the most successful designers. However, during the design of functional products the detailing of ideas is a recurring activity that is essential to successful product development. When PIP Style data were looked at it was Analytics who achieved a higher score than Wholists. However, the Cognitive Psychologists were partially correct, in that it was Analytics working in a Wholist Designing Style who achieved the highest result of any cognitive style grouping. The students who were the least successful were those who preferred to process information in wholes, and yet, possibly because of inputs from academic staff, had felt they needed to produce more sheets showing details of ideas than sheets displaying complete ideas and therefore designed in a mismatched mode.

In order to understand the implications of this latter finding the data needs to be re-visited to look in more depth at two particular groups of students. Those who prefer to process information in parts and yet who's mismatched Wholist Designing Style achieved the high scores and those who prefer to process information in wholes and used a mismatched Analytic Designing Style that achieved poor results. By doing so it is hoped to provide a better insight into how best to support students who have difficulties with this important aspect of the design and technology curriculum.

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Mental Models in Design and Technology Education: bringing theory to practice

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Abstract
What mental resources do students call on when faced with novel situations for which a problem must be solved or a design created or manipulated?

Mental model theory is robust and helps to explain the cognitive and physical interactions of teachers and students when engaged in learning, particularly with artefacts. Individuals construct working models of the world in their mind before, during, and subsequent to any event. These cognitive structures inform us of how to plan for and interact with many environments and aid the subsequent reflection of those decisions and actions. Mental models are, therefore, both process and product: tools that enable us to understand and to act.

This paper discusses how the theory of mental models can be applied to find answers to questions asked every day by teachers. It proposes that teachers can use an understanding of mental models to engage students in Design and Technology activities that not only result in the attainment of standards but also engage students in learning about their own learning. On the way, teachers, too, may discover more about their own learning journey and its pedagogical impacts.

Introduction

Defining mental models

Mental model theory was first proposed by Craik (1943) when it was used to explain human thought processes through the recognition that users had mental models of system interfaces created by designers. Craik suggested that mental models were dynamic representations of the system's reality held by individual users. This early work was taken up by others in a variety of fields due to its capture of the 'account of the deductive competence, biases, and pragmatic effects' that individuals require in order to interact successfully in a multitude of environments (Evans, 1996; p.232). Johnson-Laird (1983) used mental model theory in his experiments in formal deductive reasoning in text comprehension. Gentner and Stevens (1983) used mental model theory to explain knowledge and understanding in science. Others (Meiser, Klauer, & Naumer, 2001; Gentner, 1998; Barker, van Schaik & Hudson, 1998) have used mental model theory to explain how individuals understand the real-world phenomena that they represent in a wide variety of contexts. Barker, van Schaik, Hudson, and Meng Tan (1997) go so far as to suggest that mental models are important as they form the basis of all behaviour.

A working definition would include the premise that mental models enable us to 'understand the world by constructing working models of it in our minds' (Henderson & Tallman, 2006, p.22). Pitts (1994) defines them as 'cognitive constructions that are a network or web of related understandings' (p.23). They are cognitive representations rather than scale models and are created individually to reflect structures of our environment, the tasks we undertake, the problems we solve (Halford, 1993), and even abstractions such as truth (Newton, 1996) that are encountered on a daily basis. They work as memory retention and meaning-making devices that enable individuals to interact cognitively and physically with information, concepts, and relationships within a domain.

The multiple functions of mental models

Norman (1983) recognised that individuals construct functional mental models that still may be deficient in some ways. They are sometimes incomplete or inaccurate (Johnson-Laird, 1983; Halford, 1993) but continue to aid the investigations of alternatives to problem-solving situations (Renk, Branch & Chang, 1994). Their individuality arises from their reflection of our interactions with the environment, a situation, a task, procedure, concept or phenomenon (Halford, 1993). They also contain reflections of problems, events, and stories that are imaginary (Byrne, 1992). They arise from our constant interaction and complex experiences with the world and the individual ability to develop the relationships and dialogue necessary to guide our understanding of such interactions and experiences. Mental models have multiple functions that enable multiple environments and problems to be explored.

Explanatory function
Mental models have an explanatory function as they 'facilitate cognitive and physical interactions with the environment, with others, and with artifacts (sic)' (Henderson & Tallman, 2006, p.25). They are the tools we use to understand, seek alternatives, and make choices in dealing with problems (Henderson & Tallman, 2006). When a learner is faced with a problem that must be solved, they retrieve the mental models that will enable them to understand the alternatives available to solve the problem and to validate the solution or find counter-examples (Johnson-Laird, 1983). Mental models are therefore both processes and products (Henderson & Tallman, 2006) because they enable the learner to both understand the situation and to take subsequent action.

Predictive function
While mental models are created and reflected upon in working or short-term memory they are stored in long-term memory (Gentner & Stevens, 1983; Henderson & Tallman, 2006). Mental models are retrieved and run (Johnson-Laird, Oakhill & Bull, 1986; Norman, 1983; Payne, 1991) to find appropriate solutions. The more accurate and complete the mental model, the more predictive power it provides to guide possible scenarios suitable to the situation. Several mental models can be run simultaneously and any that prove ineffectual can be discarded or manipulated and refined in order that a workable solution is found.

Controlling function
Teachers can be conscious of running mental models particularly in the classroom where they may be following a lesson plan in a new area of study. They may retrieve ideas or concepts from past lessons to scaffold the new knowledge or create an analogy that will enable the students to interact meaningfully with the new concepts. In this way, teachers control their mental models (Henderson & Tallman, 2006) if they divert from the prepared text of their lesson plan to clarify the incorporation of new concepts for all students. Most of the time, however, mental models are run unconsciously and teachers automatically call on those models that will enable a problem to be solved.

Diagnostic function
Students who have rich mental models in an area of learning usually perform better (Barker et al., 1998) so having many opportunities to run and subsequently develop mental models in challenging environments improves cognition and learning. Stripling (1995), in her research with library teachers and their programs, discusses how 'real learning' happens when the mental models held by learners are 'restructured to include new ideas in a meaningful context' (p.165). She proposes that real learning can only happen if 'a learner is confronted with a contradiction, a new idea that cannot be incorporated into an old model' (p.166). Ritchie, Tobin and Hook (1997) used the term 'perturbation' to explain these contradictions where new knowledge will link with prior knowledge to create a modified mental model that incorporates the new experiences and concepts. The diagnostic function of mental models for teachers, therefore, relies on their understanding that a learner may be working with a mental model that does not allow them to assimilate new concepts (Royer, Cisero & Carlo, 1993). Instructional intervention would then be required to enable the learner to modify the flawed

mental model. How learners' mental models are communicated is, therefore, of vital interest to practitioners.

Communication function
Mental models also serve a communication function by allowing individual cognitive structures to be known to others. Williamson (1999) used concept maps to 'exteriorise' (Barker et al., 1998) the mental models of pre-service teachers. He found that mental models function to communicate individual conceptions to others. Henderson and Tallman (2006) found that 'collaborative critiquing of one's own and others' mental models requires simultaneous work on a single model' (p.47). The act of sharing or communicating our mental models to others usually involves discussion where the social negotiation of a transitory model occurs (Anderson, Howe & Tolmie, 1996). Analogy is one of the dominant characteristics of mental models. It is used to communicate mental models to others through the use of the transferable characteristics of the analogy to the concept or problem being discussed.

Memory and organisation function
Mental models are cognitive constructions that create a network of related understandings or knowledge (Pitts, 1994) and they are stored in long-term memory (Gentner & Stevens, 1983; Johnson-Laird, 1983). The ability to retrieve from long-term memory the mental models necessary for manipulation in short-term or working memory is important for making inferences and relating propositionally in problem situations. Mental models are therefore run in working memory and the effectiveness of this can be influenced by many factors such as students' meta-ability (Anderson et al., 1996; Johnson-Laird et al., 1986) and their ability to utilize their working memory effectively for that situation (Anderson et al., 1996; Johnson-Laird et al., 1986; Newton, 1996).

Applying mental model theory to pedagogy
Pedagogy
The mental models of teachers have an impact on the learning that happens in a classroom (Stripling, 1995) because a teacher's mental model provides an 'explanatory function for understanding the complexities in teaching and learning situations' (Henderson & Tallman, 2006, p.25). How curriculum is planned, implemented, and assessed is informed by the teacher's mental models of the intricacies of the components of learning such as content, context, and theory. For a reflective practitioner, mental models can either continuously activate reflection on pedagogical practice or limit continued learning.

As well as being the mechanism by which teachers can reflect on their own pedagogical philosophy, working with, and understanding students' existing mental models in any domain enables teachers to identify what students already understand about the content and concepts they will be addressing in the classroom (Stripling, 1995). This appreciation of the implicit knowledge with which the student is operating goes beyond conducting a needs assessment exercise which at best concentrates on the content of the task. Understanding their own and their students' mental models enables a teacher to address erroneous or limited mental models of all participants in the learning experience, thereby improving both their delivery of the curriculum and student cognition. Indeed, Stripling (1995) warned that educators 'will not succeed in changing students' limited or incorrect mental models unless the mental models themselves are addressed' (p.164).

The question remains, how does a teacher enable students to exteriorise (Barker et al., 1998) or externalise their mental models so that they can be understood and addressed? Mental model researchers have used a variety of methodologies to exteriorise mental models such as stimulated recall interviews (Henderson & Tallman, 2006; Edwards-Leis, 2006), questionnaires (Gentner & Gentner, 1983), partial and complete computer simulations (Johnson-Laird, 1983), and varieties of statistical analysis. Many of these methods are time-consuming, involving individual discourse or complex statistical analysis; both constraints on the practising teacher. Williamson (1999) used concept mapping to identify pre-service teachers' mental models. He found that 'concept mapping may demonstrate attitudinal changes as well as cognitive knowledge accommodations' (p.29) that are necessary to determine mental models.

Various studies by Novak (1990) have attributed value to concept mapping as an effective instrument both to evaluate and to instruct. Concept maps allow the concepts or components of knowledge to be related using annotations on the connecting lines thereby encouraging higher-order thinking. They allow the person constructing the map to make links that are personally meaningful thereby exteriorising the mental models that are being run to complete the map. Novak (1990) found that students younger than eight or nine years were unable to construct concept maps without assistance but students above these ages are capable of constructing detailed concept maps that have hierarchical form with labelled links.

The implication for teachers is that the mental models of their students can be made known and understood in ways that do not add to an already over-burdened curriculum. Once completed, the 'espoused' (Henderson & Tallman, 2006) or pre-experience concept maps can 'aid the learner in making sense of what they know and how parts or components of a concept map relate to the whole' (Williamson, 1995; p.23). Wandersee, Mintzes and Novak (1994) suggest that teachers can create environments that promote constructions of knowledge that can be critically scrutinised by all participants but first must know and understand the students' prevailing conceptions. Applying the functions of mental models to both the creation of, and interaction with, the design brief enables the teacher to promote more meaningful student engagement because prevailing mental models have been externalised and communicated.

Design briefs

An important component in most Design and Technology learning experiences is the design brief. What general experiences and concepts do students have that will enable them to approach the experience in a designerly approach (Archer, 1991)? What explorations will the students engaged with and what outcomes are being sought? If a concept map of students' existing mental models has been completed then the teacher would know if 'a learner was working with an incorrect model' and the teacher's knowledge of 'the nature of the model would be an important diagnostic' (Royer, Ciserao & Carol, 1993; p.221). The *explanatory function* of mental models would be evident in the concept map through the inclusion and matching of alternative solutions to the problem as well as evidence of existing experiences and concepts. This evidence would enable the teacher to prepare a design brief that delivered the instructions required for the explorations while addressing any flawed or missing mental models held by students.

The *predictive function* of the mental models being run to complete the pre-experience concept map would also be evident in the alternative solutions to the problem. Because several mental models can be run at once, even at the concept mapping stage, the predictive power of such models would guide the student to include a range of possible solutions to the problem that demonstrate their personal concepts of the materials, skills, and processes required to find solutions. This pre-experience running of the mental models required to address the complexities of the design brief allows the students to discard any ineffectual ones or manipulate those that will enable a workable solution to the problem. It also enables students to be aware of what they need to know because 'assessing new knowledge and skills in response to demands in the task is a fundamental characteristic of capability in design and technology' (APU, 1994; p.67).

What is clearly evident in the completion of the pre- and post-experience concept maps is the *communication function* of mental models. Mental models allow personal ideas, constructs, and conceptions to be known to others through communication strategies such as analogy. While instructional analogies (Gentner, 1998) are useful for teachers to create causal relationships for students (Gentner & Stevens, 1983), student analogies are also a rich source of information. A design brief can provide the opportunity for students to express their mental models through analogy which demonstrates how they map their existing knowledge and concepts to a new domain or problem. The capacity of Design and Technology to integrate the whole curriculum is demonstrated through the transference of conceptual understanding to the critiquing and/or development of systems and artefacts. The integration of contextualised cross-curricula concepts in Design and Technology experiences enables the development of the network of related understandings and knowledge (Pitts, 1994). In a similar way, mental models are integrated, cross-curricula representations that are made more robust and referable because of the propensity of our cognitive structures to integrate knowledge and concepts for better understanding and retention.

The *memory and organisation function* of mental models can also be facilitated by providing a design brief that includes opportunities, such as concept mapping, to relieve the load on working memory. The design brief itself provides support for graphically displaying the necessary steps in critiquing, designing, and making. The inclusion of the pre-experience concept map allows the student to document the mental models they have retrieved from long-term memory so that they have constant access to the knowledge and concepts relevant for thinking inferentially and relating propositionally with the design process. The concept map as a memory aid should help to diminish the load in working memory as well as documenting the mental models being run and manipulated.

Conclusion

When we challenge students in Design and Technology settings with novel situations for which they must solve a problem or critique an existing artefact, they retrieve the mental models that will steer and modify the thoughts and actions they take. The process of running a mental model invokes a mechanism or tool that allows understanding and action (Henderson & Tallman, 2006). Mental models enable conceptualisation, memory retention, interpretation of the internal and external environment, prediction of outcomes, control of performance, and communication of understanding. Teachers engage in pedagogical practices that aim to validate the learning process they undertake in the classroom. As O'Loughlin (1992) states, 'a truly emergent curriculum would validate the ways of knowing students bring to school by grounding the curriculum in their voices and lives' (p.814).

This paper has sought to highlight how pedagogical practices in Design and Technology can be adapted to be inclusive of students' personal realities and responses to learning by creating opportunities to externalise their mental models. It has offered a relatively simple strategy that strengthens the critique and design process while promoting a more complete understanding of student capability in design and technology (APU, 1994). All learning is recursive as learners, teachers and students alike, move through the processes of problem-solving, decision-making, and reflection. While any externalised representation of the mental models used to engage meaningfully with the environment will itself be a snap-shot in time, its power to communicate the richness of personal understanding is unquestionable.

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Aspirations, policy and practice: the use of ICT in one Tanzanian University

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Abstract
Information and communication technology (ICT) is taken for granted in many parts of the globe. Since the mid-1970s there have been radical technological innovations. These innovations invariably impact on other technological systems and on economic and social activities thus creating a new world information economy. For much of Africa this technological revolution has passed it by. This paper examines the ICT capacity within a Faculty of Education in a University in a developing country. It explores the hardware available to students and, crucially, examines the students' ability to access and harness this technology.

Introduction
Africa, like other world continents, needs to create a computer literate society if she is to compete and participate in the knowledge economy (Maltha, 2002). However, many countries in Africa are faced with significant problems that are more persistent than the use of computers or Internet thus excluding her from participating effectively in the emerging technological revolution (Stonier, 1983; Boyer, 1987; Castells and Tyson, 1989). Africa, the second largest continent of the globe, is said to be the least computerised continent in the world (Darkwa, 1996). Consequently, Africa lags behind other countries in the use of computers and the Internet. In the year 2001, for example, it was estimated that Africa had approximately 816 million people, of these, 1 in 130 (5.9 million) had a PC and 1 in 160 (5 million) used the Internet (African Internet Status (2002). It was further revealed that in Africa, each computer with an Internet or e-mail connection usually supports a range of three to five users. The increasing digital divide between developed and developing countries requires urgent attention lest African countries become excluded further from the knowledge economy.

Tanzania has *achieved notable progress in deploying ICT* (MOC&T, 2003, page 1), especially when it is bourn in mind that there was a prohibition order on electronic computers and television sets from 1974-1984. However, the lack of overall policy has led to *random adoptions of different systems and standards, unnecessary duplication of effort and waste of scarce resources* (MOC&T, 2003, page1). It was against this backdrop that the National ICT policy was constructed in order to tackle Tanzania's developmental agenda.

Linking to this policy is the Tanzanian Development Vision 2025 (MOE&VT, 1999). This far reaching and laudable vision has as one of its five main attributes *a well educated and learning society* (MOE&VT, 1999). Included in the Vision is the need to embrace *the new opportunities that ICT is opening up* so that they *can be harnessed to meet the goals of the vision* (MOE&VT, 1999). Nonetheless ICT is for the main part concentrated in the commercial capital Dar es Salaam with other urban areas and rural areas remaining un-serviced (MOC&T, 2003).
In common with other Africa countries, Tanzania's infrastructure to support the development of ICT is weak (MOC&T, 2003). Thus inherent difficulties face Tanzania as she implements a policy for ICT development. Infrastrcuture, internet availability, hardware and software and access, to name but a few, all pose challenges for the country. Nevertheless, the development of ICT alongside the building of human resource capacity in ICT are accepted as important within a knowledge economy and this is true for Tanzania. In acknowledgement of this, the Government introduced the Secondary School Computer Studies Syllabus for forms I – IV in 1997. However *qualified teachers coming out of African teacher training colleges today have had only limited exposure to ICT and almost no actual*

training in how to incorporate ICT into their teaching practice (Isaacs-Bardien, 2004, pg 23). This, coupled with the acknowledgement that the evolution of technology occurs at such a rapid rate that any computer studies syllabus is outmoded almost before implementation, results in a disjointed approach to ICT in education.

African higher education has witnessed unprecedented expansion in the past few decades (Juma, 2001, page 1). Abegaz (1995) and Widstrand (1995) both highlight the crucial role that African Universities will play in sustaining the expansion of their nations. Within a University ICT might be regarded as critical if academics are to participate at a world level with their colleagues in developed countries. Joint projects often rely on technology to facilitate early discussions between partners. Access to the internet offers African academics the opportunity to source and contribute to information from across the globe. Indeed Luhanga et al (2003) suggest that the success of African Universities to manage global challenges will be judged by several criteria including *the local capacity to operate, develop and maintain ICT facilities so that connectivity is guaranteed at manageable costs* (page 13). However there is perhaps a difficulty here if we accept the findings of the *Review of Basic ICT Skills and Training Software for Educators in Africa* report which suggested that many educators had been left behind in the digital revolution (James et al, 2003).

The purpose of this study was to investigate the current situation regarding ICT within the Faculty of Education in a University in a developing country. The availability of ICT hardware and the working knowledge of one hundred fourth year students within the Faculty were explored.

Methodology and sample

The main research method selected for this study was interview. While an interview allows the researcher to follow up ideas and investigate replies there are a number of limitations to this form of research. As Bell (1993) states *it is a highly subjective technique* (Bell, 1993, page 91). Due to its subjective nature there is an ever-present danger of bias appearing in interviews. As Sellitz et al. (1962) indicates *interviewers are human beings and not machines* (Sellitz et al, 1962, page 583). Any social action comes per se with a set of values and as such a value free position for the researcher is unrealisable. Interviewers, respondents and the content of the questions may all affect the bias of results. Intonation or closed questions may direct the respondent to answer in a particular way, thus unintentionally giving credence to the preconceived ideas of the interviewer. It may be possible to misconstrue the respondents reply or indeed the respondent may misinterpret what they are being asked. Moser and Kalton (1971) give an account of an interview as *a conversation between interviewer and respondent with the purpose of eliciting certain information from the respondent* (Moser and Kalton, 1971, page 271). The simplicity of this statement masks an intricate process, which has to be planned carefully if results are to be valid.

The researchers also carried out an audit of available and working technology within the Faculty of Education and communally accessed machines in UDSM.

At the University of Dar es Salaam (UDSM), students who embark on an education course can be registered under different faculties. Some students register under the Faculty of Arts and Social Sciences, others register under the Faculty of Science and still others are registered under the Faculty of Commerce and Management. However, most education students are registered under the Faculty of Education. On leaving the University of Dar es Salaam (UDSM) they go on to work in Secondary schools, teacher training colleges or in the Ministry of Education and Culture (MOEC). At the time of this study, the Faculty of Education had 1,377 undergraduate education students and 63 Masters students. A total of 100 fourth year students from the Faculty of Education took part in this study. Sixty four female and thirty six male students were selected as participants as they were completing their time within the University and were therefore more likely to have had exposure to ICT throughout their time in the Faculty. These students will also graduate soon and be part of the Tanzanian workforce so this cohort of students would also offer some idea of how many soon to be qualified teachers had knowledge of ICT.

In total twelve questions were asked of each participant. Questions related to three key themes – access, availability and ICT competency. This was considered important baseline information and it was seen as laying the foundations for possible future research work regarding the use of ICT in relation to teaching and learning. The lead researcher and two Masters students interviewed the participants. All respondents were asked following questions, answers were recorded on paper by the researchers as there was no access to any form of technology eg recording equipment, PC etc.

1. Did you have computer knowledge before you joined the University? Yes/No. If you answered yes go to question 2 and 3. If you answered no, go to question 4.
2. if you answered yes, where did you learn these skills and what knowledge do you have?
3. how would you rate your skills with 1 being poor and 4 very competent (poor, moderate, competent, very competent)
4. does the University give you course leading to computer literacy? Yes/No. If you answered yes, please name the course
5. did you learn both theoretically and practically? Yes/No.
6. if you used a computer during your course, approximately how many students shared the one computer?
7. do you have a computer in your parents' home? Yes/No
8. do you have a computer in your dormitory? Yes/No
9. how many times each week do you use the internet?
10. during teaching method classes, are you taught how to use computers for teaching and learning?
11. how many of your professors/lecturers use technology such as power point when they teach?
12. what do you consider are the main obstacles to computer use during teaching and learning at the University of Dar es Salaam?

Qualitative data is concerned with comprehending the individual's viewpoint of the world around them. Empirical generalisations cannot be made from this kind of research, however general concepts which locate the claims and conclusions in the broader theoretical framework may be made.

Results

A stock take on computer facilities in the Faculty of Education found that there were 12 computers which were in working condition, and 26 which were out of order. There was therefore one computer for approximately every 120 students. It is perhaps hardly surprising that access was reported as being a key issue during the interviews. Students reported that it was impossible to just walk into a computer suite and use a computer. Some reported waiting for several hours others waited as long as a day, some students simply gave up waiting. In the University Main Library there were six Online Public Access Catalogue (OPAC) computers and sixteen PCs in working condition. In the Reference Room and at the main desk there were twenty four computers of which nine were found to be working. 16,000 students in total are enrolled in UDSM, clearly this number of communally accessed computers is insufficient to meet demand.

Interviews

The students were asked if they had knowledge of computers before they entered the University. Sixty-six respondents reported that they did not have any knowledge, and the remaining thirty four said they had some knowledge of computers before they were enrolled. Those who had knowledge had learnt through independently through privately owned computer training centers. When asked about use of the Internet, only ten students reported that they had good knowledge of Internet use. The others had knowledge of the introductory methods to computer use. Of the remaining ninety, forty eight respondents rated their knowledge as moderate while forty two respondents rated their knowledge as poor.

All the students indicated that they had taken a course in computer at the University of Dar es Salaam. The University of Dar es Salaam requires that students register for a computer course. However, all indicated that the course considered the theoretical use of computers with little practical work being undertaken due to lack of computers. During the course, a group of students would be assigned to one computer. The respondents indicated that sharing one computer for a few minutes did not offer sufficient opportunity to practice the theoretical situations covered in lectures. For example, fifteen students interviewed reported that in their class thirty or more students shared one computer. Ten participants said twenty six students shared one computer while five students said ten students shared one computer during the computer course. The instructor used one computer, which he used as a model while teaching. When asked if they were computer literate, seventy students said they were not computer literate even after taking the computer course thus suggesting that a theoretical knowledge alone is not sufficient.

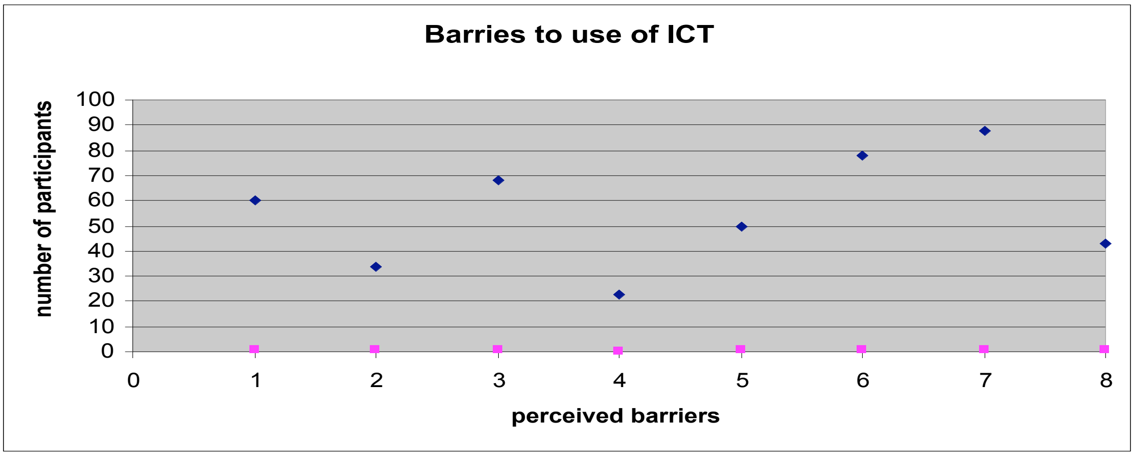
Participants stated that they had little access to computers. Only five students said they had personal computers with sixteen students having access to a computer in their parents' homes. When asked about use of the internet, thirty-two students accessed the Internet once a week, thirteen twice a week and fifteen students accessed Internet three times a week. The remaining forty students did not use Internet at all. When asked what the students why they accessed the Internet common answers included writing and sending emails, typing, playing games and searching for information.

Very few students accessed the Internet for learning purposes and they stated that the main reason for this was the lack of access to computers. As an integral part of the education course that considers teaching methodologies, students are taught the importance of using computers for teaching and learning purposes. There is a paradox here when in reality few computers are readily available.

In terms of technology being used by staff within the course, students reported four out of forty one lecturers in the Faculty of Education used power point in some of their classes. These lecturers did not use power point consistently. Data projectors and laptops or PCs are not available in lecture theatres or teaching rooms therefore it was only when lectures could supply their own technology were they able to use power point. Power cuts also affected the use of power point sometimes. It is hardly surprising that with these obstacles, the use of chalkboard becomes the only reliable alternative.
The respondents agreed that the use of computers and the Internet for both teaching and learning at the University of Dar es Salaam was important. However, they identified eight barriers that exist in relation to the effective use of this technology including:

1. poverty
2. lack of knowledge
3. ICT is expensive
4. lack of experts for maintenance
5. financial problems
6. power cuts
7. inadequate computers
8. enrolment expansion at UDSM

Table 1: Barriers to using ICT



Sixty participants considered poverty to be an issue relating to access. The cost of computers discriminated against people who were poor with one respondent saying *when someone lives under a dollar a day, it is difficult for such a person to think of buying computers instead of food.*
Power cuts are common in Tanzania and this poses another serious obstacle to the use of ICT. Seventy eight of the respondents suggested that interruptions to power supplies made computer use difficult and unreliable. While alternatives such as solar power and radio computers may offer a way forward, solving the electricity problem alone is unlikely to be enough.
The number of students at the University of Dar es Salaam is increasing with the result being that more students share one computer than in previous years. Forty three of the students stated this was an obstacle to using computers successfully for teaching and learning.
In a country committed to inclusion, it was interesting to note that students with, for example, visual impairments complete their degree having at no point had access to a computer. None of the computers within the University provide audio output for students with visual impairments.

Conclusion
Information and communication technology (ICT) provides many new ways of supporting and improving traditional means of educating students. Tanzania, like many other world countries, acknowledges the fact that ICT and computer literacy are vital in today's information society. However, it seems that the University of Dar es Salaam is faced, at present, with an infra structure that makes the use of ICT at best difficult. This leaves UDSM facing an interesting dilemma. The availability of adequate, current and useful information to inform courses is a key aspect of quality. Students and staff have at best limited access to that information through the use of ICT. UDSM could therefore invest in hardware, software and training, all of which would take considerable funding and time or she could invest in updating and developing traditional and existing methodologies currently used by staff. *There is greater recognition that most of the poorest countries are trapped in a vicious cycle of stagnation and poverty, and are unable to benefit from globalization* (Rugumamu, 2005, pg 191) thus finding a people-centred strategy that maximises the learning opportunities of all offers a way forward. While Microsoft may have signed an agreement with Tanzania to develop ICT (2006), UDSM cannot afford to wait until the effects of such international agreements reach grassroots level. For sure ICT plays a significant part in the technologically driven 21 Century but as can be seen from this study, even secondary school and soon to be University graduates have little knowledge of ICT. If Tanzania is to ensure her children are educated and ready to participate in the 21 century then she has to ensure that teachers can teach and are not reliant on an, at present, utopian technological world.

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The EdaDe and Paulo Freire's pedagogy: an approach.

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Abstract
This paper summarizes briefly the thoughts of Paulo Freire about the philosophy of education and tries to show the possible approach between his ideas and the EdaDe purposes. It begins with some words about Freire biography; tries to explain his epistemology and the principles or foundations of his pedagogy, it presents the stages and the steps of his method and finally, tries to show how Freirean pedagogy could be applied in the children and youth education by design.

Key words: EdaDe, Freire's pedagogy,

Introduction
EdaDe is a neologism created and used for the purpose of the education of children by design activities and tasks (FONTOURA, 2002). It is an acronym of the Portuguese expression 'Educação através do Design' [Education by Design]. The EdaDe has its pedagogic bases on constructivism and interactionism into educational field. The EdaDe results from a doctoral research work that investigated the international experiences consolidated in others countries, among them the British D&T, the Scottish Technology subject and the American Technology Education. The EdaDe purpose aspires to be an appropriated model to the Brazilian educational reality. The EdaDe research made a review of precepts defended by The Brazilian New School Movement and the educational concepts of Anísio Teixeira (1) – Brazilian disciple of John Dewey. In this path we crossed, indirectly, with the filiation of Paulo Freire to Anísio Teixeira and like this, in a way, to Dewey's pragmatism. EdaDe seeks to surpass the 'learning by doing'. It tries to promote the 'learning and thinking by doing'. But it is not limited by these. It also seeks to contribute with the education of conscious, critical and engaged citizens, capable to live and intervene in the construction of a better world and to interact with the new emergent technologies. This paper aims to make an approach between EdaDe and Freire's educational philosophy. It tries to identify the possible contributions of his pedagogy to the children education by design.

Who was Paulo Freire?

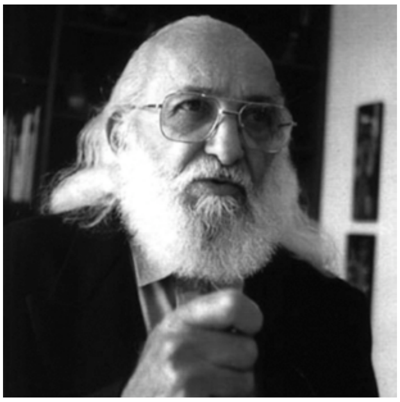

Figure 01 – Paulo Reglus Neves Freire (1921-1997)

Paulo Reglus Neves Freire, was born in Recife in 1921 in the northeast of country, one of Brazil's poorest regions. He attended the Law School but he never worked as a lawyer. The education was his passion. He was exiled after the military "coup-d'état" in 1964. In Chile, he wrote in 1968, the famous book Pedagogy of Oppressed. In exile he developed works and projects in some Latin American Countries, in Europe and in Africa. He acted as a professor at Harvard University's School of Education, in the United States. He also worked in the World Council of Churches in Geneva. He returned to Brazil in 1980, during the Brazilian amnesty process. He worked at the State University of Campinas and in Pontifical Catholic University of São Paulo. From 1989 to 1991 he was the Secretary of Education in São Paulo Capital. He received dozens of Honoris Causa doctorates from universities all over the world and numerous prizes, including UNESCO's Peace Prize in 1986. On April 10, 1997, was launched his last book, entitled Pedagogy of Autonomy. He died in 1997.

Freire was more than an educator; he was a philosopher of education. He devoted his work to the popular education and to the adult's literacy. He didn't believe in a neutral education. The education process is always a political action that results from relationships among power, domination and freedom of people. He defended a pedagogy that frees the oppressed people. This should go by an intense dialogue between educator and learner.

Paulo Freire was opposed to that he called 'bank' education. For him, the conception of bank education is characterised, by the existence of a depositor – the educator – and a receiver of the education – the student. Freire believed that this kind of education generate alienated persons, unable to read the world critically.

'It is necessary to give an end to the bank education, that in which the teacher deposits into their students his knowledge'.

He was always worried about the educational qualification. The educator should be a provocative of learning situations; he should be a cultural agent in an atmosphere in which all learn in communion.

'Nobody teaches anything for anybody and the people don't learn alone'.

Method or epistemology?

There are some studies and academic works about the called 'Paulo Freire's Method'. They won't be shown here. Actually, we tried to understand which are the principles and practices of this 'method'. Freire understood his proposal as much more as a 'theory of knowledge' than a 'teaching methodology'. For him it was much more a 'method of learning' than a 'method of teaching'. His 'theory' is based on the respectful relations with the learner, in the conquest of the learner's autonomy and in the dialog [dialogicidade] while methodological principle.

The Freire's method was created in the beginnings of 60's and through its dissemination, he was known internationally. At this moment, the adults in Brazil were literate with the same procedures used in the children's literacy. The new method had as presupposition the use of 'generating words', 'generative words' or 'generate themes'. The generating words or themes are expressions that make part of the learners' current vocabulary - words used in the student's social and cultural context. In Freire's point of view, they shouldn't just learn how to form words out of theirs context of use. They should understand theirs true meaning and theirs function in the society.

The method allowed obtaining great results not just in terms of adult's literacy, but also to promote the rural workers' consciousness (2).

Paulo Freire conceives the literacy as an emancipatory and socio-cognitive process. Adult literacy is a complex process of liberation. He called attention to illiteracy as a consequence of poverty and exploitation. Literacy process is not only cognitive. It is also social and "ideological". That is, the literacy process needs to attack also the causes of inequalities in society.

The Freire's proposal begins in the 'study of the reality' – learner's speech – and in the 'data organization' – educator's speech. In this process the 'generating themes' appear. They are extracted of the learner's life 'problematization'. The contents and issues are results of diological methodology. Each people and each group involved in this pedagogical action have in themselves, although in a rudimentary way, the contents that should be worked. The most important thing isn't to transmit specific contents but to awake a new relationship with the lived experience. The transmission of structured contents out of the learner social context is considerate as a 'cultural invasion' or a 'deposit of information' because they don't emerge from the popular knowledge. Therefore, before any other thing, is necessary to know the learner. To know him while a person inserted in a social context from where should leave the 'content' to be worked.

While the Freire's proposal is addressed for adults' education, EdaDe seeks young and children education. Then, to extract 'generate themes' of learner's life 'problematization', in EdaDe context, actually don't have the same meaning and power. However, we must recognise that children and teenagers, today, bring to our classrooms many pieces of knowledge, although incomplete, some times mistaken and rudimentary, but always knowledge. There are in themselves symbolic and referential universes – subjective realities – that should be explored. The contents also can be chosen from those realities. In a constructivism point of view, the new knowledge appears from the confrontation of the learner's subjective reality with the objective reality presented to him or her. We can do it by a kind and a competent dialogue with our students.

The principles or foundations of Freire's pedagogy

The two maim principles of Paulo Freire's educational philosophy are:

1. The politicize way of the education action
One of the axioms of Freire's thought is: 'neutral education doesn't exist'. The education understood as constructions and continuous reconstructions of meanings in a specific reality (context), foresees the human's action on that reality. The naive vision that persons have of the reality can transform them in slaves. It happens when they don't know their own power to transform this reality and then they undergo that. The disbelief in the possibility to intervening in their reality, many times are fed by the school manuals that put men and women as observers and don't as protagonists of that reality.

2. The dialogical vocation of educational action
We can talk that Freire's pedagogy is founded in a dialectic philosophic anthropology whose goal is the person's engagement in the fight for social transformations. The basis of this pedagogy is the dialogue. The education practices demands dialogue. It is a dialogical relationship. This premise is present on Freire's thought in several ways: between educator and learner; among learner, educator and the object of the knowledge; and between nature and culture. The dialogue between nature and culture, humans and culture and between humans and nature, were common practices in adults literacy proposed by Freire.

These two main principles are fully valid for the practice of EdaDe because, when children or teenagers transform the ambient, when they set up and disassemble objects, when they study, analyze, design and build things, they change themselves.

According to Freire the educational action should always be an action of re-creation and of re-significance of meanings. To learn is an act of knowledge about the concrete reality, that is, about the real situation lived by the learner and it only has sense if it results from a critical approach of that reality.

'Before teach someone to read words, it is necessary to teach him to read the world'.

The Freire's proposal seeks to promote the debate among the human, the nature and the culture, the debate between the human and the work, finally between the human and the world in that he or she lives. As a dialog methodology, it tries to prepare the human beings, to live in the world with its contradictions and conflicts and then to become aware about the need of intervening on the present for the construction of a better future.

The Freire's dialogical method makes sense to the EdaDe. The interaction, critical and provocative confrontation of the children with design problems (activities and tasks); of them with objects which they are studying, analysing and building; of them with the ambient that they interact; of them with other children and with the educator in the classroom, should promote in them reflection and understanding.

Paulo Freire continued developing his 'method', distancing it of every technical connotation. He wouldn't like to see his theory of knowledge reduced as just a method (3). Therefore we can't study the stages or steps of his method without understanding it in the context of his epistemology.

Method's stages
Paulo Freire conceives the literacy as an emancipatory and socio-cognitive process. He considered the adult literacy as a complex process of liberation. He called attention to illiteracy as a consequence of poverty and exploitation. Literacy process is not only cognitive. It is also social and 'ideological'. That is, the literacy process needs to attack also the causes of inequalities in society. The method of the formation of a critical conscience passes through three distinct stages. They can be described as follows:

1. Investigation stage
In this stage, educator and learners together, look for the words and more significant themes of learners' life, inside their universe vocabulary and in the community where they live (thematic investigation - sociological research: investigation of the vocabulary universe and study of the way of life in the place - study of the reality). In this stage the universe of vocabulary are discovered and the words and generative themes are found. They are related to the daily life of learners and of the social group to which they belong. The generative words are chosen according to their syllabic length, their phonetic value and mainly for their social meaning for the group. The discovery of their vocabulary universe can be made through informal meetings with the dwellers of the place, living with them, sharing their worries and feeling their culture. The selection of generative words is based on: their phonemic richness, phonetic difficulty and their pragmatic tone – engagement of word in political cultural reality.

2. Thematization stage
This stage refers to the moment in which the conscience of the world is obtained by the analysis of the social means of the words and themes (thematization is the process of choice of the generative themes and words). The themes resulting from the initial awareness stage will be codified and decodified. They will be contextualized and they will substitute, by a critical and social way, the first sights. Then, new generative themes, related to those initially found, are discovered. In this stage the cards – discovery cards – with the syllables and the phonetic groups of the words are made.

3. Problematization stage
In this stage the educator challenges and inspires the learners to overcome their magic and ingenuous vision of the world, and to be more conscious. The problematization stage seeks to overcome the first sights and to substitute them for others more critical and capable to transform the context. It is a return from the abstract to the concrete. The limits and possibilities of the existential situations were found in the first stage. Concrete action which will overcome the limiting political, cultural and economic situations, that is, the obstacles to hominization – the process of becoming a human being – is

necessary. The alphabetization process is, under this view, an instrument of struggle, social and political activity. The main objective of the method is concientization.

The EdaDe proposes to use design activities (tasks) as a way to teach and to promote learning. These activities can be practical, such as constructions, intellectuals such as analysis and investigation or creative such as design and conception of new products or solving problems. The activities are proposed by educator in the classroom or outdoor. The activities allow somehow integrating knowledge of several curricular areas – Math, Science, Arts, Geography, History, etc. But they are always related to the word of technology and design.

In an attempt of appropriation of Freire's method, in EdaDe's practices, the investigation stage could be characterized as that initial moment, in which the teacher and the students try to identify and to diagnose, through a dialogue process, their subjective universes and the cultural and social references involved in the design problem to be solved. The thematization stage could be characterized as the moment that the student get conscience and enlarge their knowledge by analysis and discussions (dialogue process again) about the variables involved in the studied problem. The thematization stage would be the moment, in which teacher and students together, create, develop and build concepts and they materialize solutions, overcoming the initial ingenuous vision, generating a more critical vision of the problem and of their possible solutions.

In a practical way, the Freire's method, begins with dialogues and chats and arrive to a list of generating words. These words are used in charts made with their syllables. They are used to promote a systematized learning. For instance, the Portuguese word 'tijolo' [brik], it can be used, in a subsequent stage, to work with the syllables and phonemes ta-te-ti-to-tu, ja-je-ji-jo-ju, la-le-li-lo-lu. However, what matters more in this method is the capacity to use the dialogue as a resource to teach and to develop, in the learner, what Freire called critical conscience.

The Freirean procedure to teach the adult to read and write with syllables and phonemes, as a method, it is surpassed. But the use of generating words continues being quite current.

The Brazilian educator, Moacir Gadotti (1999), Director of Paulo Freire Institute in São Paulo, colleague and Freire's disciple, describes the steps of the method as:

1. To read the world
The first step of his method is the reading of the world. Paulo Freire insisted, all his life, in this key concept. The curiosity is the condition to enlargement of knowledge (interest, for Habermas). Freire still insisted on the student's autonomy. The learner is who knows.

2. To share the reading of the world
For Freire, it is impossible to know if the reading of the world accomplished by the learner is correct or not. The condition to know about it is to compare his readings with the readings of others. The dialogue isn't just a pedagogical strategy; it is a criterion to obtain the truth. The veracity of an individual point of view depends of the glance of the other and of the communication process involved. Only the glance of others can give veracity to his point of view. The dialogue doesn't exclude the conflict. It is born from the dialogue and confrontation of different glances. Freire understands the confrontation of glances as a way to obtain the common truth. Otherwise the truth that is obtained is naive and non critic. The other is ever on in this search. This second step directs the learners to the solidarity. The individual's knowledge is only valid when it is shared with somebody. The communication action is part of the knowledge's search (Habermas, in the Freire's thought again). It isn't an action of the human's generosity of understanding. It is an ontological and epistemological necessity.

3. The Education as production and reconstruction of knowing.

To know is not to accumulate knowledge, information or data. To know involves the change of attitudes, to learn to think and not just to assimilate contents of the knowledge just called universal. To know is to establish relationships: to know is to create entails (Piaget in Freire's thought). The content becomes forms. Paulo Freire was combated by the "content educators" because they didn't still understand that, in education, the 'form is the content'. To know is to change the form, to create the form, is to form ourselves. To educate is to be formed.

Only recently, the educators got to understand this new vision of education when they discussed the education of the future, as in the report of Jacques Delors of UNESCO (1998) in which he establish four great pillars: learning to know, learning to do, learning to live together and learning to be. For the first time the specialists in education noticed that to educate is to create entails and not to decorate contents. Paulo Freire was early at least 50 years. When he created his "Circle of Culture"(4), he also created a practical methodology that offered the bases for the construction of those pillars and breaking up with the classic notion of "class".

4. Education as a practice of freedom.
At this moment, it is possible to observe some similarities between Freire and Piaget thoughts. But the constructivism critical of Freire went beyond the Piaget concepts because he affirmed the political nature of the knowledge. Education isn't only a science; it is an art and praxis, action and thinking, understanding and project. For Freire, the education as a project, it has a mission: to recuperate the hope. Nothing is more current than this concept, in this moment in that many educators are more disenchanted than hopeful.

The aim of EdaDe practice is to provoke the learner's curiosity and motivate them for the autonomous search of knowledge. It is possible when the EdaDe activity promotes the discussion about a specific subject and tries to establish its connections with the student's daily life; therefore, it is in syntony with the first step of Freire's method.

When EdaDe promotes discussions, dialogues and interactions among the students, before, during and after its practices, the children share and confront their different glances. They share with others theirs thinks, they agree and disagree, finally, they build their knowledge, through a dialectic relationship – second step of Freire's method.

When the children and the youth build, assemble and disassemble, analyze and investigate, design objects and discuss the design process, they don't just assimilate knowledge but, they establish relationships and bonds among what they did and what they thought - thought and action, hand and brain -, among what they know and what the others know - subjective reality and objective reality -, among what they are and what the others are, and among all these things and the implications of them to change the students' attitudes. In other words, they actually learn – third step of Freire's method.

When the children and the youth are designing things, they are transforming the world and transforming themselves at the same time. They are getting political conscience of their history condition, of their human existence and of their social reality. They are contacting the culture material of their society. They are assimilating new moral values and building new knowledge. Finally, they are beginning to be more critical, conscious and responsible - fourth step of Freire's method.

To conclude
The structural axis of Freire's pedagogy or epistemology is the idea that: to educate is more than to develop human abilities. He calls the attention for the necessity of a good and ethic qualification of teachers. The teachers should become aware about the importance of stimulating the students to think critically their reality. Freire emphasized some primordial aspects that should be adopted by the current society: simplicity, humanism, good-sense (ethic) and hope. In his point of view, the capitalism leads the society to an exacerbated consumerism and a collective alienation, mainly,

through the vehicles of mass communication. The lack of connections between the teaching and the apprentice's social and economical context, maintains the social status quo, because the school is still one of the most important ideological machines of the State.

In spite of Freire's pedagogy has been originally directed to adult literacy, and has been, for a long time, erroneously reduced to a sequence of techniques, its bases are on the dialogue, on the hearing and on the respect to the learner as a person capable to be an active producer of meanings and not just a passive receiver of lessons. The possible approaches of EdaDe with the steps and thoughts of Freire seem to be in consonance with epistemology proposed by him. Therefore, the constructivist pedagogy of Freire should be, more and more, a significant way to the practices and the thinking's exercises on EdaDe. Without question, the life and work of Paulo Freire has contributed in immeasurable ways to contemporary understandings of the meaning of pedagogy, literacy, and social action.

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Notes:
(1) - Anísio Spinola Teixera (1900-1971), studied in 1928, at Columbia University in New York, where he knew John Dewey. In 1932, he wrote with others educators the Manifest of New Brazilian School Pioneers. The manifest represented the start of Brazilian educators' engagement in the fight for a free, compulsory, public and democratic school for boys and girls.

(2) - The conscience is, fundamentally, the strictly human capacity, to foresee and to plan the own activities, to contemplate them during the action and to compare the results with the previous plans, with the principles and with the theoretical or practical ideals. The conscience is the capacity to plan, to contemplate and to criticize. It results from the confrontation between the material things and the human spirit. This confrontation takes place primarily in the action of producing, in other words, in the manipulation of the raw material for the production of the necessary objects to the human survival.

(3) - There are many interpretations of Freire's thoughts in which he didn't get to recognize himself. Some interpretations are very dogmatic and political; others are made with low academic rigour.

(4) - The Freirian Cycle of Culture is a strategy to promote the freedom education. In it, there would not be place for the bank teacher, who knows everything, nor for a passive student, who knows nothing. The Cycle of Culture is a place where everybody has voice. It is a place where everybody read and write the world. It is a space of work, research, expositions and existences that make possible the collective construction of the knowledge.

Developing "PISA Tasks" for Teaching Technology Literacy

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Abstract
Over the past two years, international comparative tests such as the TIMMS and the PISA have become important items in the Israeli educational calendar and have impacted significantly on the integrated Israeli Science and Technology curriculum. In order to help students prepare for these tests, "PISA Tasks" were developed and introduced into the curriculum for grades 9-10. In some cases these tasks came to form the major part of Science and Technology studies.

Pencil and paper PISA Tasks focus on mathematic literacy, reading literacy, scientific literacy and problem solving. The Department of Technology Education in the Israeli Ministry of Education decided to employ the concept of task based teaching and assessment for technology literacy (TL) as part of the grade 10-11 technology education curriculum.

A conceptual framework that serves as a basis for developing "PISA Tasks" for teaching, -learning and assessing TL (similar to PISA Tasks for scientific literacy and problem solving) is described in the paper.

The paper is divided into four sections: (a) Introduction – a review of literature on different aspects of technology literacy; (b) Conceptual framework for developing "PISA Tasks" for technology literacy; (c) Structure of "PISA TL Tasks" and (d) Reflections and Dilemmas.

Key Words*: Technology Literacy, Technology Knowledge, Technology Capabilities, Technology Literacy Assessment, PISA*

Introduction
The following review of literature focuses on two key issues in the development of PISA TL Tasks: (a) the dimensions of TL and (b) the "PISA" framework.

Technology Literacy
The goal of educational systems is to prepare students for a positive role in society – and society today is highly technological. The widespread acceptance that TL is a desirable outcome has led to the development of different conceptual frameworks (curriculum organizing principles) and the implementation of various innovations in technology education curricula.

On the theoretical level, most definitions of TL have in common three main dimensions: technology knowledge, technology capabilities and attitudes toward technology. On the practical level, they all have in common aspects of Design, Make and Appraise.

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A deeper analysis of the dimensions and aspects of TL in the curricula of various countries reveals differing interpretations, meanings and implementation. TL has been discussed extensively over the last twenty years and it is still being redefined. This paper will survey only the most recent publications on the topic.

According to the Academy of Engineering, TL is visualized in three dimensions: knowledge, capabilities and ways of thinking (Technically Speaking, 2002).

Four years later, the last dimension was redefined as decision making and critical thinking (TechTally Report, 2006).

A different set of dimensions for TL was proposed by Kierl (in Dakers, 2006) as follows: (a) operational dimension – learning to use and to do; (b) cultural dimension – learning in the world how to design and make products and learning through technology and (c) critical dimension – learning about, and to be with technology.
The conceptual framework that will be presented later in this paper is an interpretation of the above and includes three dimensions as follows: technology concepts, technology knowledge and technology capabilities

What are Technology Concepts?
De Vries & Tamir (1997) distinguished between two types of Technology Concepts: (a) concepts of technology - the overall concepts of the nature of technology and (b) concepts in technology – the theoretical concepts that are used in technological activities

Others have defined technology concepts as framed by three areas of study: physical products, human processes and environmental systems which include concepts such as: structures, materials, fabrication, mechanisms, power and energy, control, systems, functions, aesthetics and ergonomics (Hill, 1997). Yet another view sees these concepts as trade-offs, resources, systems, processes, optimization, control and requirements (ITEA, 1995, 2000).

In New Zealand's curriculum for technology education, the second objective introduces the notion of *technological principles*, the list of which includes modification, adaptation, user-friendliness, fail-safe features, flexibility of use, reliability, fitness for purpose, efficiency, ergonomics, aesthetics, and optimisation (Compton, 2004).

Although, there are different approaches to the issue of concepts, there is wide consensus about the necessity of teaching technology concepts, "…not only skill, but also concepts of technology need to be taught" (De Vries, 1997).

The importance of teaching technology concepts led us to include them as one of the three dimensions in our conceptual framework and separate it from technology knowledge.

What is Technology Knowledge?
While there is still substantive debate internationally surrounding the notion of technological knowledge, there is a growing body of literature that considers technological knowledge as a distinct and fundamentally different area of knowledge. Based on this premise, technological practice has been analyzed in order to identify different types or categories of technological knowledge (Compton, 2004).

Vincenti (1984, 1990) identified three categories of technological knowledge: a) descriptive, b) prescriptive and c) tacit. Descriptive knowledge describes things as they are, prescriptive knowledge prescribes what has to be done in order to achieve a desired result and tacit knowledge is implicit in activity.

McCormick (1997, 2006) referred to technology knowledge as both procedural and conceptual knowledge. Procedural knowledge is defined as "knowing how to do it". Design, modeling, problem solving, system approaches, project planning, quality assurance and optimization are all examples of technology procedural knowledge. Conceptual knowledge, on the other hand, is concerned with relationships among "items" of knowledge: when students are able to identify these links they have acquired "conceptual understanding". While thinking about curriculum and pedagogy the key point that distinguishes "knowing-that" from "knowing-how" is that "knowing-that" can be expressed in terms of propositions and "knowing-how" cannot. This, no doubt, has consequences for teaching. Knowing-how cannot be expressed in propositions and therefore cannot always be taught in the same way as knowing-that. Knowing-how probably needs to be learnt by experience, by watching and doing (Ryle in De-Vries, 2005).

Mioduser (1998) described technological problem solving within the framework of a taxonomy of technology knowledge, based on specific cognitive goals (e.g. to be aware, to understand, to use …and to design). According to this model, technology knowledge ranges from the basic facts (factual knowledge) through device topography, debugging procedures, and finally to systematic design methodology.

The problematic of technology knowledge is presented in the following quotes from De-Vries:

> "… The epistemology of technology is by no means yet a fully developed area; however it is already clear that conceptual knowledge is an essential component…" (1997).
> "…Technological knowledge has certain characteristics (e.g. normative element) that make it different from scientific knowledge" (De-Vries, 2005, p.35).

Therefore, it is difficult to define technology knowledge in the terms of scientific knowledge as it is more complex and, because technology knowledge is linked to a specific activity, it cannot be easily categorized and codified as can scientific knowledge.

Being aware of the problematic issues that refer to technology knowledge, it is an essential dimension of TL and therefore, one of the three dimensions in our conceptual framework.

What are Technology Capabilities?

Technology Capability has been defined as "the combination of skills, knowledge and motivation that transcends understanding and enables pupils creatively to intervene in the world and 'improve' it" (Kimbell, 1997).

Characteristics of technologically capable students include the ability to:

- Recognize problems needing practical solutions;
- Develop and evaluate a variety of alternative solutions to a perceived problem;
- Evaluate, select and optimize appropriate resources;
- o Solve problems which require the application of technological, mathematical and scientific knowledge;
- Work within imposed constraints and with limited resources;
- Evaluate the effectiveness of technological solutions;
- Make value judgments regarding possible and actual actions taken;
- o Feel comfortable learning about and using systems and tools of technology in the home, in leisure activities, and in the workplace". (Kimbell, 1991)

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A different approach to technology capabilities within TL has been taken by the NAE (National Academy of Engineering), emphasizing a range of hands-on skills such as using a computer, fixing simple mechanical problems at home and making informed judgments about technological risks and benefits (Technically speaking, 2002).

The TechTally report (2006) defines the "capabilities dimension" as how well a person can use technology (defined in its broader sense) and carry out a design process to solve a problem.

While common to all approaches is the notion that problem solving capabilities are the most valuable, it is not quite clear whether to treat problem solving as a technology capability or part of procedural knowledge.

For the purposes of this study, problem solving will be regarded both as procedural knowledge (in the Knowledge dimension) and as capability (in the Capabilities dimension). Problem solving as procedural knowledge is the ability to identify different strategies for solving different technology problems (e.g. - design as the methodology/process by which the problems are solved). The capabilities nature of problem solving refers to the hands-on and cognitive skills required to solve the problem.

PISA Tasks

The OECD Program for International Student Assessment (PISA) is a collaborative effort to measure how well 15 year old students are prepared to meet the challenges of today's world. OECD/PISA combines the assessment of domain-specific areas such as reading, mathematical literacy and scientific literacy with important cross curricular areas. Paper and pencil tests are used with assessment lasting a total of two hours for each student. The test is a mixture of multiple choice and open-ended questions. The emphasis is on the mastery of process, the understanding of concepts and the ability to function in various situations within each domain.

PISA Tasks in science literacy deal with three domains: (a) scientific knowledge and concepts; (b) scientific process and (c) areas of applications.

PISA Tasks in problem solving focus on generic reasoning and the problem solving process though these areas are not part of the defined subject matter. The tasks assess how students come to: (a) understand the nature of a problem; (b) characterize the problem by identifying variables and relationships inherent to the problem; (c) select and adjust representations of the problem; (d) solve a problem; (e) reflect on the solution of a problem and (f) communicate the solution of a problem.

Problem solving tasks are divided into three areas or problem types:

(a) decision making – the student needs to select from a number of given options. In order to do so, the student must combine information from a number of diverse sources and select the best solution;

(b) System analysis and design – the student must be able to analyze complex situations and determine the relationships defining the systems or to design a system that satisfies the given relationships and achieves the relevant goals. Additionally, the students must be able to evaluate, justify and communicate a solution;

(c) trouble shooting – the student needs to understand how the device or procedure works, identify the critical feature for the diagnosis of specific problem, create or apply the relevant representations, diagnose the problem, propose a solution and execute the solution.

A Conceptual framework for developing tasks

The following three dimensions were chosen for our conceptual framework based on the review of review and taking into consideration the project of developing "PISA Tasks": technology concepts, technology knowledge and technology capabilities

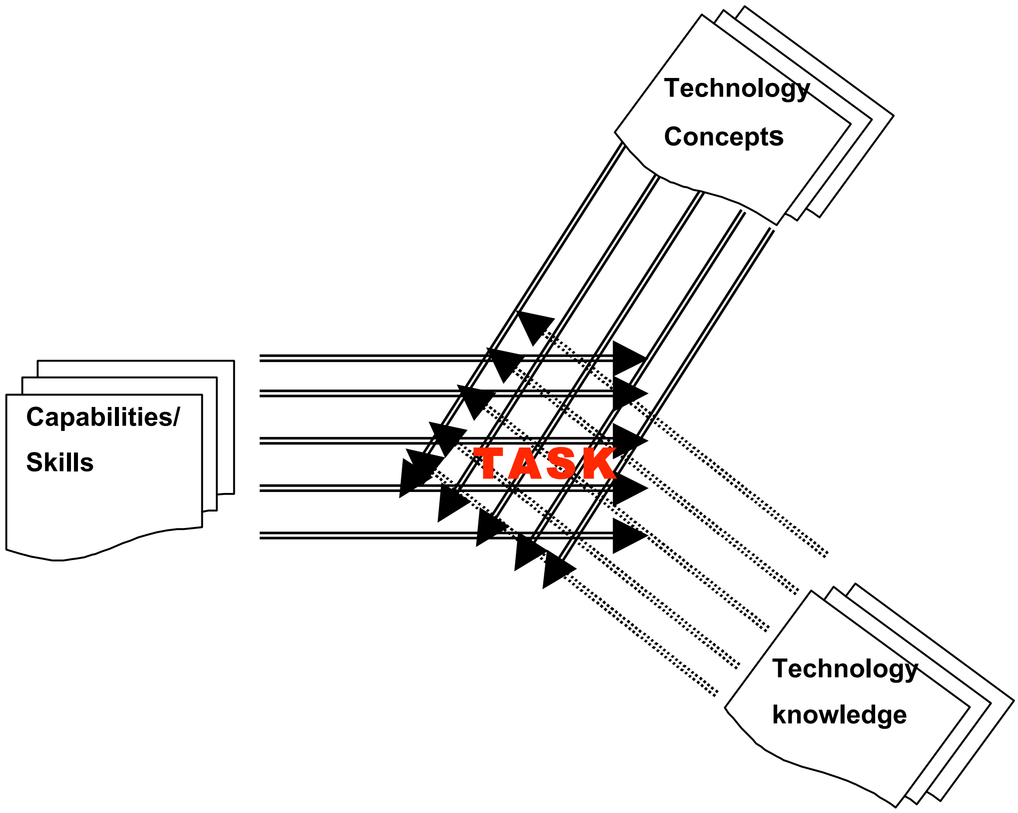

Figure 1: Conceptual Framework for Technology Literacy

The next step is to define the categories within each dimension:
Technology concepts (knowledge of technology): refers to an understanding of the nature of technology

For example:

- Technology results from human ingenuity.
- A technology problem has a variety of solutions.
- Each solution is a matter of trade-offs
- Technological activities require resources
- People create technological systems to satisfy needs and wants.
- Technological activities have both positive and negative impacts on the individual, society and the environment

Technology knowledge (knowledge in technology): refers to two types of knowledge

a. Conceptual knowledge ("knowing that") with regard to the following subjects:
   - Materials – properties, classification, techniques of manufacturing, history of using materials
   - Energy - resources, classification, conservation, history of using energy
   - Information and Communication – classification, history of communication
   - Systems – classification, basic terms, graphic representation
   -

b. Procedural knowledge (knowing how) with regard to the following subjects**:**
   - Problem solving strategies- knowing how to approach a design problem
   - Troubleshooting strategies - knowing how to analyze the subsystems and variables

Technology capabilities:
The PISA Tasks will be developed in order to teach and assess TL capabilities, e.g.: hands-on as well as cognitive capabilities. During the first phase of development pen and paper tasks are given highest priority. Technology capabilities include:

- decision making – choosing among alternatives under constraints
- system thinking – identifying components and relationships within a system
- design – defining a problem, developing ideas, drawing
- trouble-shooting – diagnosing faults in an operating system
- critical thinking – evaluating impacts of a situation or a solution

These tasks will be developed in traditional content areas such as transportation and manufacturing, as well as and innovative areas such as nano-biotechnology. These content areas can and should be modified on the basis of technological advance.

In the second phase of developing "Design- Make –Appraise" tasks we shall address technological capabilities in terms of hands-on plus mind-on capabilities.

Structure of a TL PISA Task (pen and paper)
Based on the structure of PISA Tasks for science literacy described above, the structure of a technology task (in phase one) is based on reading a short article and answering written questions that could be multiple choice, true/false, open-ended or any other type.

Each task covers certain elements of the three dimensions described in the conceptual framework: concepts, knowledge and capabilities.

An example of a task developed to assess knowledge in manufacturing technologies (content area) can be seen below (Figure 2). After reading an article about the history of mass production, students are questioned about: technology concepts that appear in the article, technology knowledge of mechanisms as well as how they work together (procedural and conceptual knowledge), and the impact of mass production (critical thinking).

The mission is to develop 30 PISA activities (pen and paper tasks) and eight Design –Make- Appraise tasks that will cover the full space[JK1] and the content areas

Reflections and Dilemmas
In this preliminary stage of developing the conceptual framework for TL as well as the PISA Tasks some difficulties and dilemmas arise that we would like to share with you:

Were the proper dimensions chosen? Will these three dimensions and their categories provide the entire TL picture?
Are the categories within each dimension assessable in a written task? It is important that we understand this as we should not teach anything we cannot assess.

Above all, can we expect that teaching and assessing through pen and paper tasks will develop TL and especially problem solving capabilities?

Problem solving and design lies at the heart of technology education. Students' technological capability is developed through their participation in a series of technological design problems: "You cannot know quality by reading about it you have to see it, touch it, and do it" (Kimbell, 1991). Therefore, developing pen and paper tasks at the initial stage of learning sends a misleading message about TL and emphasizes "teaching about technology" instead of "teaching technology".

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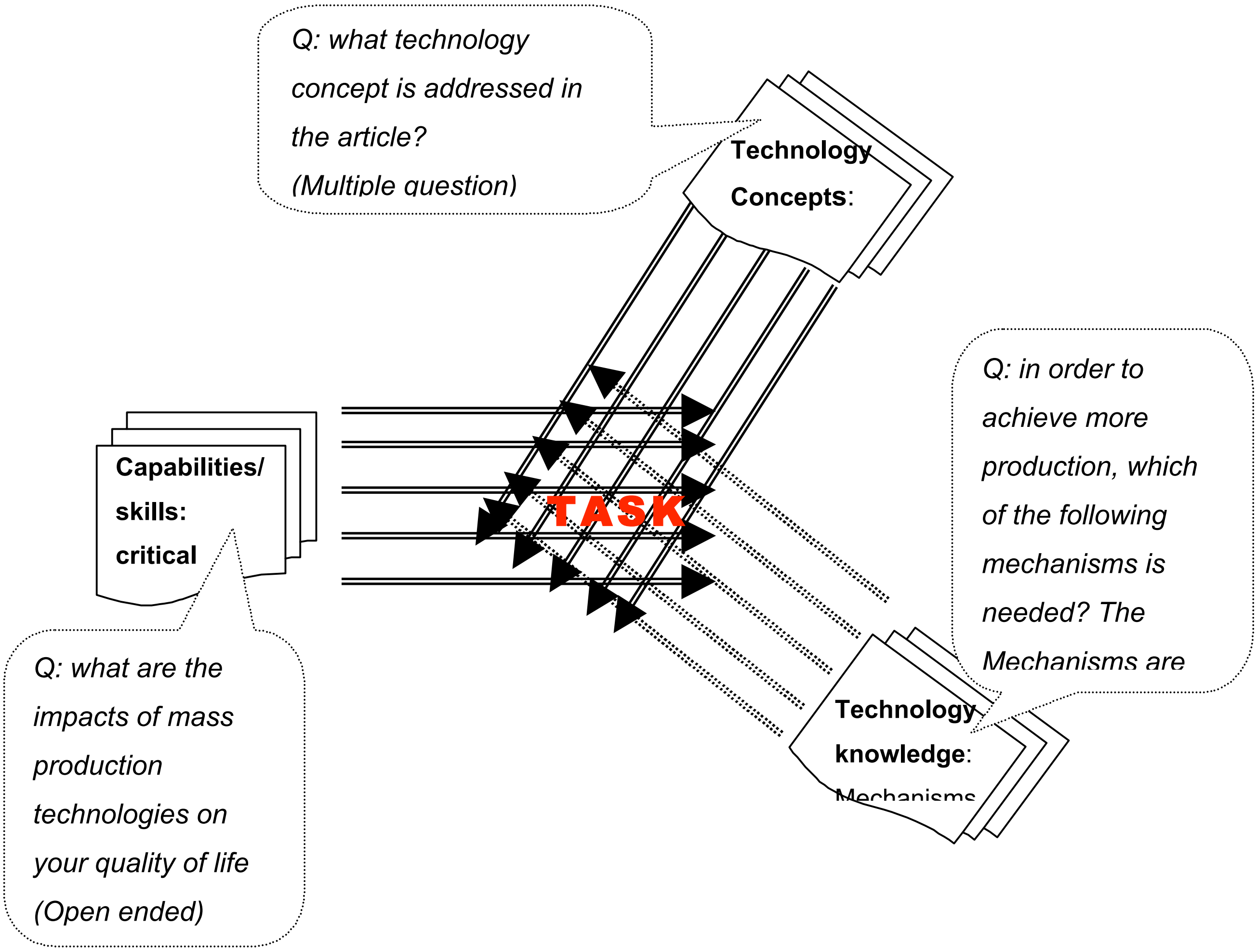

Figure 2: An example for a PISA Task in the Conceptual Framework for Technology Literacy

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Educational Technologies in the Nursery Education: the Italian Experience

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About ten years ago the Italian Ministry of Public Education initiated the National Plan of the Development of Didactic Technologies (1997) with massive investments in the introduction of informatics in schools . At that time little attention was paid to the nursery schools and this is revealed by the allocation scheduled in the first triennial Plan for the Didactic Technologies for 1997 -2000 , in which only 4% of the funds were directed to the nursery schools, compared to 30% to the primary schools and 30 % to the upper secondary schools.
An error of prospective and contradicting the first experiments made by the same Ministry that in 2001 through the ALICE project 2 formed some informatics centres dedicated exclusively to the nursery schools. A paradigmatic experience that led to different televisual initiatives all over the national territory with the organization of E-learning teachers' training finalized with the preparation of the network tutor (Lombardia, Campania ,Tuscany , Marche).
After some official initiatives for the introduction of the New Technologies , between 2000 and 2004 MIUR participated at the KidSmart project , promoted by the IBM Italia foundation and already successfully experienced in The USA.
The initiative of the American multinationa l intended not only to improve the learning contexts in the Italian nursery schools by donating hardware and software to the participating schools but it had also planned training courses for teachers with counselling from the experts in didactical technologies. Apart from monitoring the two projects which other impact did this series of "technological experiences" have on the reality of the nursery schools? There are two topics we would like to explore: a) the one of the scholastic programmes dedicated to the 3 to 6- year-old category to evaluate whether the children got accustomed to the new communicative and informational context of the contemporary society; b) the area of educational research with a particular interest in the results of its proposed goals.

From the Orientation of 1991 to the National Indicators

In the nursery schools of the orientation of 1991 the topic of the new technologies received the deserved attention in the field of the "messages " experience , forms and media that included "all the activities connected to the manipulative- visual ,sound- musical, theatre-dramatic, audiovisual and mass medial " communication and expression together with their continuous interaction.
The programming text with its educative and methodological –didactical property, indicated a multitude of demands and opportunities referring to different media (graphics and designing, dramatic , musical ,mass media) through which the child has the communicative contact with his own reality and the others. Nothing more could be said in that period at the beginning of the 90's when the new technologies started to be introduced in the Italian schools. A step forward was made with the Law of Reorganization of the scholastic categories accompanied by the reorganization of the school curriculum in the elementary school.
On one hand it was admitted that " projects of research , formation , experimentation making use of the new technologies" were required in the nursery schools. On the other hand there were complaints from this area about a "cultural emptiness" because of the lack of clear directions with the absence of a systematic monitoring of the accomplished experiences and of the scarcity of ideas especially dedicated to this level of research.
The scholastic reform of the minister Moratti in 2003 (Berlusconi government) , concluded with the Legislative Decree n.59 of February the 19th in which the general norms for the nursery school and for the first cycle of education were defined , speaks about the introduction of informatics in the

nursery schools both in the National Indicators and in the Recommendations. There were two documents referring to this scholastic period of children between 3-6 years of age; the first one compulsory , the second one orientating and indicative. In the National Indications (compulsory objectives) it is mentioned the use of computer in the area and in the production of messages without any other details . The Recommendation (the orientating document) is richer in details and it reckons that " Educating through Informatics and audio-visual materials (TV ,cameras etc) is an essential aspect of the nursery school that has as a main objective the comprehension , only intuitive and explorative at that moment of the fact that technology does not have to prevail over the process of knowledge and expression but they have to strengthen it with stronger and more accurate forms. Statements too generic to cancel that "cultural emptiness) previously mentioned.
Nowadays with the government of Prodi and the Minister of Education Fioroni , all these orders have been repealed and are not efficient anymore. The Italian nursery school that was not sufficiently considered regarding the new technologies, has nevertheless showed its best by participating at innovative experiences , at school projects financed by Enti ,national and international agencies.

Educational Research: the prophesy proves to be true

In the field of the educational research the nursery school remains the big absent ;because of prejudices and misunderstandings (the naïve child needs only manual skills and concrete experiences not stimulation) it has never been the subject of detailed observation in order to reveal this issue of the connection between the new technologies and the process of teaching\learning. This negative fact is valid both for Italy and for other UE countries regarding the 3 to 8- year-old children who surf the internet and whose number hasn't changed since 2002. This topic was discussed in a comparative survey of Nielsen\ Net Ratings done on 4800 children between 3 and 8 years old from Italy ,France ,Germany and England. The two charts below show that the percentage of young cyber navigator children increases with age (chart 1) and depending on their scholastic level so the primary school has the highest level(illustration 2).

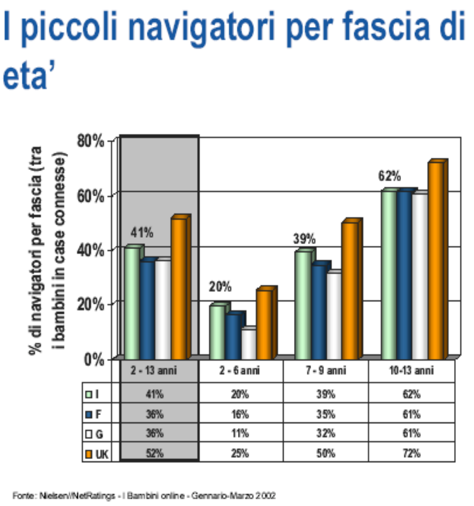


Illustration 1 *Top* Young navigators and age
Illustration 2 *Bottom* The way of growth in Italy. The school influence

In Italy the most recent quantitative facts go up in 2005 and are reported by the ISTA survey done on a representative sample of 24000 families and a total of 55000 people

Illustration 7(in the chart)- children / young children from 3-17 years old and how often they use the personal computer and children from 6 to 17 years old and how often they use the Internet , depending on sex and age- 2005 (for 100 people of the same sex and age)

Tavola 7- Bambini e ragazzi di 3-17 anni per frequenza con cui usano un personal computer e bambini e ragazzi di 6-17 anni per frequenza con cui usano Internet, sesso e classe di età - Anno 2005 *(per 100 persone dello stesso sesso e classe di età)*

CLASSI DI ETÀ	Uso del personal computer					Non usano il pc	Uso di Internet					Non usano Internet
	Sì	Tutti i giorni	Una o più volte alla settimana	Qualche volta al mese	Qualche volta all'anno		Sì	Tutti i giorni	Una o più volte alla settimana	Qualche volta al mese	Qualche volta all'anno	
						MASCHI						
3-5	19,6	4,4	8,6	5,7	0,9	74,9	-	-	-	-	-	-
6-10	51,9	9,1	33,3	8,0	1,5	46,0	12,7	1,3	5,4	4,0	2,0	84,0
11-13	73,2	23,2	43,5	5,2	1,3	25,4	41,7	3,8	20,4	10,5	6,9	58,0
14-17	80,9	37,1	38,1	4,6	1,1	18,6	63,1	16,2	33,6	9,7	3,6	35,9
Totale	**58,0**	**18,9**	**31,8**	**6,1**	**1,2**	**39,8**	**37,6**	**7,2**	**19,0**	**7,6**	**3,8**	**60,7**
						FEMMINE						
3-5	14,2	1,4	5,4	5,5	1,9	81,6	-	-	-	-	-	-
6-10	54,5	6,2	37,1	9,0	2,2	43,9	13,3	0,9	6,5	4,1	1,9	84,8
11-13	70,7	12,7	43,9	9,4	4,8	28,7	36,3	3,1	16,9	11,7	4,6	62,7
14-17	78,5	21,4	48,2	7,2	1,7	20,5	60,9	7,8	37,1	11,9	4,1	37,7
Totale	**56,2**	**10,7**	**35,1**	**7,9**	**2,5**	**42,0**	**35,7**	**3,8**	**19,8**	**8,7**	**3,3**	**62,8**
						MASCHI E FEMMINE						
3-5	16,9	2,9	7,0	5,6	1,4	78,2	-	-	-	-	-	-
6-10	53,2	7,7	35,2	8,5	1,8	45,0	13,0	1,1	5,9	4,0	2,0	84,4
11-13	72,0	18,0	43,7	7,3	3,0	27,0	39,0	3,5	18,7	11,1	5,8	60,3
14-17	79,7	29,6	42,9	5,9	1,4	19,5	62,0	12,2	35,3	10,8	3,8	36,8
Totale	**57,1**	**14,9**	**33,4**	**6,9**	**1,8**	**40,9**	**36,7**	**5,6**	**19,4**	**8,2**	**3,6**	**61,7**

In the second part of the chart the 3to 5 period was neglected.(illustration 3)

Two short observations referring to the Istat chart (illustration 3) , the first regarding the use of the PC that increases with age. Among children between 3-5 only 16,9 % use the computer , from 6 to10 more than half of the children (53,2%) and between 11-13 ,72% and between 14 and 17 ,79%.A fact that refers to young children (16,9 %) , regards the family environment and has nothing to do with the school teaching \learning process

The second opinion about the survey is that apart from the Istat chart that we reported, there is no other possibility to illustrate the data regarding the children between 3 -6 years old. Generally speaking , all the European research on the new technologies in the school environment take into consideration the children starting with primary school (6 years old) until the upper secondary school (18 years old) .The same Nielsen research shows clearly that 2-year –old children start surfing the Internet , while the starting point for looking for information is related to 6 years of age.

In 2006-2007 in Italy it was the University of Studies of Udine to develop a survey on Young Children and primary schools done on a multiregional scale of 1212 children in Abruzzo ,Friuli Venezia, Giulia , Sicily , Tuscany and Veneto .Very significant results ,but limited to a chosen sample of children between 8 to 11 years old so very far away from the young learners. The Anglophone countries were luckier with the United States on top as they did two studies in 2005 , analyzing the problem of the connection between the computer and the children of nursery schools.

But the quality –quantity aspect has been cut down and this represented a big limit especially when the sample of children interviewed was restricted to twelve children(seven males and five females) as that of the survey entitled “Young Children’s Initial Exploration of computers “done by Mary Jo Graham § Steven R. Banks of the Illinois University. The results of the second survey of the Sheffield University(UK) published in 2005 and entitled “Digital Beginners: Young Children ‘s Use of Popular Culture “ were more explicit .

The study realized on 1852 parents of children who attended 120 centres for young learners with 524 experts in this area , did not reveal any significant elements for the understanding of the relationship between children and computers for which there are generally mentioned multimedia terms such as PC , TV , cartoons , videogames.

Coming back to the Italian context ,we can mention two very specific surveys .The first one done by the University of Bergamo , the Science Department represented by Marco Lazzari and Elisa Rinaldin (2006) regarded the use of computer by 5-year –old children. A classical experimental method: a group of children of the last year of nursery school used the PC and some graphics to learn numbers. The same group was then the subject of a test to control the apprehension and they got better results than the group that was simultaneously learning the numbers with traditional methods.
The second experience , documented in the volume" The computer in The Nursery Schools "(2003) realized by IRRE Liguria , represents the first example in Italy of a survey done on regional basis in the realities of 111 nursery schools ,chosen with the specific objective of analyzing the role of the computer in the formation of children from three to six years of age.
The representative sample of about 40% of the nursery schools in Liguria , all of them equipped with at least one computer , was attentively analyzed through a standard survey done to reveal the problems and the didactical and organizing implications connected to the children's "early "exposure to the new technologies. This category of children was questioned for the first time about the arrangement of computers in the schoolrooms (question 3 illustration 4) and about other activities done with the computer (question 7 illustration5). We can notice from the results the prevailing arrangement of technological equipment in the laboratories (48%) and in the schoolrooms (23 %), while the major use of computer is dedicated to gathering and spreading pedagogical information- 81,5% and 50,8% for the didactic curriculum. The obvious merit of this work consists in turning the attention of the experts from the instrumental aspects of the new technologies for young learners(drawing ,inventing and telling stories) to those connected to the scholastic teaching \learning process.

Illustration 4
Arrangement of the computers in the school

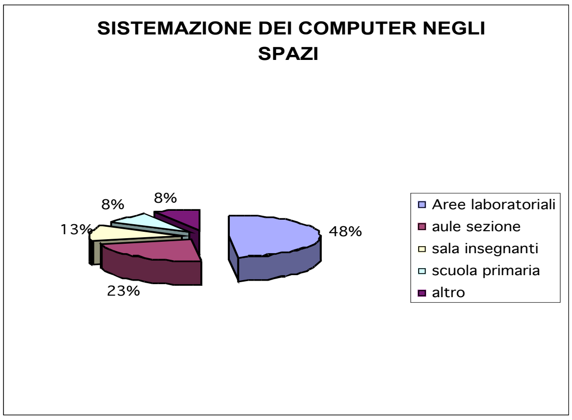
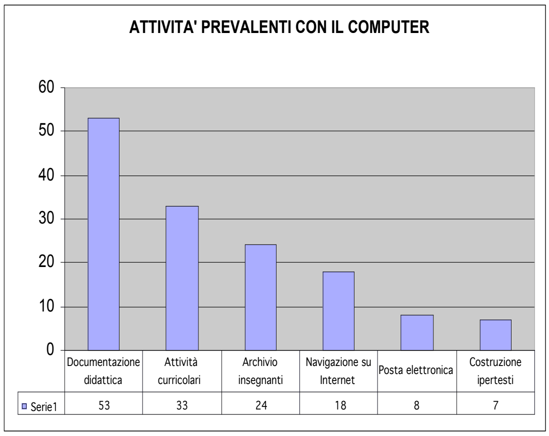


Illustration 5
The main activities with the computer



At the same level we can exemplify some other quality of the project realized in Italy by some experts in this domain as Linda Giannini ,but which are limited to specific geographical and territorial scholastic realities .The multitude of studies and qualitative research done in nursery schools can be completed by the two experiences of Kissmart (IBM) that we mentioned at the beginning of this presentation and by the survey started by Susanna Mantovani and Paolo Ferri from the Biccoca University in Milan.
The Kidsmart project began in 2000 and concluded in 2005 intended to furnish the nursery schools with multimedia technologies projected for children of this age. It was supposed that even in primary schools the availability of new technology represented a development of the formative contexts. For this reason some schools situated in difficult places from the point of view of the introduction of the new technologies have been furnished with special devices for kids from three to six years old. Secondly, due to the intervention of IBM Italy in the scholastic environment, it was compulsory to

initiate a research programme dedicated to the improvement of the knowledge of the interaction between children and the new technologies at school and at home. But not always did the rich theoretical debate about the connection between the new technologies and learning match with the empirical realities and they sometimes remain just ideological facts.

While in many cases empirical facts about how the children consider and use the new technologies in the school environment were lacking , Kidsmart had the answer to this problem. QUA SI is the name of the research started by the Faculty of Sciences of Formation of the University of Milan Bicocca on " Children , teachers and computers at school :teaching, learning and educational relationship"(Paolo Ferri e Suanna Mantovani). The survey intended to explore the modalities in which the children of nursery and primary schools (5-8 years old) get accustomed to the new technologies , noticing the first spontaneous approaches to the computer , the changes in the systematic use of it, the cognitive strategies and the active relational modalities. The project combined elements of qualitative research(observation, interviews and focus groups) with some methodological indications that derivate from anthropology and sociology .Although the scientific part of the two proposal was appreciated ,we have to mention that the weak points of both projects were the representation of the sample of the two schools chosen on purpose: two hundred schools all over Italy in the first case and only three school realities from Milan.

It must be appreciated the positive result of these experiences that took into consideration and documented for the first time the modalities of learning through which young learners approach the computer in the school environment for didactic use of this essential instrument in order to develop curricular activities(Linguistics ,Science ,Logics ,Mathematics).Another positive element of these two survey regards the fact that the active research has been connected to a simultaneous activity of parents and teachers ' formation.

The presentation of the connection between computers and nursery schools allows us to answer positively at the question we asked ourselves at the beginning of this work .This group of children often neglected by the academic research , through the introduction of the new technologies demonstrated in reality the beginning of some innovative processes whose formative capacity has not yet been measured. And this is the challenge to the educational research that in the next years will have to measure all these experiences from the qualitative and quantitative point of view, taking into consideration that human intelligence develops mainly in the first years of the children's lives and each later educational or formative action (from 7 8 years and later) always becomes less efficient .

Sustainable practices as an aspect of technological literacy: research findings from secondary school teachers' and their classrooms

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ABSTRACT
The purpose of the study reported in this paper was to investigate the scope of environmentally sustainable technology practices in secondary schools as well as the nature of teachers' thinking concerning these practices and sustainable development. The central intent of this three-year, federally funded research is to strengthen the study of technology and to understand the issues and factors which will enable teachers and school systems to follow and support better forms of sustainable technology practice, which we consider to be one aspect of technological literacy. This paper reports findings from year one (Phase One) of the research.

INTRODUCTION

Our need for scientific, technological, and social innovation to reduce our collective *ecological footprint* has never been greater (Myers, 2000; Organization for Economic Cooperation and Development (OECD) 2002; United Nations Environmental Program (UNEP),2002; Wackernagel, 2000; Wackernagel, Schultz, Deumling, Linares, Jenkins, & Kapos, 2002). It is projected that during the century and a half from 1900 to 2050, a period of barely two lifetimes, humanity's annual impact on the planet's natural environment is projected to multiply over forty-fold (Homer-Dixon, 2000). Technology education has an important role to play in ensuring that future citizens simultaneously understand and incorporate sustainability thinking in all facets of technological endeavour, and appreciate that environmental technologies are an area of dynamic employment and opportunity.

THEORETICAL FRAMEWORK

For the purposes of this paper the term sustainable practices refers to a broad range of concepts, principles and practices related to efforts aimed at reducing the environmental impact of our built environment. This encompasses issues such as: dematerialization, cleaner production, design for disassembly, design for recycling, product stewardship, product service systems, the precautionary principle, sustainable consumption, eco-efficiency, industrial and construction ecology, life cycle assessment (LCA), design for the environment (DfE), full cost accounting, green chemistry, and permaculture to name a few (Birkeland, 2002; Cunningham, 2002; Government of Canada, 2002; Hoepfl, 2001; McDonough & Braungart, 2002; White & Stoughton, 1999). All of these processes are concerned with changing the manner in which we design, manufacture, use and reuse or dispose of technological products and systems. The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2004) 'Bonn declaration' recognized the global importance of skills development within technology education, emphasizing the importance of 'sustainability industries' such as environmental conservation, cultural heritage site preservation, and renewable energy production; areas which can lead to economically and environmentally sound communities.

Yet, the extent to which teachers feel prepared and supported to teach about sustainable technology practices is unknown. The degree of support for sustainable technology practices and their scope within pre-service (teacher education) programs in Faculties of Education is also unknown. Preliminary evidence from several provinces indicates that beyond a few basic concepts relatively few eco-technological principles or practices have been incorporated into provincial curricula (Elshof, 2005).

Elshof (2002; 2006) and others (Petrina , 2000a, 2000b; Petrina & O'Reilly, 2001) have argued for more critical attention to the technocratic dominated processes of production and consumption within technology education. However, often teachers are "not equipped, personally or professionally" to deal with the affective and existential domains of global problems and so they often ignore them in the classroom to focus solely on cognitive dimensions of these issues (Hicks & Bord, 2001, p. 423). A number of critics have argued that the prevailing learning model of teaching and learning model within the technology education curricula is behaviourist in nature (Dakers, 2005; Petrina 2000a, 2000b). Instrumental and narrow hegemonic models can mitigate against curricula that would engage students in questions of a more critical nature concerning technology, including issues related to ethics and values as well as social and environmental justice. Sustainable technology practices are consistent with and enhanced by a 'reconstructionistic' (Hill, 1997) approach to curriculum, one in which creativity and design are fostered in students who become creative community 'change agents', helping their communities become more sustainable. Because philosophy 'frames worldviews', informs decision-making, creates awareness of alternatives and ultimately guides action (Hill, 1997; Hill & Dewey, 2001; Elshof, 2001), critical worldview reflection becomes a critically important starting point for consideration of reconstructive practices (Elshof, 2003).

"Design processes guide problem solving in technology education in an analogous way as the inquiry method guides science education" (Hill, 1998, p. 203). These processes should be situated in real-life, authentic contexts and involve dynamic and iterative processes which join conceptual and procedural thinking processes and be closely linked to human and environmental interactions (Hill, 1998; Hill & Anning, 2001). Given the fact that technological products inescapably create environmental 'wakes' of differing magnitudes and longevity, technology education can no longer ignore or marginalize the significance of these ripple effects on distant human and nonhuman communities, nor can it ignore its responsibilities to future communities. Effective technology education requires that students be engaged with modeling the long-term impacts of the products they design on ecosystems as well as thinking about social justice and community dimensions of technological decision making. Linking technology education in school to the community outside school, through community-based projects, is one way to foster such thinking (Hill, 1999; Hill & Hopkins, 1999).

OBJECTIVES OF THE RESEARCH

Four objectives were set for the research. They were:

1. To understand how technology education educators and curriculum leaders conceptualize environmental sustainability and sustainable practices.
2. To understand the influence of personal worldviews, professional socialization and institutional factors on teachers motivation and confidence in undertaking environmentally sustainable practices in their classrooms.
3. To understand the scope of sustainable technology practices taught in secondary schools and also the extent of these practices within pre-service teacher education.
4. To understand how technology educators conceptualize sustainable practices through an online group discussion and a videoconferencing activity.

METHODOLOGY

The research is situated within a transformative–emanicipatory research paradigm (Mertens, 2003). Because we wanted to understand the breadth and depth of sustainability thinking within technology education in two Canadian provinces, Nova Scotia and Ontario, and to identify practical strategies and policies that will further sustainability in technology education in Canada, multiple methods were required, specifically, the study used a mixed method sequential exploratory design. Since the three-year study is exploratory in nature, data collection was planned in three stages, an initial qualitative phase (Phase One) followed by a quantitative phase (Phase Two) and lastly by a qualitative action research phase (Phase Three).

In Phase One, the first year of the three-year study, a series of focus groups and individual interviews were conducted in Nova Scotia and Ontario with technology teachers, curriculum leaders, and teacher educators respectively in order to elicit their worldviews and perspectives on the concept of sustainable practices and sustainable development in technology education. This data provided an in-depth understanding of the interviewees' worldviews and perspectives. All interviews were guided by a set of semi-structured qualitative interview questions and were audio taped. The audiotapes were transcribed verbatim. Data were then organized on a question-by-question basis and content analysis was carried out to identify themes in participants' responses to each question. This paper reports on year one, Phase One, of the study and on the technology teacher focus group data only.

RESULTS FROM THE TECHNOLOGY TEACHER FOCUS GROUPS

An interview schedule consisting of semi-structured questions was prepared prior to the focus group interviews. Questions were organized into three categories: (1) breadth of sustainability, (2) professional dimensions, and (3) curriculum. This section reports on key findings from selected focus group questions; questions that pertain to the PATT-18 conference theme. Findings below are reported, question-by-question, from an initial examination of the selected focus group questions and data.

Breadth of Sustainability

What does 'environmental sustainability' mean to you?

Surprisingly, all teachers in the Ontario focus groups passionately provided a definition of environmental sustainability. These definitions had both similarities and differences. Similarities were: (a) a need to keep the world safe for future generations, (b) a concern for depletion of resources, (c) a desire to find ways to replenish resources as they are used, (d) a call to find alternative resources, (e) a requirement to balance human needs with the use of resources and pollution of the environment so future children, citizens, humans can "carry on for generations to come", and (f) a consistent reference to resources and pollution. The constant reference to resources may be a Canadian phenomenon as Canada is rich in natural resources. This mirrors a similar finding in Nova Scotia where teachers with the distinction that resource recycling and recovery was frequently mentioned as a dimension of sustainability. This may in part be related to the extensive resource recycling system in place in the province. Pride as a North American leader in this field was a recurring theme.

Differences can be categorised more as *context* within which similarities were expressed, rather than difference of opinion as to whether environmental sustainability was important or not. Differences in context for concern about environmental sustainability were, for example:

- The importance to distinguish between what would happen naturally and what happens due to human impact; what we can change and what we should change.
- The pace of natural resource consumption.
- The term is an oxymoron; the two words do not go together because we are already out of control.
- The need for a balance between use of resources and what humans give back.
- The need to keep the earth 'safe' for generations to come.
- To live in harmony with the earth, much like aboriginal ways of life before European settlement. We cannot bring back the environment to where it was but we need to keep it from getting worse. The importance of using not abusing natural systems so they may continue to supply us with materials.

What do you see as the most worrisome dimensions of technological impact on the global environment?

Some of the same worries expressed in answers to the above question were revealed as answers to this question, but other most-worrisome dimensions of technological impact on the global environment were also posited.

- The production of Greenhouse gases and the impact on climate change.
- The exponential creation of technologies that designed to be disposable and the consequent material waste flows that threaten to overwhelm our ability to safely dispose of them in landfills.
- The return of nuclear technology and the toxic wastes it generates.
- The present generations' cultural behaviour is to quickly replace instead of repair.
- Big businesses and competition, especially in electronics (computers, MP3 players) where items are quickly outdated and these items are not recyclable.
- Technologies oriented at making life easier, but just because it is there should it be used.
- Technologies oriented at making life easier that actually make life more difficult.
- Unwillingness of people in power and large corporations to make changes
- Economics, large companies, political groups, and politics are driving forces that suppress change (consumption of fossil fuels).
- Lack of infrastructure planning for alternatives.
- Alternatives cost three to four times more than present products, fuels etc. (solar panel arrays, composite decking).
- Public image of companies to produce environmentally friendly products; the public is happy but the real story is not always told.
- The production process of some environmentally friendly products produce worst emissions or pollution than the original product (electric cars, ethanol, wind generators), but marketing the product makes it look good.
- With regards to new solutions, "…we advance too quickly and we don't look at where we're going." (Ontario, Thomas, Focus Group 3, November 30, 2006). More time on research is needed before action is implemented.
- Complexity over simplicity as a basis for solutions.

What do the phrases 'sustainable development' and 'sustainable practices' mean to you on a personal level? As a technological studies teacher?

All focus group teachers indicated that meanings they gave to these two terms represented their perspective on both personal and teacher levels; they did not see the phrases differently inside or out side of school. "…as a teacher you bring a lot of your personal experiences to a class." (Ontario, Frank, Focus Group 3, November 30, 2006), "For me it's kind of hard to distinguish the difference between personal and teacher because it's almost the same, it's a philosophy of life almost." (Ontario, Luke, Focus Group 2, August 7, 2006) For the most part, sustainable development was associated with ideas, design, production of a prototype, and production processes that considered the concept of sustainability, the environment, or was environmentally friendly. Sustainable practice was associated with how development was used in either mass production, or how we use designed items on a daily basis, or our daily practices in the world around us. Teachers in the Ontario focus groups revealed that they thought quite profoundly about these phrases and issues raised by these phrases. Only a couple of the Nova Scotia teachers in each group had done any thinking about sustainable development and how what they did in the classroom connected to their personal world views.

What does the phrase 'environmental stewardship' mean to you on a personal level? As a technology teacher?

All focus group teachers indicated that meaning they assigned to environmental stewardship represented both their personal and teacher perspectives. All were able to articulate a meaning to the phrase 'environmental stewardship'. "…the way in which we try to organize how we do things to promote a good environment and the way we manage ourselves on a personal level and in the classroom." (Ontario, Thomas, Focus Group 1, August 7, 2006); "…to be a role model." (Ontario, Phil, Focus Group 1, August 7, 2006); "…think globally, act locally." (Ontario, Susan, Focus Group 2, August 7, 2006); "…respect for the environment." (Ontario, Frank, Focus Group 3, November 30, 2006); "…taking care of our environment, being a leader that shows and leads the way." (Ontario, Thomas, Focus Group 3, November 30, 2006); "Making sure that we leave things better than we found them (Nova Scotia, Glen Focus Group 1, Nov 15 2006); "Minimizing waste and energy use" (Nova Scotia, Steve Focus Group 2, Nov 15 2006); "It's about showing students options for living" (Nova Scotia, Fred Focus Group 2, Nov 15 2006)

Professional Dimensions

Have you ever taken a course in environmental science or studies?
In Ontario, 4 of the 15 teachers in the focus groups had taken one to several courses in environmental science. All four had taken such courses within an undergraduate program at university. For three of the four, such courses were taken as a mandatory part of their program. Another one of these four individual also had courses related to the environment while in the workplace. In Nova Scotia five of the teachers indicated that they had taken an environmental science course in their undergraduate program.

Have you ever taken a course in environmental design? LCA, DfE etc.
Two of the four Ontario teachers who had courses in environmental science had taken courses in environmental design as well. One of the individuals took environmental design courses in the context of his Architectural/Environmental Studies baccalaureate degree. The other teacher took such a course in the context of upgrading skills in the construction industry. Only one Nova Scotia teacher indicated that he had completed a course in "sustainable technology practices", it was in the transportation area in which the concept of 'life cycle was used. He tried wherever he could to bring real-world examples of "conservation and renewability" into the classroom.

Do you feel that your background professional training and professional development support is adequate in this area? Why/why not?
Most of the teachers in the three Ontario focus groups indicated that their professional background provided them with sufficient knowledge about the environment and about sustainability. Most indicated that they had learned a lot about issues of environment and sustainability on their own. Some of the teachers said that knowledge about these issues was not part of their professional training programs. All indicated that the schools in which they were employed relied on them to know about these issues and to ensure that their classrooms were environmentally friendly. Teachers in both provinces emphasized that schools were mostly concerned about meeting WHIMIS standards. All indicated that there was no professional development from their school or school board on these topics, either on professional development days or other. The majority of Nova Scotia teachers indicated an interest in taking this type of professional development if it were available. However most shared the sentiment that professional development opportunities rarely met their need in any technological area, expressed succinctly by one teacher "if we don't organize and run it ourselves, nothing gets done" (Nova Scotia, Kim, Focus Group 2).

Was this area adequately addressed in your pre-service teacher education program?
Overall, the teachers in the three Ontario focus groups found that environmental sustainability was adequately addressed in their pre-service teacher education program. One teacher said, "I think we have definitely addressed it as best we can within the time constraints we've been given." While a few indicated that "more could be done". Some specific examples were cited:

- Existing objects were reconfigured into new objects
- Existing object were re-engineering
- One project criteria, was that we recyclable materials or environmentally friendly materials be used as much as possible
- WebCT was used in courses to reduce paper handouts
- It was discussed throughout the program. It was perhaps not explicit, not as one section called the environment

One teacher pointed out that "The environment has played a big part in our, in our professional or our pre-service teacher education. My only issue is with the individual boards themselves." Nova Scotia teachers expressed similar sentiments with most indicating that environmental issues had been treated in a manner but without very much in the way of a systemic perspective of environmental practices or detail of particular environmental practices within technological education. None of the teachers mentioned any connection to broader sustainability frameworks like the 'Natural Step' or 'Industrial ecology' and nearly all were unaware of these concepts.

Would professional development in the environmental dimensions of technological design and use, be something that interests you? Why/why not?
While all teachers in the three Nova Scotia and the three Ontario focus groups indicated that either their professional background and/or professional training provided them with some or sufficient knowledge about the environment and about sustainability, they all agreed that ongoing professional development (PD) would interest them to keep them up-to-date with new developments. In addition, some stated that such PD for environmental sustainability should be offered by school boards to all teachers, not just technological education teachers, and that it should be part of the whole school culture.

Have you been able to access PD of this nature? Why/why not? Specifically what would you like to learn more about? How would you like to learn about it?
In Ontario and Nova Scotia, none of the teachers in the focus groups had received PD of this nature from their schools or school boards. PD days were generic in nature and for all subject teachers. Some mentioned that the recent craze was, testing, testing, evaluation, evaluation, evaluation…Teachers mentioned items specific to their technical area (e.g., solar and wind energies, sustainable practices), but also that they would like to be informed about arising issues about the environment and sustainability. This said they also realized that it would be difficult for a school or school board to address these issues in PD days for all of the existing technology courses. Personal interest and motivation were quoted as main venues of obtaining information about these issues. Some teachers indicated that attendance at professional teacher conferences were supported by their school and that sometimes there was information on new technologies that was related to the environment and sustainability.

If you wanted to make your classroom teaching better reflect 'sustainable practices' what barriers would need to be overcome? What kinds of resources/training/support would you need?
In Nova Scotia and Ontario, the most commonly cited barrier to creating classrooms with better 'sustainable practices' was budget. Teachers indicated that new resources were needed; resources in terms of new tools and equipment. Many teachers had inherited classrooms that were set up some time ago with old tools, equipment, mechanical systems, etc.

The second most common barrier cited was that administrators did not see anything wrong with the existing classrooms, even when presented with problems relating to the environment and sustainable practice and a long-term plan for improving the situation. Teachers articulated that they were, "…trying to teach kids current information with out-of-date practices or out-of-date technology." One teachers said, "I know for me going from private industry to the school board was a big step back as far as technology."

Curriculum

Do you believe technology education in your province reflects an appropriate concern for the environment? Why/why not? Examples?
Overall, Ontario teachers thought the curriculum reflected appropriate concerns for the environment. They cited example frequently, for example, "…the Construction curriculum it often talks …about renewable resources, sustainable resources." However, some of the teachers indicated that the curriculum was quite open-ended. Some of the teachers felt that this was a positive aspect of the

curriculum; others indicated it could be more concrete. These latter teachers wanted to see a curriculum where there would be no ‘loop hole’ to ignore issues of the environment and sustainability in a course. They said too much was left up to the individual teacher. “…if it’s key to the teacher you’re going to get more of it.” “…it’s definitely in the curriculum and the teacher definitely plays a huge role in implementing it and making the students aware.” All of the Ontario teachers indicated that the curriculum could have a greater emphasis on these issues. Nova Scotia teachers were more concerned that environmental issues were not consistently covered in their curriculum. Several said “what curriculum?” A common expressed concern was the lack of support at the provincial departmental level for technology education and the fact that many of the documents were long out of date. Teachers indicated that because there was no provincial technology education support coordinator, important things like curriculum revision was not an ongoing process. Like the Ontario teachers they felt much more could be done in environmental areas.

What if anything in the provincial curriculum needs to change to better reflect a concern for the environment?

Some of the Ontario teachers cited specific examples for curriculum change to better reflect concern for the environment. For example,

- in transportation technology, more emphasis should be placed on new engine systems; electric engines and fuel cell technology;
- in construction, inclusion of alternative house construction. However, here there were concerns that the program needed to be realistic with what could be done in industry.

However, all Ontario teachers’ indicated that even if the curriculum included more content to encourage concerns for the environment, teachers were the gatekeepers. “We can change the curriculum, we could teach different things, but until we truly internalize these things and live them that it’s not going to really matter…if it states it in the curriculum or not. (Ontario, Luke, Focus Group 1, August 7, 2006)

The general consensus of the Nova Scotia teachers was that because some parts of the curriculum were so dated and general in nature, that the responsibility for introducing specific issues pertaining to sustainable practices were left entirely to the individual teacher. This they indicated was done on an ad-hoc basis and depended on the interests of the classroom teacher.

What would you cite as a good (the best?) example of technology helping to improve the quality (health) of the environment in your region? Have you used this as an example in your classroom teaching?

Both groups of teachers cited a range of examples that they deemed good examples of technology and that they used in their classroom teaching. The examples varied widely across the different broad-based technologies and included:

- Recycling. A poster project that picked an environmental issue and designed a poster on recycling was part of classroom teaching (Communications Technology).
- Reduction of waste. This was translated into a paperless classroom where handouts and assignment submissions were electronically distributed (Communications Technology).
- In remote northern regions where there is a lot of reliance on snowmobiles and boats, a change of focus to 4-cycle engine technology from 2-cycle engine technology. The 4-cycle engine technology is more environmentally friendly to the air and to the water. Classroom teaching on small engines has a focus on 4-cycle engine technology (Transportation Technology).
- New ways of protecting the environment with vehicles that put out fewer emissions. These new vehicles are used in classroom teaching and practice (Transportation Technology).
- The Canadian Coast Guard have phased out steel manufactured buoys painted with toxic paints and replaced them with plastic buoys. The plastic buoys are less toxic, lighter to remove from the water so required smaller watercrafts with less fuel consumption to remove them, use solar power, and have no toxic battery materials. (Manufacturing Technology).
- New manufacturing facilitates that have motors that are more efficient, that are more environmentally friendly, and that are power and energy efficient. Manufacturing that use alternative sources of fuel, for

example, tire burning. The pros and cons are discussed in classroom teaching (Manufacturing Technology).

- Business and industry that use sophisticated filtration and heat recovery units make a significant reduction in the manufacturing sectors' impact on the environment. Examples are part of classroom teaching (Manufacturing Technology).
- Solar and wind generator technologies. These are discussed and used in classroom teaching (various technologies).
- Recycled and biodegradable, longer lasting diapers for elderly patients. The pros and cons are discussed in classroom teaching; while more costly but better for the environment, there is an increase in bacterial problems and an additional added increase in costs due to an increase in the use of antibiotics (Heath and Personal Services).
- Concrete in the construction of houses. While it is not used in the classroom, it is discussed. As it becomes more standard in the industry practice would be done in the classroom. Alternative heating systems. (Construction Technology).
- Hybrid cars, the effect of mass transit on the environment, alternative housing construction. These are studied in class and there are field trips (Technological Design).
- Growing return to the use of local food produce. Recycling of food and food packaging. These are part of classroom practice (Hospitality and Tourism).

Do you believe that students in technology education would be interested in learning more about the relationship between technology and the environment? Why/why not?

Interestingly, Ontario teachers' responses to this question were varied. Teachers who worked and lived outside of large cities cited that their students are definitely interested in learning more about the relationship between technology and the environment. Reasons were that they lived more with nature around them and could see impacts on the environment. Teachers who lived in large cities did not think their students would naturally be interested; "…Most of my students in our school come from very wealthy families…they've had everything quick, easy, and if it broke you just bought a new one: (Ontario, Luke, Focus Group 1, August 7, 2006). But some nevertheless expressed hope with regard to capturing the interest of students: "Where I teach…on the outskirts of a major city…they don't get to see nature and I think they take a lot of things for granted…I think if you can make them aware and get them to connect to the future somehow…then I definitely think they would...be extremely interested in it. (Ontario, Phil, Focus Group 1, August 7, 2006)

The response of Nova Scotia teachers also reflected the importance of context, but in a different manner than in Ontario. Rural teachers expressed skepticism concerning the interest levels of rural students in 'green' issues in technology education. In rural Nova Scotia many families earn their income from the resource extractive industries, forest, mining and fishing. Some felt that a critical look at resource use and green technologies would not be appreciated by students

Conclusion

Overall, Nova Scotia and Ontario teachers had concern for environment and sustainability issues in their personal lives. Their personal world views were brought into their classroom teaching. The Ontario teachers indicated that the curriculum did adequately address issues of environment and sustainability, but that there could always be a greater emphasis. Interestingly, they saw the individual teacher as more important than the curriculum itself with regard to bringing the study of environment and sustainability into the classroom.

Canada is a resource rich country so many references were made to natural resources. Oil shortages were highlighted in the news in the summer of 2006, so many examples provided were around issues of energy shortages. It seemed that teachers' knowledge about the environment and sustainability were influenced by both the media as well as professional and personal experience In Ontario, one technology area that stood out as different in how it could address environmental and sustainability issues was Personal and Health Service. Here, health issues presented dilemmas and limitations with regard to how this technical area could contribute to reducing the human impact on the ecological footprint. Interestingly, most teachers thought that a focus on the environment would have little influence on encouraging more girls to study technology in secondary school. A few of the teachers were well read about gender differences and did feel that it would make a difference.

At the time of the Ontario focus group interviews, curriculum revision for Technological Education subjects had begun but draft documents were not available. Since that time, the draft curriculum documents have become available for feedback purposes. The draft curriculum, to be implemented in September of 2008, does reflect a greater emphasis on the environment and sustainability. In every curriculum guide a new strand for content has been added called, *Environmental Stewardship & Societal Implications*. In Nova Scotia, a new curriculum for *Energy, Power and Transportation Systems* is under development and indications are that environmental sustainability will play a larger role.

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Exploring the Nature of Technology: Students' intuitive ideas as a starting point

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Abstract
New Zealand is currently attempting to support a shift in technology education to encourage students to develop a deeper, broader and more critical technological literacy. The Draft Curriculum: Technology Materials for Consultation (Ministry of Education, 2006), presents a new structure for this support by way of three strands – The Nature of Technology, Technological Practice and Technological Knowledge. The Technological Practice strand has been developed over ten years of classroom-based research. The Technological Knowledge and Nature of Technology strands have been developed out of a two-year research project funded by the Ministry of Education. This paper presents findings from this research on students' intuitive ideas about the nature of technology. These findings suggest that although technology education in New Zealand has embraced an empowering technological literacy focus, resulting student understandings appear to be limited in breadth, depth, and criticality.

Introduction
After more than ten years of implementing technology education, New Zealand is currently attempting to encourage students to develop a deeper, broader and more critical technological literacy than that supported by the initial 1995 technology curriculum (Ministry of Education, 1995).
The *Draft Curriculum: Technology Materials for Consultation* (Ministry of Education, 2006), presents a new structure for this support by way of three strands – The Nature of Technology, Technological Practice and Technological Knowledge[1].

Classroom based research into technological practice and/or assessment in technology (Compton and Harwood, 2003; Compton and Harwood, 2005; Jones and Moreland, 2003; Moreland, Jones and Northover, 2001) has reinforced the importance of teacher formative interactions in enhancing student learning. Teacher understanding of what knowledge and skill their students bring to the learning experience are key to these interactions, as are their understandings of what the next steps should be in learning, and the pedagogical strategies that would be most effective in ensuring that progression occurs (Compton and Harwood, 2004). The Technological Knowledge and Nature of Technology strands have yet to be explored within classrooms[2]. As part of the Technological Knowledge and Nature of Technology (TKNoT) research however, preliminary investigations into students' intuitive ideas around the nature of technology have been undertaken.

This paper presents these initial findings as starting points to inform the further development of progression ideas in the Nature of Technology strand. It also provides some ideas for thinking about how to incorporate the nature of technology into programmes of learning and pedagogical strategies that support the development of understandings in keeping with the two components, within this strand.

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[1] For an explanation of the recent developments in technology education in New Zealand see Compton and France, Redefining technological literacy in New Zealand: From concepts to curriculum constructs.
[2] For a discussion of programmes of work focused around the components of the technological practice strand, please see Harwood, Implementing Technological Practice in New Zealand: A foundation for technological literacy.

TKNoT Research into the Nature of Technology
One aspect of the TKNoT research was to begin to establish the initial ideas students have with regards to the established components under the Nature of Technology strand - these being the *characteristics of technology* and the *characteristics of technological outcomes*[3]. The purpose of the Nature of Technology strand is to provide opportunity for students to develop a philosophical understanding of technology in order that they may develop a more informed and critical technological literacy.

Characteristics of technology focuses on a sociotechnological (Bijker & Law, 1992) understanding of technology as volition (Mitcham, 1994) and therefore highlights the purpose and epistemic base of technology as human activity alongside its inseparability from the world into which it intervenes. *Characteristics of technological outcomes* focuses on the resultant interventions from technology (Mitcham's Technology as Artefact, 1994) and specifically explores the interrelated dual (physical and functional) nature of such outcomes (Kroes and Meijers, 2000; de Vries, 2005), and the complexity of the interface between designer intent, end-users and outcome use and usability.

In this preliminary research, the focus was placed on obtaining students' intuitive ideas about their concept of technology and its purpose, their understandings of the dual nature of technological outcomes, how and why they might be developed and the base upon which they make judgments regarding the worth of such outcomes.

Methods
Questionnaire
Initially students were asked to respond to a written questionnaire. The same questionnaire was used for all students and data was collected from year 3 (average age 7) through to year 13 (average age 17) students. A total of 220 students provided responses to this questionnaire.
Questions related to the nature of technology included:

1. How would you describe technology?
2. Choose three examples of technology and explain why you chose them?
3. What is the purpose of technology?
4. How does technology affect you?

No gender or ethnicity data was collected as part of the questionnaire, however year level of each respondent was noted. The split by year level was as follows:

Year group	3/4	5/6	7/8	9/10	11-13
Number	19	77	37	60	27

Interview
Based on the analysis of the student questionnaires, a semi-structured interview was conducted with students from 5 - 17 years of age. The same interview schedule was used for all students. The focus of this interview was to explore students' ideas about a technological outcome and in particular their understanding of the dual nature of the technological artefact - its physical and functional nature and the relationship between them. This is in keeping with the call from de Vries (2005) for such research around students' perception of technological artefacts. A cell phone was used as an initial familiar technological outcome prompt, with students being asked to describe it. The interview explored the extent to which students located the cell phone in a wider social context when making judgments about it as 'good' or 'bad' and also when suggesting 'how the cell phone was made'. The interview then focused on a less recognisable object – a metal fish which was in fact an egg holder but this function was not obvious. Students were asked to describe the fish and suggest possible functions in an attempt to see if they could

[3] For a full explanation of these components and the concepts behind them see Compton and France, Redefining technological literacy in New Zealand: From concepts to curriculum constructs.

draw from the physical nature to suggest possible functions. They were also asked to make a judgment about how ‘good’ or ‘bad’ the fish was as an egg holder.

A total of 209 students have been interviewed, and gender, ethnicity and year level data was collected. The interviewed students show a gender balance with 103 or 49.3% girls and 106 or 50.7% boys. One hundred and ten of the students are Pakeha (52.6%), 43 Asian (20.6%), 35 Maori (16.7%), 8 Pasifika (3.8%) and 13 categorised as other (6.2%). Ethnic representation within this sample shows a reasonably close alignment for Pakeha and Maori groups where Pakeha student enrolments constitute the largest ethnic group in New Zealand at 59.6%, followed by Maori at 21.6% (Ministry of Education statistics from 2006). The percentage of Asian students is higher than that seen in the general population (categorised within the ‘other’ category at 9.9%) and the percentage of students categorised as Pasifika was lower than the general population (8.8%). This reflects the cultural dominance of one of the selected school locations. The students were drawn from a mix of socio-economic and rural/urban backgrounds.

The split by year level is as follows:

Year group	NE/2	3/4	5/6	7/8	9/10	11-13
Number	33	19	39	40	55	23

The size of the interview sample within each ethnic group means that an analysis in terms of ethnicity would be of little value. This data was explored in terms of gender and year group to ascertain any potential difference or trends. While not statistically significant due to sample size, any percentage difference of 5% or more are reported on. The overall findings from both the questionnaires and interviews are summarised and discussed below.

Findings: Students’ Intuitive Ideas of the Nature of Technology

Findings from the Questionnaire
Q1 Describing technology
The most common response to this question fell into the ‘description of technology education’ category – rather than describing technology as a domain. This was particularly noticeable for the higher year groups (yr 7-13) with close to 50% (56.8%, 48.2%, and 55.6% up the groups respectively) of the responses falling into this category. Equating technology with science was only evident in the year 3-4 group, with just over a third of this year group doing so. Over a third of the year 3-4 group also stated ‘don’t know’ in response to the question, with the remaining viewing technology as a process of making something.

It was noticeable that the dominant view of technology education was that it was a place to ‘make things’ in the lower year groups, and ‘undertake technological practice to solve an identified need’ at the higher levels. It could be inferred therefore, that the year 3-8 group’s responses categorised as technology education could be seen as indicative of technology as a ‘process of making things’, while the year 9-13 could be indicative of technology as the more socio-cultural category of ‘improving life/meeting needs’. While it is interesting to note the overall predominance of ‘hi-tech’ artefacts in the responses that described technology as artefacts, conflating these categories allows trends between artefact, process and practice to be more readily identified. The categories of ‘don’t know’ and ‘other’ could also be usefully conflated – given those categorised don’t know actually stated this was the case, where as the statements categorised as ‘other’, strongly indicated they don’t know by the nature of what was written. Working from this conflation of categories therefore, the most common view espoused by this group of students was that of technology as ‘improving life…’ with a consistent upwards trend for this to be the case as year group increased. The second most common category overall is that of technology as artefact (at 15.9%), however this category does not show a regular trend across year groups. The newly formed category of ‘don’t know’ now shows a general trend down as year group increases – although not completely consistent with an irregular dip at year 7-8.

Q2 Examples of technology
Students' views of technology were also explored in the second question that asked for examples of technology and explanations of why they were chosen. Three examples were requested in this question and the responses at times fell across two categories. For example, all but one of those categorised as 'Artefact – general' also provided 'hi-tech' examples. The responses to this question showed even more clearly the predominantly 'hi-tech' nature of students' view of technological artefacts, and in fact of the default position of giving examples of artefacts as representative of technology – even if they had previously identified technology as a process or practice of improving life. The responses to this question therefore resulted in an overall reversal of the most common view of technology with the majority (64%) exemplifying technology as artifact, and only 20% exemplifying technology as a process/practice. This general pattern of reversal was seen across all year groups.

Q3 Purpose of technology
Question three asked students to state what they thought the purpose of technology is. A third of the responses focused on technology education again, rather than technology as a domain, and this was consistently high across all year groups. Unlike responses to Question 1 however, the nature of these responses meant it was not able to be inferred what this might mean for their view of the purpose of technology.

Of those responses that did address the purpose of technology, the most common purpose was that of 'meeting needs/improving life', and again, this was so across all year groups. There was a general increase in percentage of students falling into this category as the year group increased, however this was disrupted slightly by the year 11-13 group who showed a slight dip – due it would seem to the number of these students who answered in terms of technology education. It is interesting to note the high number of 'don't knows' particularly in the primary sector. The closeness in the responses to Question 1 and 3, indicate that students view the concept of technology (what it is) and its purpose as similar.

Q4 Affect of technology
Just over half the responses (54.5%) indicated that students felt technology had a positive affect on their life. A response between 40- 50% was the case for all year groups, and for year 9-10 this rose to 76.7%. It is interesting to note the low percentage of responses (4.6%) that talked about any negative affect, and these were all from the primary school sector. Larger social implications were also rarely commented on (only 5.4%), with the greatest percentage of these coming from the senior secondary sector. Fewer responses overall focused on technology education than in previous questions – although this was still a significant factor in the year 7-8 and 11-13 year group.

Findings from the Interviews
Descriptions of the cell phone
Overall, 149 students (71.3%) responded with an initial description in terms of 'naming' the artefact – as a cell phone (in most cases) or as a piece of technology. Thirty nine of the students (18.7%) focused on the physical nature of the cell phone only. Fifteen students (7.2%) described the cell phone in terms of its functional nature only. Only five students (2.4%) described both its functional and physical nature, and of these, only one (0.5%) explicitly made links between them. One student stated they couldn't describe it. There were no gender differences or trends across year groups noted.

After prompting, these figures changed with a significant reduction in students (12 or 5.7%) that provided the name of the phone as their only descriptor, and no student felt unable to describe the cell phone. Sixty eight students (32.5%) still focused on the physical nature only, and 59 (28.2%) on its functional nature alone. There was a large increase in the number of students describing aspects of both the physical and functional nature (70 students or 33.5%). Of these, only 16 (7.7%) explicitly linked these two natures. There were small gender differences noted in that females were more likely to focus on physical features

than males (19% as compared to 14%) and males showed a higher percentage focusing on functional features than females (18% as compared to 12%) after prompting.
Females also showed approximately twice as many responses that explained a relationship between physical and functional features (5% as compared to 2.5%). There were no trends across year groups noted.

Judgment on cell phones
Over two thirds of the students (146 or 69.9%) considered cell phones to be all good, 15 students (7.2%) felt they were all bad, and 46 students (22%) felt they could be both good and bad. The remaining two students 'didn't know'. Reasons given for judgments as good, bad, or both good and bad, were overwhelmingly linked to the impact cell phones have or could have on the student *personally* (196 or 94.7%). Only 8 students (3.9%) provided reasons that focused on issues which could be considered to be part of a wider social awareness. The remaining 5 students (2.4%) stated they didn't know why they made their judgments. There were no gender differences or trends across year groups noted. However, it was noted that year 7 students showed an interesting spike in terms a high percentage (almost 75%) of students who viewed cell phones as both good *and* bad. No other year group showed a percentage above 30% in this regard.

How cell phones are made
Over a third of the students (88 or 42.1%) initially stated they 'didn't know' how a cell phone was made, and a large number of these responses indicated they also didn't 'care' particularly. For example, comments such as "I don't know how it's made – I just use it" were common. Fifty eight students (27.8%) simply stated the phone was made by 'machines'. While the term 'machine' was the best catch all term for these responses, what these students actually meant by this was difficult to ascertain. It would seem they felt that there was some notion of the cell phone being manufactured in a somewhat mysterious automated way – often by robots. Twenty two students (10.5%) suggested that it was made by people in some way, but gave few details. Thirty four students (16.3%) responded by talking about the materials that the cell phone might be made from.
Initially only 7 students (3.3%) talked confidently about technological development practices with links to wider socio-cultural influences.

There were small gender differences noted in that females were more likely to state they 'don't know' than males (24% as compared to 18%) and males showed a higher percentage of responses showing an attempt linked to automated processes/machines than females (17% as compared to 11%). Females were more likely to attempt to explain how cell phones were made with reference to people than males (8% as compared to 2.5%). There were no trends across year groups noted, although it was noted that no students below year 8 were among the 7 students described above as making links to wider scoio-cultural influences.

After prompting, 60 students (28.7%) still stated they did not know and could not make any suggestions at all. At this stage, some of these students began to show a shift in their level of comfort about 'having no idea'. For example, one secondary student (year 12) reflected on this, and discussed how he felt he 'should' know but really 'just had no idea'. However, the majority of these students still made comments suggesting they were quite comfortable 'not knowing'. At this stage, 52 students (24.9%) still stated the cell phone was made by 'machines', with 31 students (14.8%) now suggesting that it was made by people in some way. Forty students (19.1%) responded to prompting by suggesting materials that the cell phone might be made from. Twenty six students (12.4%) began to give more comprehensive suggestions whereby they linked 'machines' and people, often referring to people 'designing the phone' and 'machines making it', and discussed aspects such as research and testing. These explanations however, were only gained after significant prompting by the interviewers.

After prompting, gender differences decreased to below 5% across all categories, and some of the increased number of students making wider socio-cultural links in their explanations were in years 4, 5 and 6. However, no consistent year group trends were noted.

Why cell phones were made

The majority of students (165 or 78.9%) stated that cell phones were made to meet the communication needs of people, specifically to meet people's 'need' for the convenience of portability. Only 14 student responses (6.7%) suggested any awareness of innovation or the cell phone as a realisation of an 'opportunity' or an artifact that might have been involved in the 'creation of needs'. Eighteen students (8.6%) suggested the main reason cell phones were made was to make money, and 12 students (5.7%) stated they had 'no idea' why cell phones were made.

After prompting, two thirds of the students (142 or 67.9%) still stated that cell phones were made to meet the communication needs of people. However, 39 students (18.7%) responses now suggested an awareness of innovation and/or the cell phone as a realisation of an opportunity. Nineteen students (9.1%) stated they were developed to make money, and 9 students (4.3%) continued to say they had no idea why cell phones were made.

There were no gender differences or trends across year groups noted either initially or after prompting, although an awareness of innovation was a stronger feature of the data from year 5-13, albeit in an irregular fashion from

Descriptions of the Fish

The majority of students (170 or 81.3%) focused on describing the physical nature of the fish only, with only 6 students (2.9%) focusing on possible function alone. Eighteen students (8.6%) named the object as a 'fish'. Fifteen students (7.2%) talked about both the physical nature of the fish and possible functions, but only one student response (0.5%) attempted to link the suggested functions specifically to the physical nature. These findings reinforce that more students tend to focus initially on the physical nature of an object, rather than the functional nature. In the case of the 'fish' with its less obvious function (when compared to the cell phone) this tendency was certainly exacerbated. It is interesting to note that only one student attempted to explore the physical nature for clues for possible functions at this stage of the interview. There were no gender differences or trends across year groups noted.

Function of the fish

When prompted to think about possible functions, 59 students (28.2%) stated that the fish was an ornament, and this was often followed with a statement that it had "no function". Fifty three students (25.4%) suggested possible functions however made no attempt to link these with the physical nature. An additional 47 students (22.5%) also suggested possible functions, making reference to at least one physical characteristic – in most cases the large hole. Fifty students (23.9%) stated they did not know and no student suggested the fish was an egg holder at this stage, although a few suggested a holder of some sort (e.g. candle holder, tissue holder). There were no gender differences or trends across year groups noted.

When the students were shown an egg, the majority (155 or 74.2%) immediately 'recognised' the fish as an egg holder. Thirty seven students (17.7%) made no connection between the egg and the fish. Seventeen students (8.1%) suggested an alternative function for the fish, for example, an egg opener/cracker. There were small gender differences in terms of the approximately 74 % recognising the fish as an egg holder – with 33% of these being female and 41% being male. No other gender differences or trends across year groups were noted.

Judgment of fish

The students showed a relatively even split in rating the egg holder as 'good' or 'average' (92 or 44% as good and 89 or 42.6% as average). The remaining 28 students (13.4%) judging it as 'bad'. Reasons given for the judgment, whether good, average or bad, showed that half the students focused on their perception of its ability to carry out the function (111 or 53.1%). Fifty one students (24.4%) focused specifically on the aesthetic quality. Only 29 students (13.9%) explained their judgment by drawing on both the physical and functional nature of the object. Eighteen students (8.6%) stated they didn't know why they judged it as they did. There were no gender differences or trends across year groups noted.

Summary and Conclusion

This data provides some interesting preliminary findings with regard to students' intuitive ideas relating to the nature of technology. From this data, it appears that these students' understandings of ideas related to the nature of technology are highly practice bound, personal and local. Very few students, even at senior year levels, appear able to articulate generic understandings of technology, or locate their understandings in a global or historical context. While many students recognise technology as a purposeful activity aimed at improving life, their exemplification of technology still appears to rest firmly on 'hi-tech' technological outcomes rather than the practices associated with their development.

From the interview data, it appears that there is a clear tendency for students to focus on the physical nature when describing a technological outcome, and little evidence for any understanding of the relationship between the physical and functional nature when exploring such outcomes. This may well explain the low levels of ability in using the physical nature of an object to base suggestions for possible function. These students seem to share a general lack of understanding about how things are made, even after considerable prompting. Of even greater concern is the attitude that such a lack of understanding is unproblematic. The majority of students drew from a personal experiential base when making normative judgments and appear to lack understanding of the socio-cultural nature of technological outcomes and their development. This serves to suggest these students tend not to have strengths in 'reading' technological outcomes.

The questionnaire and interview data showed very few indications of gender differences, and those that did appear tended to shift after further opportunity was provided through prompting. Given the commitment to gender inclusive contemporary technology programmes this would be in keeping with expectations. More surprising was the lack of identifiable year group 'trends'. While some year group differences were noted, no clear and consistent trends could be established in terms of shifting understandings as year group increased. This suggests that student understandings about these aspects of the nature of technology are not being progressed through coherent programmes of learning through levels of schooling. Rather, the data suggests that student understandings are the result of specific instances in their schooling or personal life, and, if developing at all, are doing so in a somewhat haphazard fashion.

These findings further support the view that the nature of the technological literacy being developed by New Zealand students currently is both narrow and limited in depth. The addition of the Nature of Technology strand should go some way to redress this situation. This strand specifically deals with developing a deeper and critical understanding of technology as a domain of human activity and technological outcomes as unique interventions embedded in the socio-cultural world.

For example, a focus on the *Characteristics of Technology* component demands that students explore and analyse a range technological developments to provide insight into the way in which different people's and institutions' values have influenced past technological decision making and technological practices and how these in turn impact on the values of others. This component provides opportunities for informed debate of contentious issues and the complex moral and ethical aspects involved. The socio-cultural and political drivers behind past developments can be explored and analysed in order to better understand how issues of diversity, equity, and respect for others have been addressed – or not, in past scenarios. Exploring technology as an interventionary force that provides potential to enhance the capability of humans, allows students the opportunity to reflect on what and who have been prioritized in the past. In this way, the notion of 'enhancement of capability' can be problematised and critiqued in terms of who has benefited and who has not, as a result of technological developments. The highly collaborative nature of contemporary technological practice also allows students an opportunity to examine the way in which technologists work together to resolve issues of difference associated with personal, professional, political and economic factors.

In addition, a focus on the *Characteristics of Technological Outcomes* component provides opportunity to examine the fitness for purpose of technological outcomes in the past, and to make informed predictions about future technological directions at a wider societal, as well as personal level. Because technological outcomes are material products and systems, developed for a specific function through the undertaking of technological practice, their interrelated physical and functional nature allows them to be interpreted when embedded in their social and historical context. Such an interpretation relies on an ability to see how the purpose behind any technological outcome was justified as of value. Examining a range of historical, contemporary and potential future technological outcomes, provides opportunities for students to interrogate the notions of what is 'fit for purpose' across people, time and place. It also allows for a critical review of the fitness of any purpose, and how this changes as the values of both designers and users change over time and place.

Future research into students' intuitive and developing understandings of the key ideas inherent in the nature of technology will be essential in New Zealand in order to provide resource developers and teachers with a strong base for their practice. The development of programmes that serve to provide opportunity for students to begin to extend the depth, breadth and criticality of their technological literacy will also require further research into effective pedagogical knowledge in technology to support such opportunities. It is hoped that this research will provide findings of use to the wider international technology community as other countries seek also to extend and develop notions of technological literacy that focus on ensuring an informed and critical citizenship for the future (Dakers, 2006).

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Redefining Technological Literacy in New Zealand: From concepts to curriculum constructs

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Abstract
This paper provides the background to the development of the 2006 technology curriculum framework currently published in draft form as the Draft Curriculum: Technology Materials for Consultation (Ministry of Education, 2006). It discusses how we are currently defining technological literacy and explains the research project undertaken to translate the concepts underpinning the definition into constructs appropriate for the curriculum framework's two new strands –Technological Knowledge and the Nature of Technology. These constructs, along with those previously established for technological practice, are then presented and discussed in terms of their contribution to overall technological literacy.

Introduction
The aim of *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) was to develop students' technological literacy. This literacy was argued as reliant on students "undertaking their own technological practice and critically analysing both this and the practice of others" (Compton and Harwood, 2003, p.2). Technological practice was therefore viewed as the vehicle that enabled students to develop technological literacy. This was to be achieved through students engaging in units of work that interlinked the three strands of the 1995 curriculum statement - Technological Knowledge and Understanding, Technological Capability and Technology and Society.

Research into assessment during this time sought to further define technological practice and/or provide tools to plan for and assess its progression (Compton and Harwood, 2003; Compton and Harwood, 2005; Jones and Moreland, 2003; Moreland, Jones and Northover, 2001). At this time, a strong sociological focus was argued as key to supporting student technological practice, in order to move technological literacy away from a 'functional' orientation to a literacy that was 'liberatory' in nature (Compton, 2001; Compton and Harwood, 2003; Compton and Jones, 2003; Davies Burns 2000). As a result of the New Zealand Curriculum Project Stocktake information and the introduction of qualifications at senior secondary school, it became increasingly evident that the nature of the technological literacy being developed by students was somewhat limited in breadth and depth and lacking in the level of informed critical analysis behind decision making. This was largely due to the focus on developing students' understandings of and about technology almost exclusively within the context of their own technological practice.

Based on the above understandings, the development team for technology sought to re-define the aim and revise the constructs of technology education as part of the current New Zealand Curriculum Marautanga Project (NZCMP). The realisation that relying on technological practice alone often resulted in a shallow and narrow technological literacy that was unable to support a level of informed criticality, initiated an argument in 2004 for a stronger focus on the philosophical basis of technology and on identified generic technological knowledge (See briefing papers - Compton, 2004; Compton & Jones, 2004). As a result, technology education was restructured around three new strands - Technological Practice, the Nature of Technology and Technological Knowledge. These strands are still seen as working together to realise the aim of developing student technological literacy. The definition of this aim however, had evolved from that of the 1995 technology curriculum to define a technological literacy in ways that are deeper, broader and more critical in nature than before. The Technological Practice strand pulls together the original three strands from the 1995 technology curriculum and is now well defined from understandings gained from classroom based research carried out in New Zealand over the last ten years.

Key curriculum constructs such as the 'components of practice', and supporting 'indicators of progression' within them, have also been developed, trialed and validated within New Zealand classrooms (Compton and Harwood, 2004; Compton and Harwood, 2005). However, this was not the case for the two remaining strands. In response to this, a two year research contract was funded by the Ministry of Education in order to define the Technological Knowledge and Nature of Technology strands and identify suitable curriculum constructs to sit within them and therefore inform the technology curriculum development as part of the NZCMP.

Overview of the Technological Knowledge and Nature of Technology (TKNoT) Research

As indicated above, the aim of the TKNoT research was to provide a sound understanding of technological knowledge and the nature of technology to ensure a strong foundation for the revised New Zealand technology curriculum to be released in 2007. The research sought to establish the key components of technological knowledge and the nature of technology and provide initial indicators of how these might progress. We thought it was important that this research should draw from a mutually informing mix of contemporary theory - from the philosophy of technology and technology education, the knowledge located in the New Zealand technology community of practice, and contemporary technology education practice via teachers and teacher educators. Key technology networks representing all significant technological sectors in New Zealand, (for example, biotechnology, engineering, food technology, control technologies, information and communication technologies, architecture, and creative design), were approached and individuals within these were identified to be research participants. These research participants included a mix of academic and practising technologists. Having access to international experts allowed us to discuss our developing ideas outside of the New Zealand context. This ensured the research outcomes were relevant to New Zealand but not so 'insular' as to render them invalid in the wider global context of which we are a part.

Teachers from the primary, intermediate and secondary sector were also approached for comment throughout the research and their students were accessed in the later phases of the research to provide baseline data around the newly identified components – particularly those within the Nature of Technology.

The next two sections of this paper present the findings from the TKNoT research with regards to defining the Nature of Technology and Technological Knowledge strands and identifying key components of each. Each section begins with an explanation of the strand, including an overview of the key ideas underpinning what the components have tried to capture. The suggested components are then identified, and a summary descriptor presented for each.

The Nature of Technology

This strand is focused on developing a philosophical understanding of technology as a domain, including an understanding of how it is differentiated from other forms of human activity, and how technological outcomes differ from other artefacts. The two key ideas established from discussions with philosophers of technology and writings in the area are explained below.

Technology as a form of human activity

This strand rests upon a definition of technology as a purposeful intervention in the world, specifically designed to meet needs and/or realise opportunities as they are perceived to be within specific time, space and place locations. Needs and opportunities can be described as focusing on the transformation, transportation, storage and/or control of materials, energy and information in some form.
That is, technologies are developed in order to enhance human capability to transform, to transport, to store and to control (Ginner, 2006). Not all technological practice results in technological outcomes.

Other outcomes of technological practice include such things as ‘no-go’ decisions, concepts, plans, briefs, and models. However, all technological outcomes are developed though technological practice.

The creativity of technologists in their initial design concept exploration, and in the way in which they realise these concepts in a material sense, provides opportunities for them to push boundaries, critically reflect on past developments, and project into future possibilities. The nature of technology has been explored in the philosophical writings of Idhe, (1983) who presents a useful definition of technology based on the work of the existential philosopher Heidegger. That is, technology as a ‘mode of revealing the world’ (Heidegger, 1977). Technology as human activity thereby allows space for ways of looking at the world differently in order to produce innovative solutions and provide mechanisms to extend human capability in ways which may well alter our perceptions of what it is to be human.

While technological practice is based upon the ‘best’ knowledge available to the technologist, and increasingly groups of technologists, it is important to understand there are always unknowns and unintended consequences when technological practice is undertaken and technological outcomes are realised. It is also important to recognise that technological practice, and its resultant outcomes, may have different value across people, places and times. This means that there is a strongly normative element to technology that is based on the social and cultural morals and ethics of particular groups of people within specific environments and eras. Therefore, while ideally technology can be thought of as seeking to enhance human capability, in practice, not all technological outcomes are universally beneficial or useful, particularly when viewed through a historical lens or from multiple perspectives as differentiated by social/cultural/political positions. Examples of this can be found in many of the technological transfers of the past whereby technological outcomes developed for the ‘first world’ were inappropriately transplanted into ‘third world’ countries as aid.

There have been numerous papers and books written in recent years relating to, and exploring, the diversity of concepts of technology. These have ranged from those dealing almost exclusively with exploring, and frequently contesting, the nature of the relationship between technology and science (for example, Allsop & Woolnough 1990, Gardner 1994, and Layton 1993), to those taking a 'wider' more sociological perspective (for example, Cockburn 1993, McGinn 1990, McCormick, Murphy & Hennessy 1994, and MacKenzie & Wajcman 1995). Due to philosophical and historical arguments the view of technology as some form of subset of science, has largely been replaced by most theorists in the field of the philosophy of technology and those working in technology education, by a view of science and technology as two autonomous and distinctive fields (Gardner, 1994). However, the concept of technology explored in many of the sociological texts listed above, is often still based on a narrow, restrictive concept of technology, albeit of a different kind. They are not narrow in terms of applied science or craft, but rather they are narrow by way of taking a materialist artefactual focus. This has meant that while critical theorists, for example, feminists Cockburn, (1993), and Rothschild, (1983) provided a much needed and powerful critique of ‘technology’, this was somewhat limited to a critique of the technological artifact itself.

Such limitations however, have been addressed with a reconceptualisation of technology as situated human activity, reliant on and reflective of social, cultural, political and environmental location. A focus on understanding the complexity of the impacts of and influences on technological development reflect an “integration of the social shaping and social impact perspectives on technology” (Bijker, 1992, p.97). That is, in the past many theorists have taken a dichotomous view, electing to focus on social impact *or* social shaping of technology. Technological determinism has developed out of the social impact theories where technology, once it has been introduced into society is depicted as ‘taking on a life of its own’ (Marx & Smith, 1994). The idea that technological development determines social change is well established and part of the way in which many writers describe technology. This view can provide useful insights into understanding the technological world both in the past and present. In contrast to technological determinism, social determinism theories hold to a notion that “societies can employ ethical conceptions to exert conscious, willful control over the norms of practice involved in technological development" (Bimber, 1994, p.81-82).

In keeping with Bijker, we assert that neither *technological* nor *social* deterministic perspectives *on their own* can provide the full picture of technology and technological development – and hence position the nature of technology within a sociotechnological stance. A sociotechnological stance therefore does more than put technological and social determinist perspectives together as reflected in the interactive view - which retains the technological and the social as separate and stable categories (Bijker & Law, 1992). Instead, a sociotechnological stance supports a 'seamless web view", whereby the social and technological are mutually constitutive and unstable. Such a treatment of technology and society as a "seamless web", rather than "distinct categories" can be managed by what Bijker has coined, the development of a "technological frame" for analysis and exploration of past, current and future technological developments (Bijker, 1992, p.98). We argue understanding the complex relationship between technology and society from a sociotechnological stance is essential for technology education and students should be given the skills and opportunities to investigate the basis of technological innovation and development using Bijker's technological frame within this stance. Today technologists show an increasing understanding of the need for their outcomes and their practice, to take account of the specific needs of the wider social and environmental matrix in which they are working. Philosophical reasoning and debate is critical in the development of potential ethical scenarios in order that long-term impacts may be critically explored *prior* to intervening in the world in ways which would fundamentally change it (Keulartz, Korthals, Schermer, & Swierstra, 2001). Also important is the critical exploration of the fitness of the purpose driving technological developments (Barnett, 1994).

Part of developing a philosophical understanding of technology is the development of an understanding of the nature of technological knowledge. Technological knowledge exists as socially constructed understandings that are accepted by those experts in the field at a particular time.
However, it can be considered to differ from knowledge from other domains because of its epistemic basis. That is, the basis upon which experts validate or 'measure' the worthiness, or not, of new ideas put forward. Technology constantly draws knowledge from other domains, and operationalises this for the purpose at hand. However, technological knowledge as distinct from this, works to give the material primacy, acknowledging that "the things we make bear our knowledge of the world, on a par with the words we speak" (Baird, 2002, p.1). Baird goes on further to argue the need for an epistemological shift by explaining that other domains (science for example) may hold to a "justified true belief" or similarly propositional criteria for validating knowledge, whereas in technology this should be replaced by an intertwining of a "materials sense of truth with the notion of function." (Baird, 2002, p.4). This epistemic difference reflects the difference in the purpose of the two domains. That is, the purpose of technology is to intervene in the world, whereas the purpose of science is to explain the world.

Recognising the increasingly interdisciplinary nature of technology requires technologists to engage in more integrative forms of technological development, where collaborative activity between people and disciplines is becoming more critical for success. Technologists need to recognise the differences between knowledge in the disciplines they are working across, and establish the value of each within particular settings. Such awareness and collaboration requires technologists to engage in constructive debate, carry out informed prioritisation and employ sophisticated strategies for decision making within their technological practice. Further to this, explicit identification and exploration of differing values also becomes paramount in understanding the nature of technology. Petrina proposes an extended framework for such explorations, which encompasses five dimensions: the existential-spiritual; the ecological-natural; the ethical-personal; the socio-political and the technical-empirical (2006, p.3). Argumentation and compromise are therefore strong features of collaborative technological discussions where decisions are based on uncertain or unpredictable knowledge (Vincenti, 1990) and the inherent complexity of interacting values.

Technological Outcomes

Technological outcomes result from technological practice and are defined by the fact they have been designed by humans to exist as material products or systems to perform an intended function. As described by Meijers (2000) "A technical artifact is at the very minimum a physical object that is the *result* of intentional behavior" (p.82). A detailed examination of technological outcomes is justified in that they encompass many forms and complexities, and are a reflection of the embeddedness of technology in that technological outcomes are considered to be intermediaries between the natural and cultural world (de Vries, 2005). It is important to recognise that 'material' technological outcomes include those which exist in a virtual sense as well as the more familiar tangible objects we often associate with technology. The criterion of 'materiality' is therefore met as long as the product or system is comprised of *matter*, as opposed to a concept or idea.

The relationship between technological products and systems can be complex. In many ways it depends on the way in which you frame your analysis. For example, a cell phone could be described as a technological system, which is made up of interconnected technological products. Alternatively it may be described as a technological product where the internal system is treated as a 'black box'. 'Black box' in this context refers to a means of representation that makes visible the inputs and outputs of a system, without showing any of that system's inner workings. The cell phone as a technological product can also be identified as a part of a more complex communication system that may incorporate a range of other technological products and systems, alongside non technological systems and components. A feature of technological products and systems is their highly integrative nature. That is, they are often intimately connected to other entities (including natural artefacts and people) and systems (political, social, cultural etc).

A technological outcome is considered to have a 'dual nature' - that is its physical and functional nature (Kroes, 2002; de Vries, 2005). As explained further by de Vries (2005) "In the first place they are objects with physical properties, such as size, shape, colour, weight, smell, chemical composition etc. On the other hand they are objects that I can use for a certain function" (p. 18).
It is interesting to explore the impact of how the natures connect through the perspectives of the different players (i.e designer versus end-user). Again, de Vries explains:

> The designer seeks a physical nature (for a not yet existing artefact) that is fit for a desired functional nature, and when using the artefact the user identifies if the physical nature (of the existing artefact) is fit for a desired functional nature. The relationship between physical and functional nature is never one-to-one pre-defined. For any desired functional nature, there are several options of physical natures and vice versa. That is why creativity can play a role both in designing and using the artefact. (2005, p.18-19).

In terms of a technological system, the way that the parts of a system are connected is the 'physical nature' of the system, while its inputs, processes and outputs identifies its functional nature (de Vries, 2005, p.25). An exploration of the relationship between the physical and functional nature of a technological outcome provides a useful analytical tool for establishing the fitness for purpose of a technological outcome during development. It also provides an analytical tool for interpreting or 'reading' existing technological outcomes and understanding their past and contemporary influences and impacts, and possible future implications.

The term 'proper' function is used to describe the designer's intended function, however other unintended functions may evolve from use. This is referred to as a 'system function' (Meijer, 2000; de Vries, 2005) but we have termed this an 'alternative' function to reduce confusion in terminology. Not only do users regularly employ technological outcomes for an alternative functions, they may modify the physical nature in order to optimize the proper function or create a new functional nature. This reflects the dynamic interaction of a technological outcome and user, showing the embeddedness of use. Meijers (2000) refers to this as a relational property of the function of artefacts, and goes on to explain such properties as those that "require for their existence, human minds and consciousness" (p.84) as opposed to observer-independent properties such as those making up the physical nature (Meijers, 2000, p.83). The concept of ‘alternative’ function is completely different to that of ‘mal-function’. Mal-function refers to a situation where the technological outcome does not carry out its ‘proper’ function successfully. The exploration of mal-functioning technological outcomes provides an interesting focus for understanding the design, material, user and environmental interfaces.

Components of the Nature of Technology

In recognition of the above discussion, the two curriculum components identified for this strand are:

- Characteristics of Technology
- Characteristics of Technological Outcomes.

Descriptor for Characteristics of Technology

Technology is a purposeful intervention-by-design human activity that can result in technological outcomes that impact in the world. Technology provides potential to enhance the capability of humans to transform, store, transport and control materials, energy and information. Technology uses and produces technological knowledge. Technological knowledge is aligned to function and validation occurs within technological communities when it is shown to support successful practice. Technology is historically positioned and inseparable from social and cultural influences and impacts. Contemporary technological practices increasingly rely on collaboration between people and disciplines.

Descriptor for Characteristics of Technological Outcomes

Technological outcomes are material products and systems developed for a specific function through technological practice. Technological outcomes have an interrelated physical and functional nature allowing them to be interpreted when embedded in their socio-cultural and historical context. The designer’s intended function is called its ‘proper’ function. ‘Alternative’ functions are those functions that are evolved by end-users in ways not intended by the developer. Mal-functioning technological outcomes can impact on people’s views of technology and acceptance of high impact innovations. A technological outcome is evaluated in terms of its fitness for purpose.

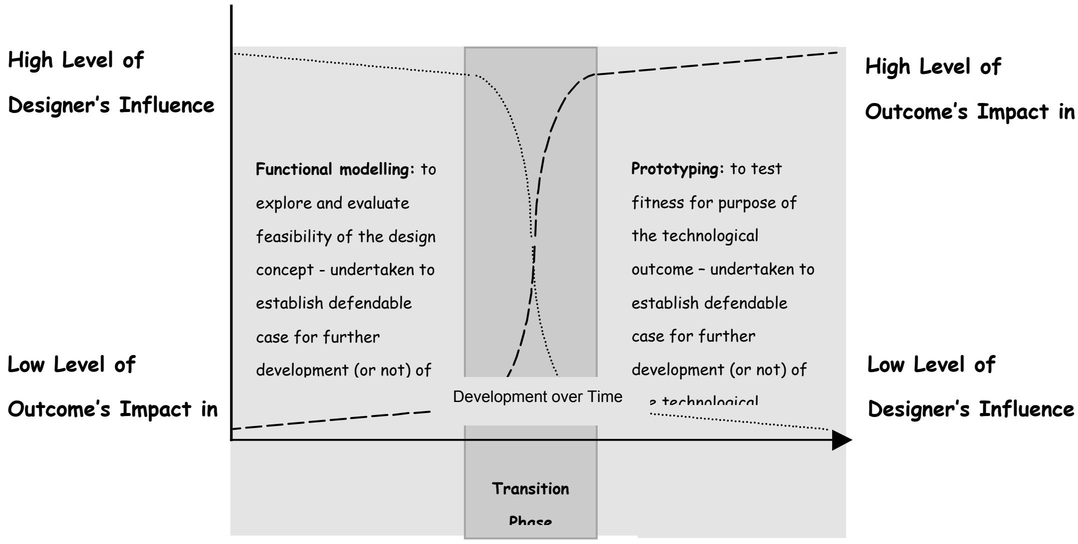
Technological Knowledge

This strand is focused on developing key concepts of technology that are generic to all technological endeavours. These concepts should be understood by all students irrespective of the specific contexts they may be studying and/or technological practice they may be undertaking. The three key ideas established from discussions with practising and/or academic technologists in New Zealand (participants in the TKNoT research) are explained below.

Technological Modelling

Technological modelling is a key concept in technology and can be differentiated into two related forms - functional modelling and prototyping. These forms are based on the purpose and timing within the development of a technological outcome. Technological modelling is critical in the exploration of influences on technological outcomes and their impact in the world as technological developments move from conceptual ideas through to fully realised and implemented technological outcomes. As Figure 1 (below) illustrates, the designer’s influence on the impact their work will have in the world decreases as development work proceeds. At the transition phase, where the design idea is first realised as a technological outcome in its material form, the designers influence declines significantly. In contrast, the impact of the design concept increases as development proceeds towards its realisation. At the transition phase, this interventionary impact increases significantly. Impacts in the world include both beneficial and harmful impacts, such as environmental, social, economic, and political benefits or costs. The transition phase should be viewed as a critical decision point in any development, for once realisation of an outcome has occurred, there is no going back. However, any future development work can of course be subsequently halted, or directions changed.

Figure 1: Technological Modelling in Technological Development



Functional modelling is used to enhance risk mitigation by providing the means to minimise the unknown or unintended consequences of possible technological outcomes. Functional modelling allows for the exploration and evaluation of the design concept in order to make justifiable decisions regarding its future development. These decisions take into account such things as known specifications, material and technique suitability, as well as historical and socio-cultural factors, in particular values such as those highlighted by Petrina (2006), prior to the technological outcome being realised in the material world. At this point of technological practice, there is a strong focus on go/no-go type decisions. If the decision is to proceed, the result may be to revise the design concept or move on to the next stage of outcome realisation as appropriate. Functional modelling is sometimes called test or predictive modelling, or animatics or mocks. Functional modelling should be used extensively in the early stages of technological practice, when scenarios for purposeful intent are being developed and 'what if' questions are posed and explored. Early stages of functional modelling often employ 'guestimation' as based on similarities and/or analogies to other 'known' situations or developments. Functional models allow for iterative designing through ongoing model testing, evaluations and refinement. The 'better' the functional modelling, the greater confidence a technologist can have in the potential for more positive than negative impacts in the world. Functional modelling provides opportunity to reduce the waste of resources that can often occur if technologists rush too quickly to the realisation phase and rely on a more 'build and fix' approach to technological development, and as such is a key tool for enabling sustainable developments.

A prototype represents the next phase of technological development where the outcome is now a realised intervention in the world. At this point of realisation, it has had a significant 'impact in the world', purely by the fact it exists. The purpose of prototyping (or prototype modeling) is to inform subsequent development decisions as based on the evaluation of the technological outcomes' performance against those specifications driving its development.

It also allows for a greater level of exploration of unintended consequences/impacts as new information from wider stakeholders is accessed. As with functional modelling, decisions from prototyping can again result in go/no-go decisions. If the decision is to proceed, this may result in a range of subsequent actions from a return to design concept, to less dramatically modifying or refining outcomes. Prototyping therefore provides the means to trial and optimise a technological outcome's fitness for purpose. Specific methods of prototype modelling are validated by different communities. Codes of standards and/or measures of acceptability should be utilised in such procedures. Prototyping for the purpose of testing scale-up opportunities can be explored in appropriate situations, and will provide key information regarding decisions around ongoing or multi-unit production and marketing for commercial purposes, as appropriate.

The modes of representation used in technological modelling will vary depending on the stage of development. They range from conceptual modes to 3-dimensional mockups in functional modelling to functioning outcomes in prototyping. Functional reasoning provides a basis for exploring the functional potential of the design concept. That is ‘how to make it happen’, and the reasoning behind ‘how it is happening’ in prototyping. Practical reasoning provides a basis for exploring more social aspects (moral and ethical) surrounding the design concept and outcome trialling. That is, the reasoning around decisions as to ‘should it happen’. In this way, practical reasoning provides a framework or rational structure to justify what ‘ought’ to happen.
Employing both these types of reasoning as part of technological modelling ensures that a holistic evaluation of a technological outcome’s potential and actual ‘intervention into the world’ is undertaken.

Technological Products
Technological knowledge underpinning technological products focuses on the use and development of materials as the foundation of product development. The properties of materials need to be understood in relation to their performance properties and this knowledge will underpin deeper understandings of material formulation, manipulation, and transformation. The contemporary field of material technology is crossing many traditional disciplines and showing increasingly diverse and exciting possibilities for material performance, and technological product function. For example, smart materials and nanotechnology would provide interesting contexts for the exploration of the relationship between material and performance properties. An exploration of the impact of material use and new material development on product life cycles will be important in supporting a technological understanding of sustainability in terms of technological products and future developments.

Technological Systems
Technological knowledge underpinning technological systems focuses on such things as inputs/outputs, control and transformatory processes. The concept of the ‘black box’ is important in understanding technological systems. As outlined above, a black box can be thought of as a representation of a component within a technological system that is reduced to inputs, outputs and a non-disclosed transformatory process or series of processes. There are advantages and disadvantages in adopting a black box approach when working with and understanding technological systems. An advantage is that it can provide an opportunity for complex systems to be explored and understood in a holistic sense. However, a significant disadvantage is that the detail of what is ‘lost’ or ‘hidden’, and therefore not understood, may pose problems in system modification and/or development. It may also result in a loss of empowerment for the end-user, particularly should any mal-function occur or when troubleshooting or repair work is required.
An exploration of ideas such as redundancy and reliability within technological system design and performance will be important in supporting technological understandings of the operating parameters. Technological systems are often represented in symbolic ways to communicate their components and function. While there appear to be some generic symbols associated with systems, such as arrows to denote direction, it is important to understand that specialised languages exist and are central to the development and communication of technological systems. For example visualisations can be represented using communication technologies (e.g. computers) in order to explore and understand relationships between components of systems and/or between systems. Different technology communities often supplement/modify generic symbols as part of more specialised diagrams/representations.

Components of Technological Knowledge
In recognition of the above discussion, the three curriculum components identified for this strand are:

- Technological Modelling
- Technological Products
- Technological Systems

Descriptor for Technological Modelling
Technological modelling includes functional modelling and prototype modelling. Functional modelling serves to explore the feasibility of a design concept for a yet-to-be-realised technological outcome. Prototyping serves to explore the fitness for purpose of the technological outcome itself. Both are key tools in technological practice that support informed predictions of possible and probable consequences of proceeding, and therefore underpin justifiable decision making. Technological modelling is underpinned by functional and practical reasoning. Functional reasoning provides the reasoning behind 'how to make it happen' and practical reasoning provides a focus for answering 'should we make it happen' questions. The results of technological modelling may include termination of the development in the short or long term, a continuation of development as planned, or change or refinement of the design concept or technological outcome.

Descriptor for Technological Products
Technological products are material in nature and exist in the world as a result of human design. Understanding the relationship between the properties of materials and their performance capability is essential for understanding and developing technological products. Technological knowledge within this component will include the means of evaluating materials to determine appropriate use to enhance the fitness for purpose of technological products. It will also include understandings of new materials formulation and their potential impacts on future product function. The impact of material use and development on product life cycles will also be important in understanding sustainability.

Descriptor for Technological Systems
Technological systems consist of interconnected components designed to work together to control the transformation of materials, energy and information. Understanding how the components work together is as important as understanding the nature of the individual components. Key concepts of technological systems are input, output, transformation, and control. Complex technological systems involve integrated sub-systems. Redundancy and reliability within technological system design and performance will also be important in understanding technological system operating parameters. The concept of a black box is useful in understanding complex systems. Technological systems are represented and communicated using specialised languages.

From Concepts to Curriculum Constructs
Based on the defining of the new strands as above, and previous work done with regards to Technological Practice – the following framework has been developed.

Table 1: Technology Strands and their Components

Technological Practice[1]	**Nature of Technology**	**Technological Knowledge**
Brief Development	Characteristics of Technology	Technological Modelling
Planning for Practice	Characteristics of Technological Outcomes	Technological Products
Outcome Development and Evaluation		Technological Systems

The framework presented in Table 1 provides a more robust philosophical and theoretical base for technology education in New Zealand and addresses all concepts discussed by Mitcham (1994) as being focused on in technology education in varying ways. These four concepts being:

- Technology as Volition – addressed via Characteristics of Technology

[1] Please see Compton and Harwood, 2005 and http://www.techlink.org.nz/Components-of-Practice/descriptors.htm for an explanation of the components of technological practice.

- Technology as Artefact – addressed via Characteristics of Technological Outcomes
- Technology as Activity – addressed via Brief Development, Planning for Practice and Outcome Development and Evaluation.
- Technology as Knowledge – addressed via Technological Modelling, Technological Products and Technological Systems.

Each component has a series of levelled achievement objectives developed as a starting point in describing progression from curriculum levels 1-8 - see the *Draft Curriculum: Technology Materials for Consultation Package* (Ministry of Education, 2006).
However, unlike those developed for the Technological Practice strand, the suggested progressions for Technological Knowledge and the Nature of Technology strands have yet to be trialed and validated in classrooms. Context-specific technological knowledge and skills are also recognised as key constructs underpinning the above framework. It is through multiple experiences of a range of specific contexts that robust generic understandings can be developed.

Summary and Conclusion
In summary, the re-defined concept of technological literacy has led to the development of a new set of curriculum constructs – namely the three new strands and their key components. These three strands work together to support the development of this literacy as follows:

The Technological Practice strand provides a basis for students to undertake their own technological practice within a specific setting and reflect on the technological practice of others. This strand allows for the development of capability in technological practice, and an experiential base for developing more generic understandings of the nature of technological practice. Students will develop their capability in the three identified components of technological practice - *brief development*, *planning for practice* and *outcome development and evaluation.* These experiences will allow students to gain a sense of empowerment as they undertake their own technological practice to find solutions to identified needs and/or realise identified opportunities. It will also provide opportunities to embed the philosophical ideas from the nature of technology and generic technological knowledge as appropriate, in order to better inform their practice.

The Nature of Technology strand provides a basis for the development of a critical understanding of how technologies intervene in the world, and that technological developments are inevitably influenced by historical, social and cultural events.

Students will be able to develop a philosophical view of technology through the two identified components of the nature of technology – *characteristics of technology* and *characteristics of technological outcomes.* Such understandings will provide opportunities for informed debate about contentious issues and the complex moral and ethical aspects that are involved. This strand also provides opportunity to examine the fitness for purpose of technological outcomes in the past and to make informed predictions about future technological directions at a societal and personal level. Such philosophical understandings are essential to the development of a broad and critical literacy for New Zealand students.

The Technological Knowledge strand provides a basis for the development of key generic concepts underpinning technological practice and technological outcomes. These concepts will allow students to understand evidence that is required to defend not only the feasibility of a technological outcome, but also its desirability in a wider societal sense. Students will be able to develop technological understandings that underpin the three identified components of technological knowledge – *technological modelling*, *technological products*, and *technological systems*. The focus on functional modelling will allow students to develop an understanding of simulated environments as compared to 'real' environments.

This differentiation will allow them to fully appreciate both the power and limitations of functional modelling, thus reducing the propensity for students to take a 'build and fix', (or not), approach in their own technological practice. Gaining a better understanding of prototyping will provide a better sense of why this is important, as well as how such modelling can enhance any technological outcomes they may develop as part of their own technological practice. Knowledge underpinning technological products and technological systems, and the relationship between the two as technological outcomes, will also enable students to infuse their technological practice with a higher level of technological understanding.

In conclusion, we argue that the new curriculum strands for technology education should provide students with experiences of a rich and varied nature within which they can develop a technological literacy that has depth, breadth and an informed criticality in keeping with that supported by recent writings in the area (see Dakers, 2006). In particular, the nature of the technological literacy driving the 2006 revision of technology in New Zealand, is reflective of the critical literacy discussed by Petrina (2000) and has the potential to create in students a "critical ethical consciousness" as espoused by Keirl as key in technology education (2006, p.90) and a wider ecocentric base to act from than the current technocentricity that resulted from a technological practice focus alone (Petrina 2000b). Programmes of work[2] underpinned by these three strands should provide opportunity for all students by the end of their compulsory schooling to have developed a level of technological literacy that will enable them to live as informed participant in whatever society the future offers. As part of this, students should be neither fearful of technology, nor blindly accepting of its lead. Rather they should have developed a critical eye with regards to this interventionary force, and an informed basis from which to make both personal, socio-political decisions for optimising the future for all people and the environment upon which we rely for continued existence as a species. As students move into senior secondary programmes in technology, the nature of this literacy should become increasingly specialized, but no less critical, in order to support students as they enter technology related careers or go on further to become technologists themselves[3]. In this way we hope to create a shift in the community of practicing technologists through the increasing number of new members with increased philosophical awareness of the domain in which they work and change our world.

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[2] For a discussion of programmes ideas based on these three new strands, see Compton and Harwood, (2006) *Discussion Document: Design Ideas for Future Technology Programmes*.

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Enabling Technological Literacy in New Zealand: The GIF – Technology Education Initiative

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Abstract
This paper provides a background to the GIF – Technology Education Initiative. This initiative has allowed a number of projects to be launched with the overall aim of enhancing the quality and delivery of technology education in New Zealand. The initiative is described and an explanation of these projects presented. The rationale behind each project is presented as opportunities in their own right, along with a discussion of the inter-relationships between them.

Background
In 2002 the Government released the Growth and Innovation Framework (GIF) through the Ministry of Economic Development. This framework was designed to pursue the long-term sustainable growth necessary to improve the quality of life of all New Zealanders. Part of this was the recognition of the role government had to play in developing stronger links between industry and education providers and building a strong and capable workforce.

The GIF was a strategy based on a vision of New Zealand as:

- a land where diversity is valued and reflected in our national identity
- a great place to live, learn, work and do business
- a birthplace of world-changing people and ideas
- a place where people invest in the future
- an environment people cherish and are committed to protect for future generations

(Ministry of Economic Development, 2006a)

Four areas were identified for government action initially identified in a 'Growing an Innovative New Zealand'. These were:

1. Strengthening the innovation system
2. Developing skills and talents
3. Increasing international connection
4. Engaging with sectors

(Ministry of Economic Development, 2006a)

Several cross-sector initiatives arose from this initial development work. A proposal requesting support for technology education was developed by the Ministry of Education on the basis that it would contribute to areas 1, 2 and 4 (above). This proposal was successful and in 2004 funding was made available specifically for: *Increased Support for the Technology Curriculum in the Senior Secondary School*. This funding provided the basis of the GIF – Technology Education Initiative (referred from this point on as the 'Initiative').

The funding came initially from the Ministry of Economic Development and was re-distributed through the Cabinet's Economic Development Committee to the Ministry of Education and other fund holders. Fund holders were government and non-government agencies that have either been given projects to manage or have made submissions to host projects as a part of the GIF. Many of these fund holders accessed the GIF funding to augment or accelerate current projects that met GIF sector aims as well as their own. Funding for the Initiative was allocated on the basis of new work. The funding allocated to the Ministry of Education now sits as vote education funds however, it has a clear heritage in the government goal of economic transformation. Vote education funds are administered by the Ministry of Education on behalf of the Minister of Education in order to enact government education policy.

Since the GIF was released in 2002, Government policy has moved toward a notion of economic transformation. Education, and in particular technology education, has a key roll in supporting New Zealand's future prosperity – "Education is the key means by which people acquire the skills, knowledge, attitudes and values to contribute to a knowledge based economy" (Ministry of Economic Development, 2006b).

A challenge to previous support for technology education in New Zealand in the past has been the often disconnected periods of funding. The funding has also often been for short periods of time - generally less than 4 years. Support was delivered as a part of the rolling implementation of the national curriculum[1]. Generally the funding was directed toward national professional development at all levels of schooling, but with a focus on the compulsory years (years 1 – 10). In contrast to this, funding from GIF is for a 10 year period, which began in July 2004. This stable funding regime allows the Initiative to be strategic on a level unprecedented in previous initiatives to support technology education in New Zealand.

Initiative Management
The Initiative is located in the Ministry of Education's curriculum team and closely aligns with other curriculum based initiatives including the review of the national curriculum. The Initiative is managed under contract to the Ministry of Education by a project manager. The project manager is responsible for coordinating all the activity and setting strategic direction for the Initiative based on Ministry of Education goals.

Reference Group
A reference group was established to scope of the Initiative and guide it progress. It does this through the provision of advice to the Ministry of Education. This group is representative of the technology education sector with members who are involved in pre-service, in-service, secondary school teaching, education policy, qualifications development, professional technology and technology education research. The group meets regularly to provide ongoing strategic and operational support for the Initiative.

Aims
The first task of the reference group was to develop a set of aims for the Initiative. These were developed in recognition of the overall aims of the larger GIF initiative and to address known areas of support required for technology education in the secondary sector. These aims were to support senior secondary technology education through:

1. Raising the quality and effectiveness of teaching and learning in senior secondary school technology courses
2. Increasing secondary school student participation in technology education
3. Enhancing teacher capability to provide senior secondary school technology courses
4. Improving alignment between secondary and tertiary technology education
5. Increasing interaction with business/industry needs/vision

Under these aims a number of operating protocols were established. These were strongly based on personal and institutional lessons learned from previous rounds of support for technology education. These protocols centred on the following:

- Professional support would be targeted on areas of established need (initially senior secondary)

[1] For more detail of New Zealand curriculum development see http://www.tki.org.nz/r/nzcurriculum/draft-curriculum/index_e.php

- The Initiative would derive material from teachers who had extensive experience and understanding of technology education in New Zealand schools
- Materials developed would be available for all technology educators in a flexible way that encouraged quality programmes and supported student achievement

Projects to Date

The Initiative develops projects that support its aims and which seek to align, wherever possible, with other government and non-government projects supporting technology education. For example, the Ministry of Research Science and Technology's (MORST) New Zealand Biotechnology Learning Hub[2].

While funds were appropriated for the support of senior secondary students (years 11 – 13) the reference group determined that projects that only begun at this level of schooling would restrict the opportunity for sustainable development. The Ministry of Education therefore decided to support work with students from years 7 – 13 on the basis that coherent programmes developed across this range would make gains for the senior secondary sector more likely. The projects established to date from the Initiative are as follows:

- Technology Beacon Practice Project
- Materials Development
- Techlink – Technology online
- Head of Department (HoD) Support
- Curriculum Support
- Promotion of Technology Education
- Biotechnology focus for Professional Development and Resources
- Year 7&8 Technology in Intermediate Schools
- Domain Knowledge Workshops

Technology Beacon Practice Project

The Technology Beacon Practice Project aims to build teacher capability in technology education, as defined by *Technology in the New Zealand Curriculum* (Ministry of Education, 1995), through a focus on quality teaching, innovative teaching and learning environments and supportive relationships. This project is based on the premise that teachers who currently demonstrate best practice can enhance this practice with the support of curriculum and other experts, and the provision of time to reflect on and implement developments.

The Beacon Practice Project provides schools with teacher participation funding[3] to release teachers and enable access to a range of specific support personnel. These personnel include:

- Professional support facilitators
- Researchers
- Writers
- Tertiary and industry technologists

The Project is interventionist in its nature. Teachers are supported by facilitators working in schools to effectively coach, model and mentor them to thoroughly embed and extend beacon practice in technology and to provide the basis for materials development[4]. The gain for the wider technology education community is access to this practice through case studiers and other resources.

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[2] See http://www.biotechlearn.org.nz/

[3] Teachers are given 0.2 of their full time equivalent (FTE) time allocation as release for this project. This is added to their normal 0.2 FTE non-contact time. Therefore teachers in the project will teach a maximum of 0.6 FTE

[4] For detail of this project please see related paper – Harwood, Implementing Technological Practice in New Zealand: A foundation for technological literacy

Materials Development

This project takes material directly from the teachers in the Technology Beacon Practice Project and develops a range of materials designed to support technology teachers through out New Zealand. This material is accessible through the Techlink website[5]. Writers interview the teacher, students, facilitators and technologists to develop the material. The development process includes external critique and the ongoing feedback from the teacher(s) involved[6].

The resources reflect the practice of over 40 leading technology teachers in New Zealand. They provide insight into how they have developed programmes, networks, relationships and professional knowledge to support their students' learning and achievement in technology, as well as providing examples of student outcomes. The resources are largely case studies, but also include smaller focussed case notes that reflect more specific current best practice.

Techlink – Technology Online

Techlink is a collaborative website developed between the Ministry of Education and the Institution of Professional Engineers New Zealand. The site is used by the Initiative as a clearing house for resources and a source of up-to-date information on technology education. The Ministry of Education has chosen not to publish material in hard copy at this stage. This is to allow for the resources to be constantly updated and the development of deeper links between resources. The site has material to support HoDs in promoting their subject, news in technology and technology education. Part of the site supported by New Zealand Trade and Enterprise has a wide and growing range of case studies of industry technological practice[7].

HoD Support

HoD workshops have been delivered throughout the country and have been very well received. The aim of this work is to support technology middle managers in secondary schools. The project has focused on the role and importance of effective learning communities. It has also provided advise and guidance on curriculum and qualification matters. The project has worked closely with the local School Support Services (SSS)[8] and built on or extended the work they are engaged in

Curriculum Support

The Initiative has jointly funded, with the Ministry of Education's curriculum development team, research that underpins the review of the current technology curriculum. This consisted of position papers (Compton, 2004; Compton & Jones, 2004) and research on technological knowledge and the nature of technology[9]. This research has contributed to the new curriculum framework for technology education as published in the *Draft Curriculum: Technology Materials for Consultation* (Ministry of Education, 2006).

Marketing and Promotion of Technology Education

The Initiative and other aspects of technology education are actively promoted within the education sector and with the wider community including parents, professional and tertiary technologists. This work involves the development and dissemination of information and various alert mechanisms in regards to new material on the Techlink website or news of events in the technology education

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[5] http://www.techlink.org.nz/tech-education/beacon-practice/index.htm

[6] The resources are developed based on guidelines developed at the outset of the project – http://www.techlink.org.nz/tech-education/ResourceGuide.htm

[7] http://www.techlink.org.nz/case-studies/Technological-practice/index.htm

[8] School Support Services provide curriculum and school leadership advisory services to schools in New Zealand. They are contracted by the Ministry of Education and based within Colleges of Educations/Universities.

[9] For more details please see papers – Compton and France, Redefining Technological Literacy in New Zealand: From concepts to curriculum constructs and Compton and France, Exploring the Nature of Technology: Students' intuitive ideas as a starting point.

community. There is a team that carries out this work based around a dedicated marketing specialist.

Biotechnology focus for Professional Development and Resources
This is an additional beacon practice project targeting materials in biotechnology. These have not been available through the current Technology Beacon Practice Project, and therefore the model is being modified to allow for material to be gathered in this area in 2007 through providing direct support to teachers interested in biotechnology. Extensive use of the Biotech Learning Hub will be made and selected teachers will work with a facilitator to develop learning experiences in keeping with best practice. The resulting student work will be used to develop additional case studies on Techlink, and further support the development of the learning hub itself.

Year 7&8 Technology in Intermediate Schools
Year 7 and 8 is the first time students in New Zealand will generally work with specialised technology teachers. As such, it has in the past led to some disruption to the development of a coherent transition from the primary sector (up to year 6) to the secondary sector (beginning year 9). This project is designed to understand and support these critical transition points.

Domain Knowledge Workshops
These development workshops recognise the importance of domain specific knowledge and skills for the effective delivery of technology education programmes. A key focus of these workshops has been on looking at how domain specific skills underpin the development of the identified generic concepts, as represented in the *Draft Curriculum: Technology Materials for Consultation* (Ministry of Education, 2006).

Links to Other Work
Technology Advisers: The Initiative has supported professional development for SSS technology advisers over the last three years. SSS support in-service teacher education in seven regions throughout the country. To date, support for advisers has been in the form of regular hui and opportunities to become familiar with aspects of the Beacon Practice Project. Some SSS advisers have also worked together with Beacon Practice facilitators at the HoD workshops[10].

National Certificate of Educational Achievement (NCEA)[11]: Developments in national qualifications and assessment will be reflected in the aspects of Initiative where it supports secondary school classroom practice in technology.

The Interlinking Nature of the Projects
With the broad aims of the Initiative established, the projects under it are required to show how they meet these aims. We have found that most of the projects address some aims more than others. Therefore the Initiative constantly evaluates the progress of each project and addresses any gaps in support to provide a balanced delivery of the Initiative aims.

As the New Zealand technology education community is small, there is often considerable overlap of personnel among projects. While this allows for much connectivity, it emphasises the critical need to build sector wide capability at all levels. This connectivity is a strength of the Initiative, and is built upon a mixture of contractual and professional links between projects and personnel in projects.

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[10] For details of the teacher education emerging professional learning community, please see Keith, Supporting Technological Literacy in New Zealand: Connecting policy with vision.
[11] The NCEA is the national qualification available to students in senior secondary. It comprises three levels (Levels 1, 2 and 3).

The nature of the overarching aims and the relative strength of support given to each aim by individual projects has provided an environment where all projects interlink to a greater or lesser degree. These links range from a critical partnership through leverage to cooperative interaction.

Critical Partnerships: These are Initiative projects that depend on the outcomes of other Initiative projects to meet their goals (Figure 1).

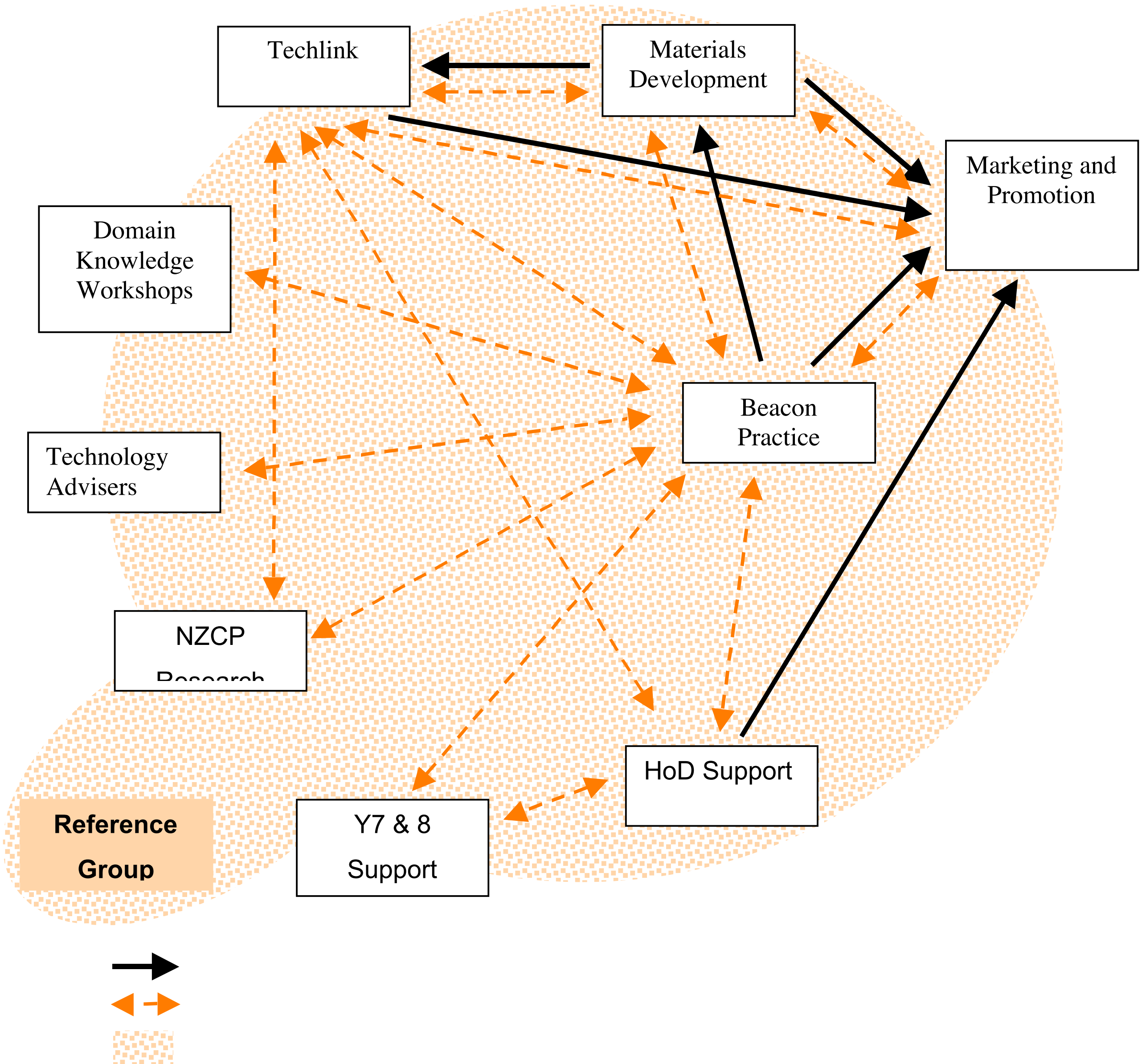
Leverage: These projects gain leverage off other projects to achieve their goals. These are generally allied projects operating under other government and non-government agencies. All these interactions are mutually enhancing (Figure 2).

Cooperative Interaction: These Initiative projects share practice, resources or cooperate when working with different sector groups (Figure 1).

An example of critical partnerships in action can be seen in the path from the Technology Beacon Practice Project through to the Materials Development and Techlink to Marketing and Promotion. Writers from the Materials Development Project work with beacon practice teachers to develop case studies focused on aspects of their practice. These developed case studies are made web ready and published on Techlink. The marketing specialist alerts website subscribers to the new resource and creates promotion material around the work or in conjunction with previously published material. In reality this is not a linear process and interactions are iterative. Linking of projects is supported by contract clauses that confirm and specify these relationships. This is further aided by the fact that the one organisation holds the contracts for the last three of these projects.

The cooperative interaction links shown in Figure 1 are illustrative of the small and dedicated community that supports the work of this Initiative. The interactions shown below are those that have formally or informally operated to date in the course of the operation of the projects. The interactions are supported through the reference group's overview of the Initiative. All projects are represented by personnel on the reference group. This allows the group to be regularly updated on the progress of the projects and any issues or opportunities that arise from them.

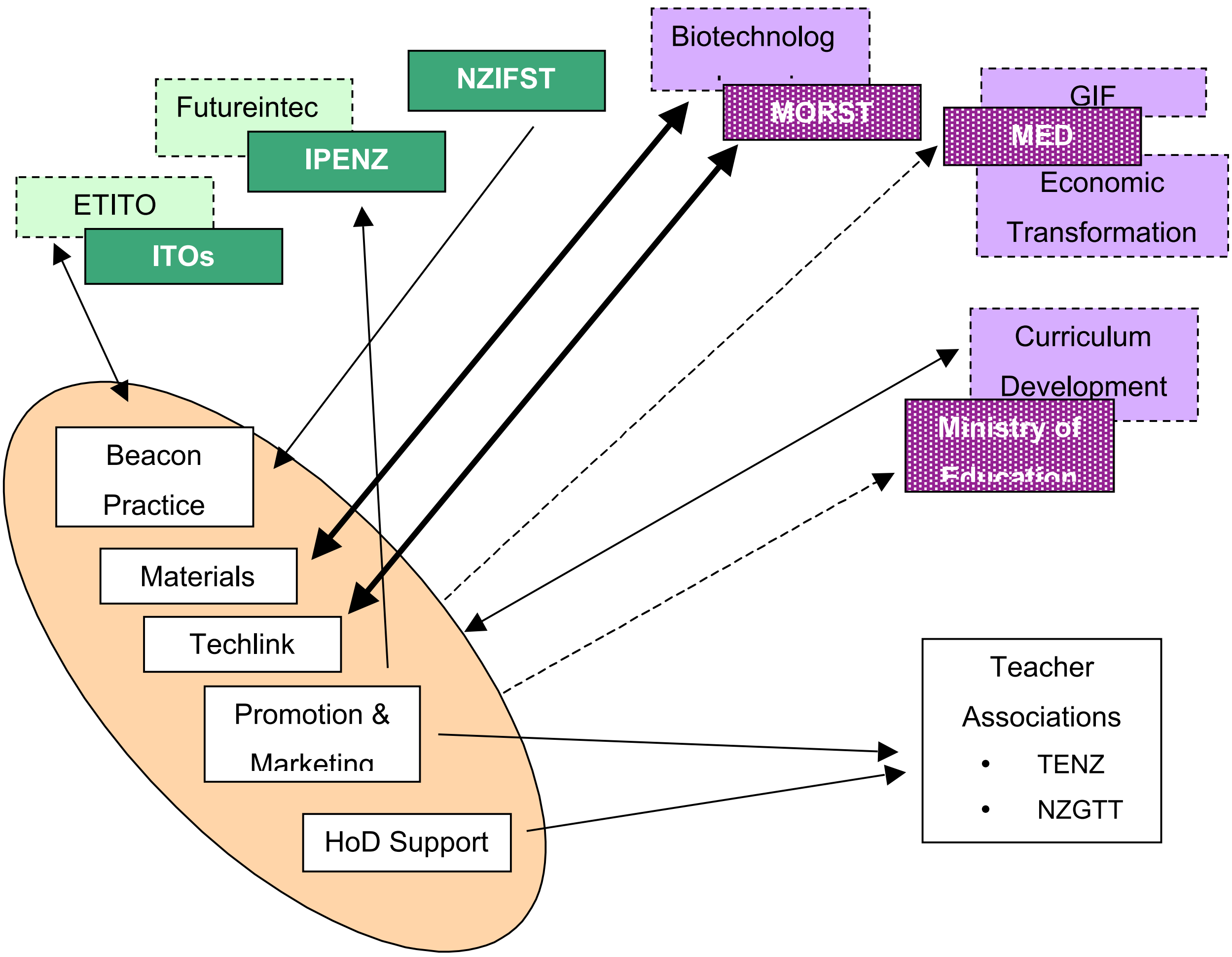
Figure 1: Critical Partnerships and Communications within GIF Technology Education Projects



The Initiative works with a wide range of projects within government and non-government organisations (Figure 2) and organisations that support technology education in schools. The nature of the interactions with these projects varies from updates and project communication to shared or linked work. Of particular note is the link to government agencies who engage in specific sector support for aspects of technology. MORST's Biotechnology Learning hub is an example of this. The Hub develops case studies of industry based biotechnology and materials to support biotechnology in schools. As outlined above, the Initiative project will develop case studies of how this material can be effectively used to support quality learning in technology education.

The New Zealand Institute of Food Science and Technology provides support to Beacon Practice through the provision of in-class support from practicing food technologists[12].

Figure 2: Initiative Leverage across Government and Non-government Organisations



Key

NZIFST: New Zealand Institute of Food Science and Technology see *www.nzifst.org.nz/* Futureintech: Support for Science and Technology Careers see *www.futureintech.org.nz/* ITO: Industry Training Organisations ETITO: Electrotechnology Industry Training Organisation, see *www.etito.co.nz/* TENZ: Technology Education New Zealand see *www.tenz.org.nz/* NZGTTA: New Zealand Graphics and Technology	Non-government agencies and projects Government Agencies and projects GIF – Technology Education Initiative projects Reporting Shared work

education are common across all projects both within the Initiative and where work is shared or linked with other agencies. The resources for teachers that are derived from the Initiative are widely and deeply connected across the community. The flexibility of the Initiative allows it to both strategically support technology education but react in-depth to issues arising across the sector.

The Initiative is currently evaluating its progress and looking at the opportunity to reframe the goals of the Initiative with a more inclusive set of aims. In the light of the first 3 years of implementation, a set of revised aims is proposed for the remainder of the Initiative. These revised aims are specifically seeking to extend the scope of the Initiative to include all levels of technology education, rather than just focusing on the secondary sector.

The newly formulated aims to support technology education are:

1. raising the quality and effectiveness of teaching and learning in technology education programmes (Y1 – 13)
2. enhancing teacher capability to provide such technology programmes
3. increasing senior secondary school student participation in technology education
4. improving alignment between secondary and tertiary technology education
5. increasing interaction with business/industry needs/vision

These take into account the opportunity to support the Ministry's goal of seamless technology education for years 1 – 13[13].

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[13] For detail of this vision please see paper Keith, Supporting Technological Literacy in New Zealand: Connecting policy with vision

Supporting Technological Literacy in New Zealand: Connecting policy with vision

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Abstract
This paper presents the vision developed for technology education and how this has supported and is supporting policy decisions within the Ministry of Education in New Zealand. It also discusses the implications for professional development of teacher educators, teachers and professional support mechanisms when focused on enhancing student learning. It raises a number of current challenges and opportunities facing technology education in New Zealand and the ways in which these are being facilitated through the development of strategic inter-relationships.

Introduction
The Ministry of Education in New Zealand has increased its commitment to technology education through the latest round of national curriculum development known as the New Zealand Curriculum Marautanga Project (NZCMP). This has involved revisiting the concept of technological literacy which underpinned *Technology in the New Zealand Curriculum* (Ministry of Education, 1995), and addressing limitations in student performance in technology especially in senior secondary in the area of technological knowledge. These limitations were highlighted in student work submitted for the National Certificate of Educational Achievement (NCEA) from 2002.

A research project (Technological Knowledge and the Nature of Technology – TKNoT) was therefore funded to establish how the concept of technological literacy could be strengthened to clarify how it could be mediated into New Zealand classrooms.[1] After discussion and agreement with the national Technology Writing Group and NZCMP cross education reference group checks, the results of this research and consultation have been published as the *Draft Curriculum: Technology Materials for Consultation Package* (Ministry of Education, 2006a). Feedback on the draft curriculum from the schooling sector and from wider community and education sectors was completed in November of 2006. Feedback from these sectors will be considered in early 2007.

The Ministry of Education is now in a strong position to ensure a clear and more coherent vision is developed and communicated effectively within the technology education sector. We are developing policy that will support implementation of the new technology framework once it is finalised mid-late 2007. Technology sits as an essential learning area within the *New Zealand Curriculum Framework Draft for Consultation* (Ministry of Education, 2006b), and as such is aligned to the vision, principles, values and key competencies within this draft national curriculum framework.

This vision supports the development of young people who will be confident, connected, lifelong learners and actively involved in a range of life contexts (Ministry of Education, 2006b). It positions students at the centre of their education and strives to ensure each student is provided opportunity to reach their potential. The principles that have been identified to guide all schools as they design and implement their own curriculum encompass notions that include valuing excellence, a focus on learning to learn, a commitment to New Zealand's bicultural heritage, an affirmation of equity and connections to family and wider community groupings, and recognition of the importance of coherent learning pathways (Ministry of Education, 2006b, p.9). Experiences across the last 10 years of technology teachers in classrooms and specialist facilities tell us

[1] For a full discussion of the concept, research and resultant draft curriculum framework for technology education see paper - Compton and France, Redefining Technological Literacy in New Zealand: From concept to curriculum constructs.

that technology is a powerful learning area which supports the integration of learning from a broad range of curricula, and that it has a strong focus on establishing community and environmental links.

The development of specific skills and knowledge within technological practice provides for student learning experiences that are engaging and constructive. These experiences have resulted in personalised learning (more readily allowing for individuals to reach their potential), and that this has been both empowering for those involved and important in establishing connections within local communities.

Other key macro features of the *New Zealand Curriculum Framework Draft for Consultation* (Ministry of Education, 2006b) are values and key competencies. Recent theorising has established the mutually enhancing role that the newly defined technological literacy can play in relation to values education. As stated by Compton, "Taken together these components should provide students with experiences of a rich and varied nature within which they can develop a technological literacy that has depth, breadth and an informed criticality that is inherently 'values' rich. That is – values as beliefs we are encouraging our students to develop, understand and critique, are central to technology education in New Zealand." (2006, p.73-74). Technology therefore provides opportunities to both 'learn about values' and 'develop values related capability' in an authentic and powerful way (Compton, 2006). In much the same way, technology allows for the development and contextualisation of the key competencies, and in turn these have been argued as potentially enhancing for technological literacy (Compton, 2004). Technology education can therefore be argued as a key learning area to contextualise and support the overarching directions of education in New Zealand as currently being framed by the *New Zealand Curriculum Framework Draft for Consultation* (Ministry of Education, 2006b).

This paper presents an outline of the developing vision driving policy decisions and currently under consultation with the technology sector. It will indicate the strategic work being undertaken to ensure integration of planning and use of available resources to ensure a coherent approach to technology education for the foreseeable future. It discusses the impact this has had to date on developing ideas of what a contemporary 'technology teacher' might look like and the challenges this poses for New Zealand in terms of ensuring teacher capability. New opportunities under development for resolving teacher capability through in-service and pre-service professional development are also outlined.

The Developing Vision

The overarching vision driving policy decisions for technology education is the desire to develop seamless quality programmes from Year 0 to Year 13. Currently across the education sector in New Zealand, we are all working towards developing a delivery model for teaching and learning that wraps all the important deliverables around each individual student's learning needs. The aim of this model is to produce individualised pathways for student-centred learning that are increasingly coherent and inter-related. We are seeking to do this, whilst also recognising the importance of families and communities as essential to the success of this process (Ministry of Education, 2006b). Within technology education we are attempting to develop this approach using the 2006 draft technology curriculum as a base to support a coherent interlinked series of programmes delivered across all sectors in New Zealand.

Broadly speaking, the vision for seamless quality technology programmes from Year 0 to Year 13 sets challenges and opportunities for the whole technology education community – including pre-service and in-service teacher educators, and classroom teachers in early childhood, primary, intermediate and secondary centres and schools. Specifically these arise from the requirement to consider the needs of their own students in the light of the whole continuum of learning implicit in the draft technology curriculum. There is a significant amount of work to do here to ensure all technology teachers and teacher educators across all sectors are aware of the importance and power of developing agreed key understandings within technology education and supporting the progressing of these for students from year to year. In this way, the whole sector will seek to collaborate and assume responsibility for providing coherent and inter-connected programmes of learning.

Links to Technological Literacy

The vision for seamless technology education embodies a vision for current and future technological literacy. This was articulated in the support document accompanying the release of the draft technology curriculum (Keith, 2006a). This is expressed as a set of literacy levels through which students may progress through the education system in New Zealand.
The levels comply with intended technology outcomes for all New Zealand students in general education and also provide insight into possible outcomes as students specialise within secondary education programmes. Three tiers of literacy were described as end points of key transition stages in New Zealand's education system.

These were described as follows:

> As a compulsory learning area, technology education helps all students develop a technological literacy for general citizenship. This includes students coming to understand how technologies work, how technology impacts on people and vice versa, and also how to undertake technological practice. (Years 1-10)
>
> Initially, post compulsory education in technology helps students to extend this literacy to gain knowledge and skills that might prepare them for trade apprenticeships, service professions and for possible careers across a range of technology-related industries. (Years 11-12)
>
> Technology is now an approved subject on the University canon of approved subjects for university entrance (in New Zealand). Students can also enter for Scholarship in technology. Technology education in senior secondary therefore provides for a more specialised technological literacy, where students gain knowledge and skills that prepare them for university courses and future professional careers in technology.
> These students may become future leaders of excellence through innovative technological practice. (Year 13)
> (Keith, 2006a, p.2)

As indicated above, in order for these levels of literacy to be available for all students, cross sector programme coherence is paramount.

Current and Future opportunities

The Growth and Innovation Framework – Technology Education (GIF-Technology Education) Initiative
The GIF-Technology Education initiative[2] is a highly significant project supporting technology education in New Zealand, with funding of $2.2 million per annum. It provides resource opportunities for technology education. This funding is managed from within the Ministry of Education, taking advice from a national reference group. The work is delivered by contractors. The current scope of the GIF-Technology Education initiative is targeted at senior secondary, however the Ministry of Education is currently looking at a re-scoping exercise as the achievement of technology students at senior secondary is recognised as being supported by high quality technology education programmes from early childhood centres and throughout compulsory schooling as outlined above.

Year 7-10 Support
Regional in-service technology advisors have been working on a combined project, using national exemplars (Ministry of Education, 2004) and the components of practice (Compton & Harwood, 2005) and targeting intermediate schools and year 9 and 10. There have been some significant shifts in teacher practice as a result. Opportunity has arisen from this work to develop a pilot cluster of intermediate schools to further explore the development of revised technology programmes in keeping with the new directions for technology education within the specialist year 7 and 8 environments.

[2] For a full description and explanation of this initiative see Dinning, Enabling Technological Literacy in New Zealand: the GIF- Technology Education initiative.

Teacher Educator Professional Learning Communities

A broad commitment has been gained from teacher educators (both pre-service[3] and in-service[4]) to continue to meet regularly (at least twice a year at a national level) to continue discussions around technology education to develop shared understandings, and to explore the implications for teacher education and ongoing teacher support.

The Ministry of Education sees this as an opportunity for longer term influence of both the delivery of technology teacher education and of teacher professional guidance through the School Support Services national advisory programme. Principles of professional learning communities (Timperley, 2004) will be employed to support the development of this group with the view of creating a self-sustaining collaborative cross sector community.

As a start to this professional learning community development, a series of recent national meetings with teachers and teacher educators was held and broad agreement was obtained for current directions. It is recognised that the generic, coherent structure of the refined 2006 draft technology curriculum, along with achievement objectives that progress across learning levels 1 to 8[5] provide technology education with a new and very exciting opportunity to build agreement across the sector for student learning. At these meetings, the introductory learning area statement, the three strands and the eight components were deemed highly acceptable to all involved (Ministry of Education, 2006a). There were some concerns expressed within the sector about the achievement objectives, however these were focused on emphasising the need for more time and professional support to unpack these to more teacher and/or student friendly language and the need for exemplification of what these may look like within classrooms. The Ministry of Education accepts these are legitimate requests and is seeking to address these concerns. For example, the TKNoT research contract will deliver a full report on the research project and provide indicators for each achievement objective that give greater clarity and specificity. It will also begin to provide examples of what each component looks like in different technological sectors. A further contract is planned to commence mid 2007, for a 3 year programme of work where researchers will work with teachers to extend existing programmes for teaching and learning in the light of the revised curriculum. Student work from a range of levels and technological contexts will be analysed to further explore and explain each component, and material will be developed into case studies and provided as web based resources for teachers.

To further support this professional learning community, the Ministry of Education is currently in the process of appointing a National Technology Professional Development Manager. The role of this person will be to provide overall national professional development and leadership in technology education.

Programme Evaluation

In 2007, the Ministry of Education plans a research based evaluation into technology classrooms and specialist facilities, at both intermediate and secondary levels, to establish in detail the nature of current pedagogical practices and programme design – and how this is impacting on student learning. There are a range of implementation issues to be explored around funding also in the year 7 and 8 area.

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[3] Pre-service teacher education in New Zealand is primarily cited in Universities and as such the Ministry of Education's curriculum division has little influence over their programmes. Adherence to national curriculum direction therefore relies on professional collaboration.

[4] In-service teacher educators are managed directly by the Ministry of Education curriculum division and therefore professional guidance and support to practising teachers must be accountable to national curriculum directions.

[5] The New Zealand Curriculum Framework currently differentiates 8 levels of learning across years 0-13. These are loosely aligned to two years of learning from levels 1-5 and then single years from levels 6-8. However, it is acknowledged that students progress at different rates, and as such, any age-level relationships are indicative only.

Supporting Synergistic Relationships
The Ministry of Education is also working to increasingly align and coordinate work between all aspects of technology education. It is acknowledged that disparate, but loosely connected groupings, can achieve a far greater synergy for a sector if collaborative ventures are supported in ways that don't compromise each groups unique purpose, status and identity. There is movement towards coordinating the major technology related teacher associations in New Zealand – for example, TENZ (Technology Education New Zealand), GATTA (Graphics and Technology Teachers Association) and HETTANZ (Home Economics and Technology Teachers Association of New Zealand). This is being supported by the sharing of communication opportunities, contributing to one another's conferences and by developing opportunities through the technology curriculum for specific skill and knowledge sets to be supported and delivered through integrated technology programmes. This especially applies to opportunities to teach at the higher secondary levels - Levels 2 and 3 of the New Zealand Qualification Framework (NZQF)[6].

Within general education we are looking to make stronger links to the world students will enter after leaving school. We therefore recognise the importance of working with the practicing technology sector and see such collaboration as key to the development of a robust technology curriculum that has currency in that world. We are also strengthening this alignment through the use practicing technologists/technology students at tertiary level to support teachers and students. This is having a significant impact on student understanding of both specific technological knowledge and skills resulting in enhanced technological outcomes, and increased understandings of technology-related careers. Technology education has a history of articulating a need for strong community links (Ministry of Education, 1995), but now we are exemplifying how this can work in practice for mutual gains between technology education and technology sectors.

The Ideal Technology Teacher – Capability and Supply
The Ministry of Education is mindful of the need for teachers who can teach technology in ways that unlock the implicit potential for learning in technology for all students. As is clear so far in this paper, the issues surrounding the capability of teachers of technology is never far below the surface. Attached to this concern in New Zealand is the national, and as far as we can tell international, issue of the shortage of appropriately educated technology teachers. The Ministry of Education has begun to explore in-depth these supply and capability issues in a more coherent and integrated way. Recent history reveals an industrially driven 'quick (and limited) fix' approach around pay and conditions which has not well served either technology education or the vision of government for a technologically literate community capable of developing economic transformation. Discussions are currently taking place that will set the scene for possible improvements in this area. Traditional recruits from industry have been prevented by a qualifications bar that was imposed in 2003 by industrial agreement. In response to this, a new degree qualification for technology teaching is currently being explored and it is hoped it will be developed in 2007. This qualification will involve a flexible, multiple entry and exit point programme, and is envisaged as being offered conjointly by a university and a polytechnic to meet the full range of technology teacher requirements; academically and in terms of teaching practice, and also for domain specific skills and knowledge. For example, electronics, foods, materials, or biotechnology etc.

The Ministry of Education's vision is "to develop a teaching workforce capable of delivering technology programmes that improve learning outcomes for all New Zealand students" and "to develop technology teachers who can teach in line with the principles of New Zealand general education and whose teaching supports government goals that maximise economic transformation at a range of levels, support social developments and meet the needs of NZ families and communities, including Maori and Pasifica" (Keith, 2006b, p.1) This statement goes on to explain that good quality teacher education will "develop a general teaching skill set for technology teachers similar to that required for a good teacher in any learning area that is in line with contemporary NZ practice" and "develop a specialist skill set for technology teachers that is

[6] This is not to same as the New Zealand Curriculum Framework levels 1-8. NZQF levels run from 1-10 and provide pathways into the tertiary sector up to Doctorate level.

appropriate for the delivery of the special requirements of curriculum based technology across a range of contexts." (Keith, 2006b, p.1).

There are of course wider funding and industrial issues being explored and considered around this venture, however the goals are to provide an adequately funded scheme to future-proof a capable technology teacher workforce for a successful New Zealand, and to provide teachers who have the ability to teach across a range of levels of the New Zealand curriculum – as is the case in other learning areas. Some will be generalist teachers of technology up to Year 10. Some will have the technical knowledge and skills to teach foundational vocational training courses and technology courses with context specific skills and knowledge at the NCEA levels 1 and 2. Others will have higher level specialist skills and knowledge to teach advanced technology courses at the NCEA levels 2 and 3 and Scholarship. The future success of technology education lies in the quality or otherwise of its teaching workforce.

Challenges to Overcome
Technology education in New Zealand has a complex inheritance of various technical training models especially at the intermediate age schooling (years 7 and 8) and in senior secondary schooling (years11 to13). The "new" technology education model was awkwardly laid over these existing models and practices, with assumptions that these teachers would naturally upskill to the new model and teach alongside new teachers who come into technology teaching from a range of different backgrounds. Significant initial funding and support provided was not consistently followed up on. In the two areas particularly mentioned above, some teachers have shifted very effectively while others have not. This has been for a variety of reasons, ranging from lack of adequate professional development, lack of adequate personal educational training, and in some cases lack of inclination or insight to see purpose in the new directions.

School Transitions
There are significant transition point difficulties for all learning areas within the New Zealand schooling environment. Historically there has been little genuine interaction between the different institutions and levels of the New Zealand education communities around seamless educational delivery. The historical conversations have been essentially functional.
The transition point interruptions to seamless student learning are partly due to structural and pedagogical differences in schooling types; for example, from a single class with one teacher primary model where teaching and learning is generally holistically planned and delivered, to a multi teacher secondary model where teaching and learning is often fragmented by both timetable and subject silos. These difficulties are further exacerbated in technology by a wide range of inherited practices and pedagogies. Variable understandings of technology embedded across the technology teaching and teacher educator workforce as previously mentioned add to this.

Secondary-Tertiary/Work Transitions
A further complex transition area is in the movement of students through senior secondary schooling and into the workforce and/or tertiary worlds (including university). Currently senior secondary schooling in New Zealand has a wide range of existing courses many of which are provided for from within general education and many of which are modified industry training courses. In the senior secondary school environment there is a tension between the flexibility to design programmes that meet the needs of local students, and the desire to offer coherent programmes nationally. Where schools are generally large, urban, well funded and lead, this model delivers excellent results. However, small, rural, financially and/or managerially challenged schools often struggle to provide the breadth of courses required to meet the needs of all their students. Many of the more effective small rural schools meet these needs innovatively – as seen by the recently established video conferencing networks using regional fibre optic loops, which have improved opportunities for many students across New Zealand who are involved in distance education.

This senior secondary environment is problematic for technology education. There are a plethora of courses offered into schools by the Industry Training Organisations (ITO's). These courses are supported and moderated in a range of ways but the impact for technology education is that these are often simple courses with workbooks for theory and credentialing by unit standards (within the NCEA). The skills and knowledge taught in these programmes which rely on unit standards for credentialing purposes are generally discrete and lack a requirement for transference, higher levels of informed creativity, visualization or critical thinking. All these are key aspects in upper levels of technology education and essential to programmes employing achievement standards (still within the NCEA) for credentialing purposes.

The connection for many traditional teachers within the broader area of technology teaching in secondary is to the technical training model of learning. It appeals in terms of ease of delivery along with bundles of readily accessible skills and knowledge that these teachers have. In addition, some students see these courses as providing easy credits for a NCEA. The concern for technology education is that while many of these courses could be reframed within a technology education context and designed with a mix of achievement and unit standards to meet the needs of a wide range of students, this requires teachers to have a strong technology education philosophy and key technology curriculum understandings. This is however, often not the case, and therefore opportunities are often lost for students to be taken into a higher world of learning – particularly in the contexts of materials, foods and information and communications technology (ICT) where unit standards and ITO programmes are specifically targeted.

All these issues are compounded by the fact that prior to the development of technology achievement standards as part of the implementation of NCEA, few technology teachers taught courses in technology at NZQF level 3 unless they were pure graphics or art design. This historical gap therefore perpetuates a technology teaching workforce needing high levels of support to develop confidence and competence to work at this transition cusp.

Having said this, the time is ripe for constructive alignments and relationships with the ITO community. With a pathway through technology to tertiary courses and university now in place, and with a robust and coherent technology curriculum framework, there are opportunities to design programmes that can offer students higher quality courses. By integrating the best knowledge and skills from context specific areas; for example in electronics, teachers can create knowledge and skills clusters that are learnt while undertaking technological practice. Courses developed in this way could be credentialed through a strategic mix of achievement standards in technology and unit standards offered by ITOs. A recent 'convergence' conference in New Zealand in 2006 specifically explored this type of relationship between an ITO sympathetic to general education approaches and the technology curriculum. This type of relationship may form a basis for future partnerships between the Ministry of Education and various industry sectors, bearing in mind these relationships need to be maintained within the intent of general education and be seen to provide students with a well rounded education and not as training for work.

Conclusion

In conclusion, the recent work to refine and clarify the technology curriculum framework and its underpinning constructs, and to develop a vision for technology education, provides New Zealand opportunity for a period of sustained growth in the learning area of technology. By drawing from best practice in technology to date, we have begun to provide quality resource support for teachers nationally. We are already beginning to see a positive effect on teacher understandings around technological literacy. We look forward to this influencing programmes design and pedagogical practice across the sector in the future. By increasing levels of common understandings about technology across the wider technology education community we expect to create a synergy that will improve outcomes for all teachers and students in technology education.

"Where there is no vision, the people perish."
Proverbs 29:18a

If we can achieve the vision for seamless quality technology education, from early childhood through to senior secondary programmes, students in New Zealand will have greater opportunities to access rich technological worlds and be scaffolded through quality teaching to develop a deep, broad, and critical technological literacy. They will undertake their own technological practice within challenging and fun programmes of learning that are engaging and student-centred. All students will progressively develop their technological literacy to prepare them to be citizens ready to engage in a technologically complex and challenging world.

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Implementing Technological Practice in New Zealand: A foundation for technological literacy

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Abstract
This paper presents an overview of the Beacon Practice – Technology (BPT) project which is part of the GIF-Technology initiative. The BPT exemplifies the successful implementation of technological practice in New Zealand classrooms in keeping with the constructs underpinning this strand in the Draft Curriculum: Technology Materials for Consultation Package (Ministry of Education, 2006). The paper also discusses the gaps that have been identified through New Zealand's experience of implementing technological practice and highlights the implications for programme design and professional development, in keeping with the newly developed technology curriculum framework.

Introduction
The Beacon Practice - Technology project was instigated from funding provided to technology education in New Zealand by the Growth and Innovation Framework (GIF). This Framework is administered for the New Zealand Government by the Ministry of Economic Development (MED)[1]. An expectation of the MED in providing this funding to technology education was that student participation in technology both within and beyond education would be increased. Identified as significant to realising this expectation was the need to raise the quality and effectiveness of teaching and learning in senior secondary school technology programmes. For this to be achieved however, it was clearly evident that the overall quality of student learning in technology from years 1-13 also had to improve.
To aid the achievement of this expectation, a range of teacher resource materials were developed using teachers that were selected to participate in the BPT.

This paper will provide an overview of the BPT project, and the outcomes of this project to date. It will also present findings from the project in terms of students undertaking of technological practice and suggest strategies that may be used to further enhance students overall learning in technology education, and their development of a technological literacy that is broader, deeper and more critical in nature[2].

Beacon Practice – Technology
The framework for the Beacon Practice - Technology (BPT) project for New Zealand schools was developed following analysis of the evaluations from the Beacon Schools (BS) initiative in England (Bullock and Muschamp, 2004; Rudd, 2001; Rudd, Davies, Jamison, Rickinson and Johnson, 2001). Feedback on two BS projects that were undertaken in New Zealand, the BS Home Economics and Health Education projects (Ministry of Education, 2005; NZQA, 2002), was also used to inform the framework for the BPT project. The BPT project purposefully set out to target teachers whose practice was currently identified as being 'beacon' (best practice), and who also showed a willingness to further progress this practice. This targeting of 'beacon' teachers reflected a belief that beacon practice in technology most often resided within individual teachers or groups of teachers in New Zealand schools, rather than it being exhibited across all teachers of technology within a school. In acknowledging the desire to provide support individual teachers or groups of teachers whose practice

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[1] For a detailed overview of the Growth and Innovation Framework please see – Dinning, N. Enabling Technological Literacy in New Zealand: The GIF-Technology Education initiative
[2] For details of the nature of technological literacy driving this work see Compton & France, Redefining Technological Literacy in New Zealand: From concepts to curriculum constructs.

was beacon, in order to develop quality resources that could later benefit all teachers of technology in New Zealand, it was decided to call the project 'Beacon Practice' rather than 'Beacon School'.

Entry into the BPT project required teachers and their schools to go through a formal selection process, conducted by representatives from the Ministry of Education. This process required schools to submit evidence of their current best practice in teaching technology, as well as examples of student learning from this practice. Teachers were also asked to provide a detailed outline of the area(s) they wished to focus on, in order to enhance their pedagogical and/or content knowledge/opportunities for student learning. As part of the selection process, teachers where visited by members from the Ministry of Education selection committee members to review and discuss their application. As a result of this process, seven initiatives were contracted to take part in the BPT project in 2005 and a further four initiatives in 2006. To assist BPT teachers to meet their identified area(s) for enhancement, a facilitated situative professional development model (Broko, 2004) was adopted for the project. To provide teachers with the necessary 'space' to enable them to reflect on their practice and the learning of their students, and engage in the professional development, the number of classes they taught within the schools timetable was reduced. The adoption of this development model assisted the teachers and facilitator to establish clear, agreed expectations of what all parties in the project, aimed to achieve as a result of their participation in it.

Situative teacher professional development and the BPT

Teacher professional development that is situative, conceptualises learning as "changes in participation in socially organised activities, and individuals' use of knowledge as an aspect of their participation in social practices" (Broko, 2004, p.4). As such, learning through participation in a situative professional development model for teachers becomes both a process of "active individual construction and a process of enculturation into the practices of a wider society" (Broko, 2004, p.4). To assist the BPT teachers to undertake 'individual construction' and become more aware of the 'practices of a wider society' (both within the technology education community and the wider community of technology) professional development facilitators were contracted to work alongside the BPT teachers. These facilitators included practicing technologists and academics involved in technology education. To ensure that the professional development provided to the BPT teachers was situated and contextualised, the BPTF undertook research to identify what teachers and their students were doing well (considered to be beacon practice) and to determine areas for further development. To do this, the BPTF interviewed the BPT teachers, surveyed their students, reviewed BPT teachers' current technology programmes and examined student outcomes from these programmes. From this research, an individualised professional development plan for each project was developed to frame the intervention(s) that were used to improve BPT teacher's pedagogical and content knowledge of technology and/or their management practices. To assist with the ongoing implementation of the professional development plan, ongoing evaluation was also identified as an essential element of the plan. As part of this evaluation, the BPTF spent time in the BPT teachers' classroom/s observing their practices. The BPTF also interacted with students to identify areas showing improvement, as well as distinguishing opportunities for further focused teacher professional development. This ongoing observation allowed the BPTF to refine the evaluative tools to ensure that the site-specific professional development provided by the BPTF was both contextualised and informed, and thus responsive to any ongoing changes. The adoption of such a situative teacher professional development model for BPT project that was contextualised to individual BPT initiatives ensured that evaluation went beyond just looking at the periphery of a teaching programme. That is, beyond just taking a 'black box' approach to evaluation, which only identified the programme planned for student learning and the student artefacts from this, to also consider the conditions that allowed the teaching programme to work and the reasons for this (Chatterji, 2004). This approach to evaluation allowed areas of concern identified within the BS initiative in England to be addressed in the BPT project model. These concerns included such things as: teacher difficulty in self identifying and communicating what it was that made them successful (beacon) in teaching technology; and the lack of external evaluation to inform the ongoing development of the initiative (Bullock and Muschamp, 2004; Rudd, 2001; Rudd, Davies, Jamison, Rickinson and Johnson, 2001).

BPT teacher release
To provide teachers with 'space' to focus their attention on the BPT project, all BPT schools were provided an extra staffing allocation that allowed them to employ additional staff so that they could release their BPT teachers from a full teaching load. This funding for release time meant that BPT teachers were not having their classes taught by relief teachers, when they participated in BPT professional development. Disruption to the normal teaching programme for students was therefore minimal.

The BPT teachers were encouraged to use their teacher release time, to reflect on their current teaching programmes and the student outcomes from these. Whilst acknowledging that reflection is often "shaped by feelings and understandings that may be tacit rather than known and accepted" (Rudd, 2001. p32), teachers were asked to analytically think about the pedagogies and resources they used to deliver technological experiences to their students. From undertaking this analysis, these teachers were able to identify opportunities to develop new and/or enhance existing technology programmes, and identify openings to develop alliances with practicing technologists, which could support their delivery of technology education. The funding provided to reduce the number of classes taken by BPT teachers, has meant that pressure on teachers time and workload due to their commitment to the project, has also not become the significant issue as it was in BS projects (Bullock and Muschamp, 2004; Rudd, 2001; Rudd, Davies, Jamison, Rickinson and Johnson, 2001; Ministry of Education, 2005).

Disseminating outcomes from the BPT project to non beacon schools
To disseminate the outcomes of the BPT project to teachers and students not involved in the project, professional resource writers were employed to develop a range of teacher and student resources. A focus of these resources is on providing *case studies* on teacher planning and delivery of technology education along examples of student outcomes. To support these case studies, a series of *case notes* that focus on such things as: teacher and student mentoring; establishing and sustaining links with practicing technologists; and the reflective practitioner have also been developed. The case studies and case notes have been developed to provide teachers with insight into the pedagogical and management practices used by the BPT teachers, as well as an opportunity to see the outcomes produced by students. Examples of case studies and case notes can be found on http://www.techlink.org.nz

In employing professional resource writers to disseminate the outcomes of the BPT project, the need for BPT teachers to partner non-beacon schools or provide professional development to other teachers in order to disseminate findings from the BPT project, as occurred with the BS initiative in England and the New Zealand BS projects (Rudd, Davies, Jamison, Rickinson and Johnson, 2001; NZQA, 2002), has been alleviated. This has meant that BPT teachers are able to concentrate solely on their own teaching practices and the enhancement of these, rather than being concerned with developing others' practice. The need for BPT teachers to develop adult facilitator skills, as was found to also be an issue with the BS initiative (Rudd, Davies, Jamison, Rickinson and Johnson, 2001), has also been resolved due to the employment of the BPTF and dedicated professional resource writers.

Progress to Date
At the time of writing this paper there are thirty-four case studies and case notes in various stages of production and twelve have been published on http://www.techlink.org.nz. These case studies/case notes are focused on such things as:

- Individual and/or class learning outcomes that have been achieved as a result of participating in a technology education programme. These cover a range of technological contexts including food technology, materials technology, textiles, and electronics and control.

- Teaching programmes that enable student learning to be identified and planned to enable students to progress their knowledge and skills in undertaking technological practice in technology.
- The establishment of school/industry partnerships to support the delivery of technology programmes and development of mechanisms for sustaining these.
- Examples of the benefits (including outcomes) of having students mentored by professional technologists', students within tertiary courses, and ex-pupils from the school who are working or studying in technology related fields. Also illustrated are examples of within-school mentoring where senior students have mentored junior students.
- Strategies for assessing student learning, capturing evidence of this learning in efficient ways, and reporting formats for a range of audiences including students, parents and teachers.

An identified key outcome for many of the BPT projects was the establishment of a programme of learning for technology that provided opportunity for all students to progress their knowledge, skills in undertaking technological practice in a seamless manner. In one BPT project composite school; this has resulted in their developing a year 1- 13 technology programme, while in another secondary school this resulted in a year 9-13 programme. Essential in the establishment of these programmes has been the ability to identify and report on what students know and can do as a result of participating in a unit of learning in technology. This has enabled students learning to be monitored with subsequent options of technology planned, to ensure opportunity for students to progress these generic components in the future. The Components of Practice (CoPs) (Compton and Harwood, 2004; Compton and Harwood, 2005) have been used extensively to assist teachers with establishing these 'seamless' learning programmes. The CoPs - Outcome Development and Evaluation, Brief Development and Planning for Practice[3], allowed teachers to map student competencies against the levelled descriptors and identify key aspects to focus on for subsequent student technological experiences to ensure their learning progressed. By confirming that all teachers in the department/faculty had a common understanding of what the CoPs descriptors meant that when students changed teachers, due to option changes (i.e. moving from one technology subject to another) and/or due to a change in year level, then student progression was not disrupted.

Key findings to date

As evidenced in the case studies published to date, the BPT project has provided opportunity for teachers' pedagogical and content knowledge of technology to be enhanced, particularly their ability to support students undertaking of technological practice. Through encouraging students to observe and critique the practice(s) of practicing technologists BPT students have gained understanding of such things as: the importance of understanding the needs, desires and issues which confront people involved both directly and indirectly in the development of technological products; the skills and knowledge that a technologist(s) applies when developing their product(s); the impacts of societal (e.g. legal, ethical legislative) and environmental requirements/considerations on the products they develop, and the developed products' impact on society and the environment.

These understandings have enabled BPT students to develop technological outcomes (as exemplified in the BPT case studies) which have been validated as 'fit for purpose'. Important to this validation, has been BPT teachers presenting opportunities to their students to develop technological outcomes in collaboration with wider stakeholders such as practicing technologists and clients who have a genuine issue/need that needs resolving.

Whilst placing importance on BPT students gaining an understanding of others technological practice has enhanced students overall technological practice (and the outcomes of their practice), their practice to date has been somewhat limited and often very *functional* in nature (Layton, 1987; Barnett, 1994; Custer, 1995). This is due to students' practice often replicating that which has been done before,

[3] For a full description of the Components of Practice please see: http://www.techlink.org.nz/Components-of-Practice/index.htm

either by a practicing technologist or one of their peers. Given that the *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) encourages students to develop technological outcomes which demonstrate understandings of technological knowledge and the nature of technology from within the boundaries of their current location (Compton and Harwood, 2003; Compton, 2004; Compton & France, 2006), then it is not surprising that student technological practice to date has primarily been *functional* in nature. The intent of the CoPs, when developed, was to provide teachers with a tool which supports students' development of a technological literacy that is *liberatory* in nature (Compton 2001; Compton and Harwood, 2003). Subsequent use of the CoPs however has shown that when they are used in isolation students may still develop a liberatory literacy, however without opportunity for students to consider the components of Technological Knowledge and the Nature of Technology from perspectives outside of their current location, this literacy is often very narrow in nature (Compton and France 2006; Compton and Harwood, 2006). Providing opportunity for students to develop a literacy inclusive of the components under Technological Knowledge and the Nature of Technology strands, has inherent implications for the sorts of pedagogical practices that teachers need to adopt, as well as the learning contexts that they provide to their students.

Focus for BPT 2006 and beyond

The following principles have been identified as supporting a shift in student technological literacy from that of functional to a liberatory that is broader, deeper and more critical in nature (Compton and Harwood, 2006). These principles are in keeping with contemporary learning theories (see Compton and Harwood, 2004 for a discussion of the role of constructivist and sociocultural learning theories in technology) that align to technology education in New Zealand and are in keeping with the intent of the Draft Curriculum: Technology Materials for Consultation Package (Ministry of Education, 2006). These principles include:

1. Programmes of learning in technology must address all components of the three strands as outlined in the Draft Curriculum: Technology Materials for Consultation Package (Ministry of Education, 2006). While these components can be focused on individually, it must be recognised that they all interrelate in order to support the development of a deep, broad and critical technological literacy.
2. The duration of programmes should be determined by wider school structures in order to maximise the opportunity to plan for and monitor student progression. That is, in primary schools and junior secondary where technology is identified as a compulsory learning area, it would be reasonable to expect that programmes of learning would be developed to support two years of schooling (new entrant - year 2, year 3-4, year 5-6 etc). In senior secondary school however, programmes of learning may well be structured around one year intervals, to allow students opportunity to access qualifications and to recognise that students currently usually select their courses on a year by year basis.
3. Programmes of learning may include a varying number and range of contexts within which a series of coherent learning experiences exist. The duration of any learning experiences is determined by the intended learning planned by the teacher and student learning needs in relation to these.
4. Selection of contexts should rest on a balance between providing students with variety and interest, and providing enough richness to sustain progression of learning both within the strand components and/or across strands.
5. Learning experiences must focus on one or more components from the technology strands (as dependent on the time allowed), as well as any other knowledge and skills needed as determined by the specific context in which the component(s) is embedded.
6. Each component has a set of levelled achievement objectives (curriculum levels 1-8). These levelled achievement objectives assist teachers to identify students' current understandings and/or competencies, and enable the planning of learning experiences that provide opportunities for them to progress these.
7. Intended learning should be pre-determined by the teacher prior to the delivery of the learning experiences to ensure students have access to generic knowledge and practice, taking into account the students prior learning as identified. However, during the delivery of the learning experiences,

> opportunity should be left to develop negotiated learning intentions that are responsive to student practice, specific contexualised learning needs or interest[4].

(Compton and Harwood, 2006, p.4)

These principles will form the focus for all BPTF interactions with BPT teachers in 2007.

Conclusion

The framework for the BPT project was developed following analysis of the evaluation of the BS initiatives conducted by Bullock and Muschamp (2004) and Rudd, Davies, Jamison, Rickinson and Johnson, (2001). This analysis focused on identifying factors that contributed to the success of the BS initiatives, and the issues that impinged on their achieving their desired goals. A significant finding from this analysis was the need to ensure that teachers involved in the BPT project were not impeded from delivering beacon practice to their students due to their involvement in the initiative and that they were professionally supported to further enhance this practice. As a result of this analysis, a framework for the BPT project was adopted that included contracting a BPTF and resource writers, and providing funding to reduce the overall number of classes that BPT teachers had to teach. This reduction in classes ensured that teachers did not suffer the burden of increased workloads and time pressures due to their involvement in the BPT project. It also provided the BPT teachers with the required space to self reflect on their progress to date, engage in facilitated professional development offered by the BPTF and form supportive relationships with the tertiary technology education and 'enterprise' communities.

Whilst the BPT project to date, has demonstrated a significant improvement in BPT teachers overall pedagogical and content knowledge of technology, and their students overall undertaking of technological practice, there still remains opportunity to move student technological literacy further, towards one which is *broad, deep and critical* in nature. Adoption of the principles as described above into the BPT project, should provide opportunity for BPT teachers and facilitators to place emphasis on ensuring that student technological practices and outcomes move beyond that of replication, to displaying dispositions of innovation and creativity.

The BPT project has enabled teachers to develop programmes of technology that provide opportunity for students to progress their understandings of and abilities in technological practice. It has also provided a range of case studies on teacher pedagogy in planning for and delivery of technology education, with illustrations of student outcomes.
These case studies are now available for all teachers of technology to access. In addition, and of great significance to further development, the BPT has also allowed us to clearly identify opportunities for extending programmes to encompass a stronger philosophical and technological knowledge base. Future developments of the BPT will now provide a platform of classroom practice within which to trial such extensions and develop and explore pedagogical strategies in keeping with this.

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'It puts a smile on your face!' What do children actually think of design and technology? Investigating the attitudes and perceptions of children aged 9-11

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Abstract
Children are increasingly regarded as key stakeholders in education and their views are beginning to be given more prominence in the fields of both educational research and school improvement. However, as yet, little research has been carried out into children's attitudes and perceptions of design and technology at primary school level.

This paper reports on a pilot study conducted with 304 children aged 9-11 in 5 schools in the West Midlands, England. Data were collected through a questionnaire designed to elicit learners' attitudes to design and technology, their preferences within the subject and the value they ascribe to it. The evidence suggests that both boys and girls enjoy design and technology; they enjoy making the most but many children also value designing. They perceive it as a subject that provides challenge and opportunities to develop their creativity and thinking abilities. They also perceive it as being useful for their adult lives.

Introduction
Developing a more accurate understanding of children's perceptions of their experience of schooling can provide us with valuable insights that can help us to improve teaching and learning (Pollard et al, 1997; Ruddock and Flutter, 2004). Recent work on pupils' perspectives has found that children of this age and younger often show considerable maturity in their observations and analysis of their experiences (e.g. Wood, 2003; Hallam et al, 2004).

The pilot study featured in this paper has grown out of on-going research into children's perspectives of writing tasks in design and technology (e.g. Lunt, 2005). Themes which emerged from interviews with children about their experiences of learning design and technology in the earlier study have been used to inform the design of a questionnaire used here with a wider sample of children. Data have been collected which shed light on a range of issues related to teaching and learning in primary design and technology, but for the purposes of this paper we have decided to focus on just three questions:

1. Do children enjoy design and technology?
2. If they do, what are the characteristics of the subject which they particularly enjoy?
3. What are children's perceptions of the value of design and technology education?

Literature review
Few research studies have focused on children's attitudes to, and perceptions of, their experience of design and technology and most of the existing work is with students of secondary age. However, there is evidence from a small number of studies that primary-aged children enjoy design and technology (e.g. Pollard and Triggs, 2000; Barlex et al, 2005). Pollard and Triggs (2000) report on findings from the children's data collected on all curriculum subjects during the PACE project (1989-1997), a major longitudinal study of teachers' and children's experiences following the introduction of the National Curriculum into primary schools. They found that design and technology was popular with children throughout the primary age range: along with Art and P.E. it received the most nominations for being liked by pupils. Design and technology achieved high scores for the criteria 'fun' and 'interesting' and comments from individual children giving reasons for their subject

preferences referred to the opportunity to make things, having fun, playing and the active nature of design and technology. Although this study was carried out when design and technology was in its infancy as a curriculum subject, it would seem that its characteristics as a practical and creative subject were already proving popular.

More recently, Twyford and Burden (2000) found that almost all the children in their small sample of 10-11 year olds enjoyed the subject with a variety of reasons being put forward for this: having fun, making choices, working with friends or in groups, making things, learning new things, challenge and problem-solving. The researchers highlight the close correlation between the reasons the children gave for enjoying design and technology and concepts from theories and research in the area of motivation – concepts such as challenge, developing competence and mastery, goal setting, group interaction and sharing, internal locus of control, and an intrinsic enjoyment in the activity for its own sake. Twyford and Burden suggest that there is something intrinsic to the nature of design and technology as an activity that fosters enjoyment and motivates pupils to participate. This notion is echoed by Grover et al (2003) in a later study with secondary pupils.

Studies in secondary schools also show design and technology as a popular subject (e.g. Hendley et al, 1996; Grover et al, 2003; Neale, 2003, LC Research Associates, 2006). The elements which the majority of students found most enjoyable were making, working with tools and designing and the least enjoyable were written tasks and evaluating (e.g. Hendley et al, 1996; Hughes, 2001). Neale (2003) found that the pupils in his survey wanted more freedom in the choice of projects and many complained about the length of coursework and the amount of unrelated written work.

Beyond the field of design and technology, there is a growing body of work that aims to gain a better understanding of learners' attitudes to and perceptions of their experiences of teaching and learning in school. For example, Ruddock and Flutter (2004) in a summary of findings from their own studies in primary and secondary schools over a ten year period identify four broad categories that describe pupils' views of what makes a good lesson:

- opportunities for participation and engagement;
- active lessons with a variety of tasks;
- challenge (that is exciting but not overwhelming); and
- opportunities to exercise autonomy.

(Ruddock and Flutter, 2004, p79)

They found a high degree of consensus among children of different ages on what makes learning effective and enjoyable. This is supported by other studies in different contexts, e.g. Gipps et al (2000) researching conditions for learning in Year 2 and Year 6; Cooper and McIntyre (1996) researching preferred teaching and learning strategies in Year 8 English and history.

Methodology

We decided for this initial piece of research that a survey, using questionnaires for both children and teachers, would be the most useful way to collect the information that was wanted, in the time available, and with the number of people to be involved (Oppenheim, 2003; Wellington, 2000). We acknowledge that it would have been useful to follow up with some interviews with groups of children where the analysis threw up interesting patterns, but this was not possible for this study. Both qualitative and quantitative data were collected through the questionnaires. Questions were included that allowed for cross checking of answers; for example, 'I enjoy d&t'/'I find d&t boring'. Consideration was given to the way in which questions were phrased, and the types of questions used, e.g. open/closed.

As this was a pilot study, we selected a group of schools known to be undertaking design and technology within reach of the researchers should any visits be necessary. A cohort of schools/subject leaders was identified, which had undertaken an Extended design and technology course, funded by the Teacher Development Agency, and undertaken at UCE, Birmingham, 2005-6. We invited Y5/6 classes (9-11 year olds) to take part in the research as the children would have been exposed to design and technology for the greatest length of time and they would be more likely to understand and be able to respond to the written elements of the questionnaire. Of the 21 schools in the cohort, the 16 schools which catered for mainstream pupils of our target age group were approached. Five responses came back within the time limit and it was these that have been used for the pilot. Others that were received later will be analysed and used in further research.

School	**Y5 Boys**	**Y5 Girls**	**Y6 Boys**	**Y6 Girls**	**Totals**
School 1	0	0	18	19	**37**
School 2	13	10	8	13	**44**
School 3	14	12	17	14	**57**
School 4	22	24	0	0	**46**
School 5	26	34	29	31	**120**
Totals	**75**	**80**	**72**	**77**	**304**

Fig. 1

A pre-pilot school trialled the teachers' and the children's questionnaires to ensure that they were clear, manageable, and that, when analysed, the information obtained was central to the purpose of the research. The teacher found the instructions on administering the questionnaire clear, the administration of the questionnaire straightforward and she reported that the children enjoyed thinking about their answers. We modified the final questionnaire in the light of her suggestions for wording some of the questions. An analysis of the responses indicated that the information gathered should support our research. A review of the whole process will be undertaken after the main pilot study.

Confidentiality, consent and a clear understanding as to the nature of the research were major considerations (Gregory, 2003). All the headteachers, subject leaders and teachers were informed by letter about the purposes of the research and all agreed to participate in the study. It was explained to the children that they were taking part in a research project about primary design and technology, that their answers would be kept confidential, and that they could not be identified. A note to this effect was included on the questionnaire and children could opt out if they wanted to. None chose to do so.

Findings and discussion

The information was gathered from Y5 and Y6 children, mainly because subject leaders chose which classes had time to take part. Whilst differences might have emerged between Y5 and Y6 depending, for example, on the difference in the amount of curriculum time they had, there were no differences between the year groups; thus findings have been grouped together.

Did these children enjoy design and technology?

Evidence for this came mainly from four questions that the children were asked: Do you enjoy design and technology? Do you think design and technology is boring? Do you think design and technology is fun? Which 3 subjects do you enjoy most?

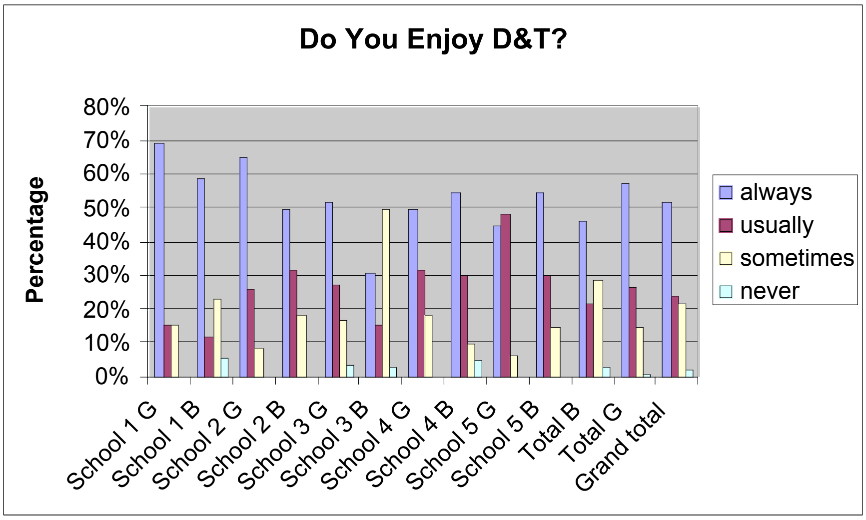

Fig. 2

Of the 76% of children overall that always or usually enjoyed design and technology, girls were in the majority - 83% as against 68% of boys. It was the 'sometimes' category that differed greatly - twice the number of boys than girls chose this category, though very few children overall chose the 'never' category.

In response to the questions about whether design and technology is boring and fun, the results were similar to the enjoyment question, the main difference being that there was no large difference in opinion between the boys and girls in any category, in any school. Children certainly identified that design and technology was not boring (93%) but fun (81%) by a considerable majority.

It could be that the anomaly of 29% of boys identifying that design and technology was 'only sometimes' enjoyable was the way in which the term 'sometimes' was interpreted, but this seems unlikely. The girls' results in that school followed the general pattern. It should be noted that it was the results from the boys in School 3 (50%) that changed the overall pattern both of the boys in each school, in addition to the overall total. Whilst there is no additional data that could be used to explain this, from the data from the three questions, there is a consensus, even in School 3, that the children found design and technology an enjoyable experience. This is supported further by the evidence from questions about the subjects they most enjoy and think they are best at. The children were asked to identify their top three subjects for each.

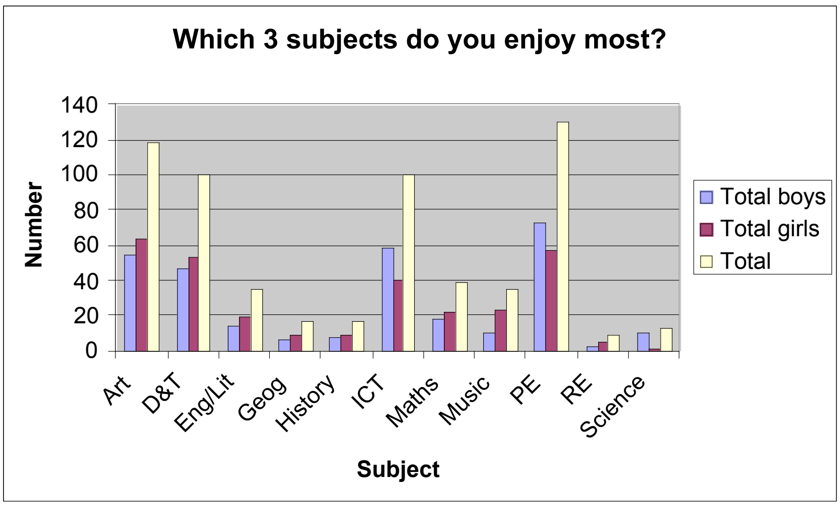

Fig. 3

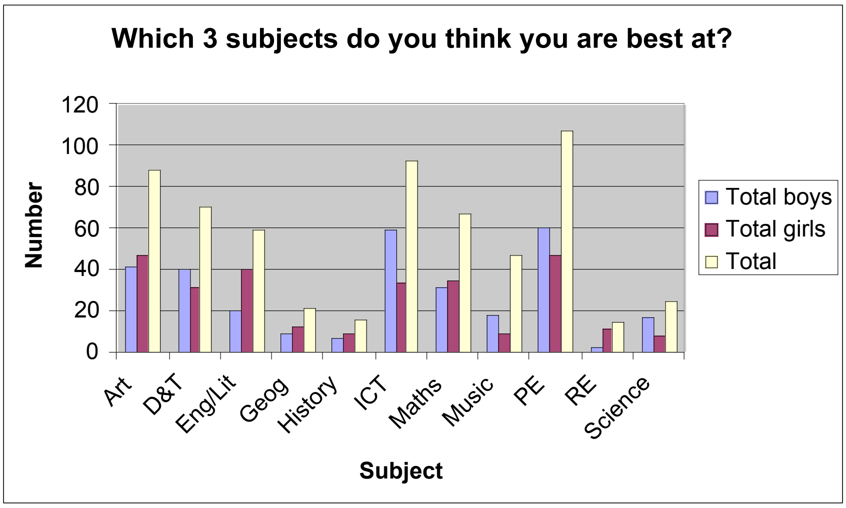

Fig. 4

The same four subjects were identified as the most enjoyable and those that the children considered they were best at – art, design and technology, ICT and PE. It is interesting to note that these are all subjects that involve the children in practical activity, and by their nature, almost certainly involve them in a variety of learning and teaching styles. In addition it can be seen from the data that there is a considerable gap between the top four subjects and the remainder, particularly with those that the children found most enjoyable. An analysis of the teachers' data supports the findings from the children. When asked what most children in Y5/6 would feel, they stated that they would find it enjoyable, fun and not boring and that this was because it was different to many other subjects.

These findings overlap to a certain degree with those of the PACE project (Pollard and Triggs, 2000) in which art, PE, maths and technology (ICT and design and technology combined) were the most popular subjects for this age group. Interestingly, maths also featured as the third least liked subject whereas art, PE and technology received a more uniformly positive response. It is important to note that the data for this study was collected in the early stages of the National Curriculum and therefore the children's experience of design and technology is likely to have been different in some respects to that of the children here. However, it would appear that something in the nature of design and technology and ICT appealed to the children. In a more recent study of student attitudes to curriculum subjects at Key Stage 3 (11-14 year olds), design and technology was placed second for enjoyment with only PE receiving a higher rating (LC Research Associates, 2006).

What were the characteristics of design and technology these children particularly enjoyed?

Our evidence base for these findings came mainly from questions relating to what the children enjoy most and least about design and technology and their responses to statements made by others about design and technology. The children's qualitative responses were coded using categories established in earlier work.

Overall the children identified that they enjoyed making the most (at least 68%) and this is also supported by data from the teachers' perceptions of what their children enjoy. In addition all the recent annual OFSTED reports identify that making is better developed in schools than designing. The next most popular category that was identified was creating products (15%), which links to making, followed by doing it yourself (10%), working with friends (6%), having fun (4%) and the practical nature of the subject (3%). There were no great differences between girls and boys or between different schools.

Evidence from the children about what they liked least is interesting in that it throws up the most differences between schools. In School 1 both boys (76%) and girls (82%) identified that writing was a real dislike for them in design and technology, although in all schools this was the least popular activity. There is no evidence from the School 1 teacher questionnaire that he/she focused on writing; indeed the teacher includes ‘active’, ‘creating’, ‘fun’, ‘fantastic outcomes’ in his/her evidence, which suggests that there could be a bias towards making and practical activities. However, there would be a need to follow this up with further questions to children and teacher to understand the way in which design and technology is taught in this particular context. It is clear that consideration needs to be given to the amount and purpose of writing, and perhaps helping children to see the need/value for a particular piece of writing whilst undertaking design and technology activity. Other least popular activities were problems with making and drawing. Evidence from the teachers’ comments identified that there were a number of teachers in these schools who felt least confident when supporting making activity.
The highlighted statements in fig. 5 show that a large majority of children perceive design and technology as being different from other lessons; that creating a product of your own ‘puts a smile on your face’ and that children like the opportunity that design and technology affords for some element of autonomy and creativity. There are no significant differences between schools and between genders in different schools for any of the statements.

Statement	Agree	Disagree	Not sure
I like d&t because it is different from most other lessons	Boys 73% Girls 79% Total 76%	Boys 10% Girls 9% Total 9%	Boys 17% Girls 12% Total 14%
I enjoy doing d&t because we get to do things with our hands (rather than just write)	Boys 57% Girls 57% Total 57%	Boys 14% Girls 13% Total 14%	Boys 28% Girls 30% Total 29%
I would prefer to just get on and make, not to design (e.g. research, think about, plan)	Boys 33% Girls 35% Total 34%	Boys 44% Girls 49% Total 46%	Boys 22% Girls 15% Total 20%
It puts a smile on your face when you have made something of your own.	Boys 88% Girls 89% Total 89%	Boys 9% Girls 3% Total 6%	Boys 3% Girls 8% Total 5%
I like d&t because we get to use our own ideas rather than just being told what to do	Boys 73% Girls 84% Total 78%	Boys 11% Girls 3% Total 7%	Boys 16% Girls 13% Total 14%

Fig. 5

The findings here support previous evidence in that the children identify with the enjoyable nature of the subject, including the practical element, and the fact that it is different to other subjects. Although the children’s preference for making is clear, their response to the third statement indicates that almost 50% of them are definite about valuing designing. However, there is a need for more evidence to be able to say why this is so.

Our findings here overlap with those of earlier research studies in design and technology. The children in the Twyford and Burden study (2000) identified having fun, making choices, working with friends or in groups, making things, learning new things and problem-solving which all had parallel statements in our sample. They also suggested challenge which was not specifically mentioned by the children in our sample but is included in evidence discussed in the next section. There is no indication in this earlier study about the relative priority children gave to any of these characteristics. Writing was also found to be unpopular in earlier studies in secondary school (e.g. Hendley et al, 1996; Hughes, 2001, Neale, 2003) although Lunt (2005) has found some contradictory evidence suggesting that many children in this age group value certain types of writing in design and technology.

What were these children's perceptions of the value of design and technology?
The evidence for this section comes mainly from the children's responses below and from the teachers' questionnaire.

Statement	Agree	Disagree	Not sure
In d&t you have to think really carefully	Boys 84% Girls 88% Total 86%	Boys 7% Girls 5% Total 6%	Boys 17% Girls12% Total 14%
In d&t we have to use technical words	Boys 48% Girls 48% Total 48%	Boys 21% Girls 19% Total 20%	Boys 31% Girls 33% Total 32%
I think designing is really important if you want to make a good product	Boys 82% Girls 83% Total 82%	Boys 6% Girls 5% Total 6%	Boys 5% Girls 12% Total 9%
In d&t we learn how to be creative (e.g. think up ideas in different ways, try out different ways of using materials)	Boys 84% Girls 85% Total 85%	Boys 8% Girls 2% Total 5%	Boys 7% Girls 13% Total 10%
D&T is important for life because it is useful in lots of different jobs.	Boys 74% Girls 78% Total 76%	Boys 12% Girls 1% Total 6%	Boys 14% Girls 21% Total 17%

Fig. 6

The evidence suggests that a significant majority of the children identified positive values associated with the subject. For these children design and technology involves being creative and having to think carefully. They highlighted the need to think about design in order to make a good product, even if other evidence suggests that they do not enjoy this aspect as much as making. To further support this, the children's response to the question 'Do you think design and technology is easy?' showed that very few children (no significant difference between boys/girls/schools) thought it easy all the time but the majority thought that it was sometimes. The opposite question 'Do you think design and technology is hard work?' provided the response that it was usually/sometimes. The subject then provides challenge for children, and is one in which they felt that they learnt much (always 48%, usually 29%). Challenge has been identified by earlier research studies as an important characteristic of what makes a good lesson and an enjoyable learning experience (Pollard and Triggs, 2000; Ruddock and Flutter, 2004).

Thinking about their future, these children perceived overwhelmingly that it is useful for many different jobs. In response to the question 'Why do you think you have to learn d&t in school?', there was a consensus of boys'/girls'/school's views that the main reasons were that it develops an ability to design and make things, that it prepares us for a career, prepares us for another aspect of adult life and that it develops other skills (not just designing and making). Clearly the children perceive it to be a subject that offers them skills that will be useful after their schooling.

Evaluation of the pilot study
All teachers felt that the way in which the questionnaire was presented and the survey carried out was appropriate and easy to administer. Whilst the quantitative data gave a good overview, there were aspects that needed more qualitative data. All schools having received their individual feedback, have already shared findings with staff and intend to follow up on areas where they felt unhappy/disappointed/interested with children's responses. In addition six new schools have taken the questionnaire and used it as a tool to gain information about their children's perception of the subject. Two of these schools are now creating a series of questionnaires for other subjects to elicit children's

perceptions and will use the evidence gathered to look at the implementation of the subject in their schools.

It must be remembered that this study was a small pilot, and whilst some evidence can be crossed checked through an analysis of evidence from different questions and teacher evidence, there are some areas that need further investigation through, for example, children's interviews, e.g. the overall response in School 1 to their dislike of writing. It is always a difficult decision as to whether the children should be asked to write comments for reasons for decisions, but for a large scale project there could be boxes added for comments for questions where responses were felt to need more explanation. It should be remembered that this could provide random data partly as this would be a writing exercise that some children would not enjoy. If children are given reasons to choose from, again this might narrow their answers.

Conclusion

Clearly the children in this study enjoyed design and technology. They felt it was a subject they were good at, and perceived its value not only while they were at school but for their future lives. Because of the nature of the subject, it involved them in practical activity, having to think, work with others, and use and develop their own ideas - all of which they valued. With very few exceptions there was little difference between Y5/6 children, gender and between schools which suggest that on a larger scale the patterns that emerged could be similar. The children's data suggest that in many respects children perceive design and technology as meeting the four characteristics of 'good lessons' identified by Ruddock and Flutter (2004, p79) in that it provides opportunities for participation and engagement; active lessons with a variety of tasks; challenge; and opportunities to exercise autonomy. From the evidence that was collected, it is apparent that the subject has an important role to play in the primary curriculum and for motivating children to learn.

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Critiquing in a democratics of Design and Technology Education

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Abstract
This paper seeks to show how the practice of critiquing can have a three-fold benefit in the educational enterprise. First, it can greatly enhance the learner's thinking capacities. Second, it is a powerful component of Design and Technology practice – aiding such aspects as values clarification, quality control and problem identification. Third, as a result of the first two benefits, as with all good education, it serves its society well too.

The paper opens with a discussion of the theory of criticism and critical thinking. The significance of critiquing to healthy democracy is presented – as are concerns for the current condition of democracy and for teachers' work. Commentary is given on the democratics of technology in society and on education-democracy relationships. The paper concludes with a discussion of critiquing in Design and Technology Education.

Critiquing and critical thinking – explorations
The sense of critique as noun or verb is well established in fields such as the arts. However, its use sits uncomfortably with many people – such are our times. Genuine criticism is far from its commonly polarised sense of negative comment. It is bound up with reasoned opinion both inwardly and outwardly expressed. Critiquing can be seen as a way of doing or being - as well as a way of thinking. It is a term that has rich meanings, roots and connections.

As will be apparent, the action of art of criticising or passing judgement is as applicable to Design and Technology (D&T) education as it is to many other aspects of life. It is something of value to be learned and critiquing might be thought of as torment, as opposition or as being supportive or empathetic (Walton, 1992)

Paul (1995), who has written expansively on critical thinking, sees little difference in the purposes of critiquing and critical thinking. As he puts it: 'Critical thinkers critique in order to redesign, remodel and make better.' (p526). He articulates powerfully the place of critical thinking theory and practice as a virtue of quality education, as tool against indoctrination and as shaper of pedagogy.

Just as the critical theory of the Frankfurt School (Habermas, 1971) showed the importance of exposing the interests at play in ways of knowing, so it is the case that any critical theory has a sense of the political about it – the questioning of a position, statements, products, images and so on. Inevitably, 'value judgements' becomes a term often used in relation to critiquing. These are readily marginalised by advocates of particular 'interests' as being subjective or irrelevant. In fact, the inclusion of value judgements is the very stuff of active and defensible critique. As Watkins (1978) says:

> There are many bad reasons for placing value judgements outside of the boundaries of genuine critical thought, most of them having to do with the idea that criticism should be neutral and descriptive, that it should say what a poem is or what it means before assessing its value and significance…(The) stance of contemplative neutrality is itself indicative of social and class attitude toward human knowledge.

(Watkins, 1978:213)

(Thus, in the above, 'technology' can be substituted for 'poem' and the orthodoxy of technology-as-neutral may be exposed.)

As Abercrombie (1960/1979) distinguishes between interpretation and judgement, so Watkins (1978) does between interpretation and criticism. In both cases, the former is about *meaning*, whereas criticism, for Watkins, is about *significance*. Abercrombie also shows the importance of bringing to consciousness the kinds of perceptual factors that exist in the unconscious and which inhibit the making of good judgements. This sense of consciousness is born out by Canby (1924) who discusses reading: 'Critical reading is human reading, where the emotions are aroused and the mind is awake. It is not pedantic, sententious reading done for duty. To be critical one has to be, first of all, very much alive…The critical reader is the human reader.' (Canby, 1924/1967:218-219)

(Thus, the 'reading' of designs and technologies both anticipates and prepares the awakened mind.)

Walton (1992) points out that critical discussion is adversarial and he addresses the important function of 'critical doubt' in argument which is not '…having a neutral point of view. It is the bracketing or suspending of the point of view you already have, in order to express doubts and questions. But such a suspension does not imply a neutral attitude.' (Walton, 1992:267).

When Watkins (1978) discusses criticism and poetry he talks of criticism as '…any act which frees the poem from its status as merely an object of thought to be "approached", defined, explained, and interpreted.' (Watkins, 1978:57). He articulates the significance for the critic of becoming '…truly conscious of his (sic) own act of thinking, the critical act itself assumes a kind of dialectical reciprocity.' Thus, there may never be 'an end' in the practice of critiquing, merely synthesis toward new beginnings. As Quinton (1999), discussing logic, says; 'Dialectical logic sees contradictions as fruitful collisions of ideas from which a higher truth may be reached by way of synthesis.' (in Bullock & Trmbley, 1999:222). Meanwhile 'informal logic' has been described as the 'craft rather than the formal theory of reasoning' (Honderich, 1995:500) - perhaps well illustrated in the text 'Straight and Crooked Thinking' (Thouless, 1930/1953). Canby (1924/1967) also argued that the critical attitude is so much more than formulated theory.

(Thus, as with the straitjacket effect of the singular, lockstep 'design process', doubt, dialecticism, and craftiness are assets that eschew formulaic attempts at critiquing.)

Critiquing in democracy

While, for this paper, democracy is taken as *the most ethically defensible form of political organization and government*, it is also acknowledged to be about an idealised set of values for harmonious co-existence. Perfection is never reached and the whole is an ever-fluid dynamic, constantly in contestation. In its healthiest form, debate and critique are the norm.

Ethicists such as Warnock (1998) and Somerville (2006) salute imagination and the education of it for the purposes of facilitating desirable futures, creativity, and empowerment to effect change – at both personal and societal levels. Meanwhile the work of Csikszentmihalyi (1997) and Florida (2003) highlights the ways creativity, as a result of corporate and governmental practices, is inhibited. Paul (1995) ably demonstrates the validity to society of cultures of both creativity and ethically-driven criticism.

Current Western society has seen the influence of ideology on democracy itself and on education. Saul (1995) argues that we are pressured to conform by corporatist agendas. The individual and the democratic must take lesser status. Decision-making is increasingly undertaken by elites, specialists and interest groups. He stresses the need to understand the significance of what is happening. Rather than minding our own business (as is the corporate concern) he urges that the essence of individualism is the *refusal* to mind your own business.

> Real individualism then is the obligation to act as a citizen. This has nothing to do with conformism or obedience to interests outside the public good…
>
> …Criticism is perhaps the citizen's primary weapon in the exercise of her legitimacy. That is why, in the corporatist society, conformism, loyalty and silence are so admired and rewarded; why criticism is so punished and marginalised. (Saul, 1995:169-170)

For education, there has been a deliberate blurring of the boundaries between democracy (and its education) and economy. As Apple (2001) says, 'For neoliberals, the world in essence is a vast supermarket…(E)ducation is seen as simply one more product…Rather than democracy being a *political* concept, it is transformed into a wholly *economic* concept.' (Apple, 2001:39). In this world, he suggests, the term 'consumers' is preferred to 'citizens'.

Current times indeed beg critical theorising of whose interests are being valorised in the name of democracy. The ethical view might be that, in a healthy democracy, nothing – theories, truth-claims, religion, politics, the economy, technologies - should be exempt from questioning or critique. Critiquing, then, could be identified as a distinctive and valid form of educational and popular activity – defensible for its democratic potential – a tool of, and for, democracy. Pranger (1968) argued that citizens should become creators of politics rather than appendages to it – being *of* a democracy rather than just *in* it. For participatory democracy, he points out, '…the politics of participation emphasises mass creativity,' (Pranger, 1968:92). He contrasts such participation with the 'pursuit of power' by individuals.

Saul (1995) argues the case for valuing and respecting uncertainty as a partner of critique in democracy. He, too, acknowledges discomfort and its place with consciousness. He concludes his text thus:

> The virtue of uncertainty is not a comfortable idea, but then a citizen-democracy is built upon participation, which is the very expression of permanent discomfort. The corporatist system depends upon the citizen's desire for inner comfort. Equilibrium is dependant upon our recognition of reality, which is the acceptance of psychic discomfort. And the acceptance of psychic discomfort is the acceptance of consciousness. (Saul, 1995:195)

Paul (1995), describes what he calls the *critical society* which promotes the values of critical thinking, eschews indoctrination and inculcation, and '…rewards reflective questioning, intellectual independence, and reasoned dissent.' (Paul, 1995:525). He draws on Sumner's words of 1906: 'The critical habit of thought, if usual in a society, will pervade all its mores, because it is a way of taking up the problems of life.… Education in the critical faculty is the only education of which it can be truly said that it makes good citizens.' (Paul, 1995:526).

Democratics of technology

It can be argued that the minimilisation of critical discourses in society today is linked to the uncritical bringing-into-being of technologies (Keirl, 2006). Our say in introduced technologies is so slight that it is hard to talk of democracy in the same paragraph. With no participation in the design or level of desirability of most technologies we are politically alienated from a key part of our existence. Yet these very technologies shape and change our individual and collective existences.

The intertwined nature of technologies with our lives is thoroughly documented. Importantly, so are the politics of technologies (see, e.g. Mumford, 1934; Winner, 1977; Wajcman, 1991; Sclove, 1995; Feenberg, 1999; 2002).

Marcuse (1968) introduces his critique of the ideology of industrial society with 'The paralysis of criticism: society without opposition' and talks of the containment of social change and how 'integration of opposites' has been facilitated by a corresponding negation of critique (mirroring the concerns of other 20th Century authors cited above).

Technologies can be viewed as having four phases to their existence – *intention* (the very conception, thought or idea that seeds the bringing-into-being of the technology) – *design* (the exploration of possibilities to bring the seed to fruition) – the *manifestation* (the bringing of the technology into the world) – and the *life* (which includes any possible afterlife, use, application, consequence, effect, etc). This simplistic analysis serves the exploration of technologies for their democratics and such an exploration should, it is argued (Keirl, 2006) be done through the critical-ethical lens.

Thus a thorough ethical critique at the intention phase may well render any design and further development unnecessary. Ethical interrogation at the design stage may introduce assessment and decision-making to assist the weighing-up of competing values positions – technologies being the nothing more than the embodiment of values. Once manifest, we critique in the hope of 'making things better' (double meaning intended) – often with a new technology to 'improve' the prior one rather than questioning the very existence of the whole. But, in this phase (and in the current economic system), critique more often than not leads to more of the same, that is, it iterates back into design-as-remodelling rather than promoting radical, ethically driven (democratic) alternatives.

Education-democracy relationships

Dewey's (1916/1966) arguments that 'The devotion of democracy to education is a fact' and that 'A democracy is more than a form of government; it is primarily a mode of associated living, of conjoint communicated experience' still hold weight. White (1973) argues in a key article: 'There is at least *one* policy which *must* be in the public interest in a democracy. This is an appropriate education for a democracy.' (White 1973:237). It is easy to see that the inter-relationship between any education system and the political system are qualitatively reflective. Thus, to return to critique, if one does not value it, the other may not either. Yet, as has been shown, critique is potentially a wonderful servant of both.

Thus, critiquing is seen as a natural component of both a quality (D&T) education and for life in sustainable democratic futures. This is no recent phenomenon. Postman (1999) has drawn parallels between 18th Century issues and developments and those with which societies are faced today. So far as education is concerned, he suggests three 'legacies' from the Enlightenment years, the third of which is:

> …the idea that a "proper education" must have as one of its goals the cultivation of a skeptical outlook based on reason… Indeed, if the question is posed, What is the principal mind-set associated with the Enlightenment?, the answer would certainly be – skepticism. Modern educators do not usually use this word, preferring something like "critical thinking". But in any case, they do not do much about it (Postman, 1999:159-160)

Now it is clear that there are modern educators who are on the critical thinking ball and do want to do much about things. But what they are up against is the current climate which subjects and enframes education-democracy relationships restrictively.

Given the climates of corporatism, suppression of individual voice, and citizen-as-consumer, described above, is there a parallel climate in education? Apple (2001) has already been cited in the affirmative. Hargreaves (2003) and his international research team document substantial evidence and offer valuable commentary. They highlight '…too exclusive a focus on academic results, examination and test scores, international competitiveness, league tables of performance and narrowing achievement gaps…Achievement has been everything and democracy has had to fend for itself.' (Hargreaves, 2003:40-41).

Apple (2001), Hargreaves (2003) and Sachs (2003) all present detailed analyses of how teachers are currently *positioned* by systems to replicate the systems' intentions. In climates of standardisation, teaching to the test, meeting targets, stifled pedagogical creativity and in isolation of any democratic social mission, critique is readily sidelined. Further, for democratic schools, as Sachs shows, democratic structures are needed as well as democratic curricula in which students are active and vocal participants.

Design and Technology within democratic education

Postman (1999) identifies what he sees as a major problem facing democratic life today, namely 'How do you teach reason and scepticism?' One of his five solutions is Technology Education which, he stresses, is *not* teaching how to use computers – already a rampant social phenomenon without schools' input. Rather, he cautions about what our young '…will *not* know, as none of us did about everything from automobiles to movies to television, (that) is, what are the psychological, social and political effects of new technologies.' (Postman, 1999:170). A critical approach is implicit.

Within the field there is an emerging critical literature: on the politics of technological literacy (see, e.g Petrina, 2000; Seemann, 2003; Keirl, 2006); on the theory of technological literacy (Dakers, 2006); as well as supportive professional development literature around the politics and challenges facing the D&T practitioner (Barlex, 2007, forthcoming). Layton's (1994) major international study exposed the multiple constructs and agendas (political, social, professional, philosophical) at work in technology education and articulated the contested nature of the term 'technological literacy'.

Thus, despite homogenising climates, there is supportive literature which articulates rich senses of technological literacy and 'technacy' (Seemann, 2003) and which acknowledges the need for critique and critical thinking. The South Australian D&T curriculum (DETE, 2001a&b) has an underpinning definition of technological literacy based on Habermasian (1971) critical theory. Further, the three organising 'strands' of the curriculum are Critiquing, Designing, and Making (Keirl, 2002).

D&T education gives students, through design, real opportunities to be engaged, to participate, and to be creators of their own knowledge but, it is argued, there are special ways that critiquing plays its roles. In setting these out, it is to be remembered that in the pursuit of critiquing within D&T practice, the students' general education is enhanced. They are practising critique and gaining voice as would-be democratic citizens. This is a strength of quality D&T as a compulsory curriculum component. For D&T's intrinsic richness and its general educational role, critiquing must be taken as purposeful and as a democratic tool of debate, values-weighing, social questioning of technocratic cultures of dependence, and so on.

Critiquing is responsive *to* something that exists or has happened - whether an idea in the mind or a physical product. Critiquing is about questioning rather than answering. Its practice helps clarify ill-defined problems through reformulation and reassessment. Critiquing uses many possible differing questions not one best question. Critiquing is reactive - after the fact. Whilst critiquing is an invaluable tool that enriches designing, it is also something more in itself. Through D&T education it helps clarify needs-wants issues, values issues, highlights the contestable, exposes the multiple effects of technologies and becomes a mirror for productive thought and action.

Critiquing is deconstructive but not destructive. In itself, it has limited problem-solving capacity but it does have excellent problem-finding or fallacy-exposing capacities. Critiquing acts as quality assurance throughout checking and rechecking validity, integrity, worth, accuracy, and fairness. Critiquing may involve looking in the mirror, reflecting alone or together, or placing in the window for public scrutiny.

Critiquing does not have components to be arranged into lockstep sequences – other than understanding the audience for the critique e.g. self, team, assessor, public. Critiquing may lead to a sharper interrogation of assessment criteria and rationales. Critiquing can be used on one's own methodology of practice – on time management, design procedure chosen, or research options taken.

Critiquing aids selection of thinking styles. Thus sophisticated critiquing is a form of metacognition. It is reflective and deconstructive but deconstructive thinking is not destructive thinking. Critiquing may involve discomfort but that is an aspect of critical purpose. The 'discomfort' of self-critiquing is not a matter of positive or negative criticism. It is a phase of the journey to a best defensible compromise. Critiquing as experience-building is the interplay of personal experience and knowledge with others' experience (community, research, opinion etc). The greater the critiquing experience(s) the greater the critical disposition. Critical friendship is an asset. Like risk-taking in creativity and designing, risk-taking in critiquing requires safety nets. Critiquing is done against a frame of reference which may be personal experience, some agreed or public criteria or a design brief. Imagination should not be critiqued.

To return to Paul (1995), critiquing is the articulation of the dialogical *and* the dialectical. We are reminded that 'Critical thinkers critique in order to redesign, remodel and make better.' (Paul, 1995:526). Critiquing is a purposeful and highly defensible aspect of any healthy democracy's education. Importantly, through Design and Technology education, critiquing can find a home as personal learning tool, as stimulus to design activity and as shaper of quality pedagogy. Perhaps this is another way that D&T might lead democratic curriculum change.

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Critiquing in a democratics of Design and Technology Education

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Abstract
This paper seeks to show how the practice of critiquing can have a three-fold benefit in the educational enterprise. First, it can greatly enhance the learner's thinking capacities. Second, it is a powerful component of Design and Technology practice – aiding such aspects as values clarification, quality control and problem identification. Third, as a result of the first two benefits, as with all good education, it serves its society well too.

The paper opens with a discussion of the theory of criticism and critical thinking. The significance of critiquing to healthy democracy is presented – as are concerns for the current condition of democracy and for teachers' work. Commentary is given on the democratics of technology in society and on education-democracy relationships. The paper concludes with a discussion of critiquing in Design and Technology Education.

Critiquing and critical thinking – explorations
The sense of critique as noun or verb is well established in fields such as the arts. However, its use sits uncomfortably with many people – such are our times. Genuine criticism is far from its commonly polarised sense of negative comment. It is bound up with reasoned opinion both inwardly and outwardly expressed. Critiquing can be seen as a way of doing or being - as well as a way of thinking. It is a term that has rich meanings, roots and connections.

As will be apparent, the action of art of criticising or passing judgement is as applicable to Design and Technology (D&T) education as it is to many other aspects of life. It is something of value to be learned and critiquing might be thought of as torment, as opposition or as being supportive or empathetic (Walton, 1992)

Paul (1995), who has written expansively on critical thinking, sees little difference in the purposes of critiquing and critical thinking. As he puts it: 'Critical thinkers critique in order to redesign, remodel and make better.' (p526). He articulates powerfully the place of critical thinking theory and practice as a virtue of quality education, as tool against indoctrination and as shaper of pedagogy.

Just as the critical theory of the Frankfurt School (Habermas, 1971) showed the importance of exposing the interests at play in ways of knowing, so it is the case that any critical theory has a sense of the political about it – the questioning of a position, statements, products, images and so on. Inevitably, 'value judgements' becomes a term often used in relation to critiquing. These are readily marginalised by advocates of particular 'interests' as being subjective or irrelevant. In fact, the inclusion of value judgements is the very stuff of active and defensible critique. As Watkins (1978) says:

> There are many bad reasons for placing value judgements outside of the boundaries of genuine critical thought, most of them having to do with the idea that criticism should be neutral and descriptive, that it should say what a poem is or what it means before assessing its value and significance…(The) stance of contemplative neutrality is itself indicative of social and class attitude toward human knowledge.

(Watkins, 1978:213)

(Thus, in the above, 'technology' can be substituted for 'poem' and the orthodoxy of technology-as-neutral may be exposed.)

As Abercrombie (1960/1979) distinguishes between interpretation and judgement, so Watkins (1978) does between interpretation and criticism. In both cases, the former is about *meaning*, whereas criticism, for Watkins, is about *significance*. Abercrombie also shows the importance of bringing to consciousness the kinds of perceptual factors that exist in the unconscious and which inhibit the making of good judgements. This sense of consciousness is born out by Canby (1924) who discusses reading: 'Critical reading is human reading, where the emotions are aroused and the mind is awake. It is not pedantic, sententious reading done for duty. To be critical one has to be, first of all, very much alive…The critical reader is the human reader.' (Canby, 1924/1967:218-219)

(Thus, the 'reading' of designs and technologies both anticipates and prepares the awakened mind.)

Walton (1992) points out that critical discussion is adversarial and he addresses the important function of 'critical doubt' in argument which is not '…having a neutral point of view. It is the bracketing or suspending of the point of view you already have, in order to express doubts and questions. But such a suspension does not imply a neutral attitude.' (Walton, 1992:267).

When Watkins (1978) discusses criticism and poetry he talks of criticism as '…any act which frees the poem from its status as merely an object of thought to be "approached", defined, explained, and interpreted.' (Watkins, 1978:57). He articulates the significance for the critic of becoming '…truly conscious of his (sic) own act of thinking, the critical act itself assumes a kind of dialectical reciprocity.' Thus, there may never be 'an end' in the practice of critiquing, merely synthesis toward new beginnings. As Quinton (1999), discussing logic, says; 'Dialectical logic sees contradictions as fruitful collisions of ideas from which a higher truth may be reached by way of synthesis.' (in Bullock & Trmbley, 1999:222). Meanwhile 'informal logic' has been described as the 'craft rather than the formal theory of reasoning' (Honderich, 1995:500) - perhaps well illustrated in the text 'Straight and Crooked Thinking' (Thouless, 1930/1953). Canby (1924/1967) also argued that the critical attitude is so much more than formulated theory.

(Thus, as with the straitjacket effect of the singular, lockstep 'design process', doubt, dialecticism, and craftiness are assets that eschew formulaic attempts at critiquing.)

Critiquing in democracy

While, for this paper, democracy is taken as *the most ethically defensible form of political organization and government*, it is also acknowledged to be about an idealised set of values for harmonious co-existence. Perfection is never reached and the whole is an ever-fluid dynamic, constantly in contestation. In its healthiest form, debate and critique are the norm.

Ethicists such as Warnock (1998) and Somerville (2006) salute imagination and the education of it for the purposes of facilitating desirable futures, creativity, and empowerment to effect change – at both personal and societal levels. Meanwhile the work of Csikszentmihalyi (1997) and Florida (2003) highlights the ways creativity, as a result of corporate and governmental practices, is inhibited. Paul (1995) ably demonstrates the validity to society of cultures of both creativity and ethically-driven criticism.

Current Western society has seen the influence of ideology on democracy itself and on education. Saul (1995) argues that we are pressured to conform by corporatist agendas. The individual and the democratic must take lesser status. Decision-making is increasingly undertaken by elites, specialists and interest groups. He stresses the need to understand the significance of what is happening. Rather than minding our own business (as is the corporate concern) he urges that the essence of individualism is the *refusal* to mind your own business.

> Real individualism then is the obligation to act as a citizen. This has nothing to do with conformism or obedience to interests outside the public good…
>
> …Criticism is perhaps the citizen's primary weapon in the exercise of her legitimacy. That is why, in the corporatist society, conformism, loyalty and silence are so admired and rewarded; why criticism is so punished and marginalised. (Saul, 1995:169-170)

For education, there has been a deliberate blurring of the boundaries between democracy (and its education) and economy. As Apple (2001) says, 'For neoliberals, the world in essence is a vast supermarket…(E)ducation is seen as simply one more product…Rather than democracy being a *political* concept, it is transformed into a wholly *economic* concept.' (Apple, 2001:39). In this world, he suggests, the term 'consumers' is preferred to 'citizens'.

Current times indeed beg critical theorising of whose interests are being valorised in the name of democracy. The ethical view might be that, in a healthy democracy, nothing – theories, truth-claims, religion, politics, the economy, technologies - should be exempt from questioning or critique. Critiquing, then, could be identified as a distinctive and valid form of educational and popular activity – defensible for its democratic potential – a tool of, and for, democracy. Pranger (1968) argued that citizens should become creators of politics rather than appendages to it – being *of* a democracy rather than just *in* it. For participatory democracy, he points out, '…the politics of participation emphasises mass creativity,' (Pranger, 1968:92). He contrasts such participation with the 'pursuit of power' by individuals.

Saul (1995) argues the case for valuing and respecting uncertainty as a partner of critique in democracy. He, too, acknowledges discomfort and its place with consciousness. He concludes his text thus:

> The virtue of uncertainty is not a comfortable idea, but then a citizen-democracy is built upon participation, which is the very expression of permanent discomfort. The corporatist system depends upon the citizen's desire for inner comfort. Equilibrium is dependant upon our recognition of reality, which is the acceptance of psychic discomfort. And the acceptance of psychic discomfort is the acceptance of consciousness. (Saul, 1995:195)

Paul (1995), describes what he calls the *critical society* which promotes the values of critical thinking, eschews indoctrination and inculcation, and '…rewards reflective questioning, intellectual independence, and reasoned dissent.' (Paul, 1995:525). He draws on Sumner's words of 1906: 'The critical habit of thought, if usual in a society, will pervade all its mores, because it is a way of taking up the problems of life.… Education in the critical faculty is the only education of which it can be truly said that it makes good citizens.' (Paul, 1995:526).

Democratics of technology

It can be argued that the minimilisation of critical discourses in society today is linked to the uncritical bringing-into-being of technologies (Keirl, 2006). Our say in introduced technologies is so slight that it is hard to talk of democracy in the same paragraph. With no participation in the design or level of desirability of most technologies we are politically alienated from a key part of our existence. Yet these very technologies shape and change our individual and collective existences.

The intertwined nature of technologies with our lives is thoroughly documented. Importantly, so are the politics of technologies (see, e.g. Mumford, 1934; Winner, 1977; Wajcman, 1991; Sclove, 1995; Feenberg, 1999; 2002).

Marcuse (1968) introduces his critique of the ideology of industrial society with 'The paralysis of criticism: society without opposition' and talks of the containment of social change and how 'integration of opposites' has been facilitated by a corresponding negation of critique (mirroring the concerns of other 20th Century authors cited above).

Technologies can be viewed as having four phases to their existence – *intention* (the very conception, thought or idea that seeds the bringing-into-being of the technology) – *design* (the exploration of possibilities to bring the seed to fruition) – the *manifestation* (the bringing of the technology into the world) – and the *life* (which includes any possible afterlife, use, application, consequence, effect, etc). This simplistic analysis serves the exploration of technologies for their democratics and such an exploration should, it is argued (Keirl, 2006) be done through the critical-ethical lens.

Thus a thorough ethical critique at the intention phase may well render any design and further development unnecessary. Ethical interrogation at the design stage may introduce assessment and decision-making to assist the weighing-up of competing values positions – technologies being the nothing more than the embodiment of values. Once manifest, we critique in the hope of 'making things better' (double meaning intended) – often with a new technology to 'improve' the prior one rather than questioning the very existence of the whole. But, in this phase (and in the current economic system), critique more often than not leads to more of the same, that is, it iterates back into design-as-remodelling rather than promoting radical, ethically driven (democratic) alternatives.

Education-democracy relationships

Dewey's (1916/1966) arguments that 'The devotion of democracy to education is a fact' and that 'A democracy is more than a form of government; it is primarily a mode of associated living, of conjoint communicated experience' still hold weight. White (1973) argues in a key article: 'There is at least *one* policy which *must* be in the public interest in a democracy. This is an appropriate education for a democracy.' (White 1973:237). It is easy to see that the inter-relationship between any education system and the political system are qualitatively reflective. Thus, to return to critique, if one does not value it, the other may not either. Yet, as has been shown, critique is potentially a wonderful servant of both.

Thus, critiquing is seen as a natural component of both a quality (D&T) education and for life in sustainable democratic futures. This is no recent phenomenon. Postman (1999) has drawn parallels between 18th Century issues and developments and those with which societies are faced today. So far as education is concerned, he suggests three 'legacies' from the Enlightenment years, the third of which is:

> …the idea that a "proper education" must have as one of its goals the cultivation of a skeptical outlook based on reason… Indeed, if the question is posed, What is the principal mind-set associated with the Enlightenment?, the answer would certainly be – skepticism. Modern educators do not usually use this word, preferring something like "critical thinking". But in any case, they do not do much about it (Postman, 1999:159-160)

Now it is clear that there are modern educators who are on the critical thinking ball and do want to do much about things. But what they are up against is the current climate which subjects and enframes education-democracy relationships restrictively.

Given the climates of corporatism, suppression of individual voice, and citizen-as-consumer, described above, is there a parallel climate in education? Apple (2001) has already been cited in the affirmative. Hargreaves (2003) and his international research team document substantial evidence and offer valuable commentary. They highlight '…too exclusive a focus on academic results, examination and test scores, international competitiveness, league tables of performance and narrowing achievement gaps…Achievement has been everything and democracy has had to fend for itself.' (Hargreaves, 2003:40-41).

Apple (2001), Hargreaves (2003) and Sachs (2003) all present detailed analyses of how teachers are currently *positioned* by systems to replicate the systems' intentions. In climates of standardisation, teaching to the test, meeting targets, stifled pedagogical creativity and in isolation of any democratic social mission, critique is readily sidelined. Further, for democratic schools, as Sachs shows, democratic structures are needed as well as democratic curricula in which students are active and vocal participants.

Design and Technology within democratic education

Postman (1999) identifies what he sees as a major problem facing democratic life today, namely 'How do you teach reason and scepticism?' One of his five solutions is Technology Education which, he stresses, is *not* teaching how to use computers – already a rampant social phenomenon without schools' input. Rather, he cautions about what our young '…will *not* know, as none of us did about everything from automobiles to movies to television, (that) is, what are the psychological, social and political effects of new technologies.' (Postman, 1999:170). A critical approach is implicit.

Within the field there is an emerging critical literature: on the politics of technological literacy (see, e.g Petrina, 2000; Seemann, 2003; Keirl, 2006); on the theory of technological literacy (Dakers, 2006); as well as supportive professional development literature around the politics and challenges facing the D&T practitioner (Barlex, 2007, forthcoming). Layton's (1994) major international study exposed the multiple constructs and agendas (political, social, professional, philosophical) at work in technology education and articulated the contested nature of the term 'technological literacy'.

Thus, despite homogenising climates, there is supportive literature which articulates rich senses of technological literacy and 'technacy' (Seemann, 2003) and which acknowledges the need for critique and critical thinking. The South Australian D&T curriculum (DETE, 2001a&b) has an underpinning definition of technological literacy based on Habermasian (1971) critical theory. Further, the three organising 'strands' of the curriculum are Critiquing, Designing, and Making (Keirl, 2002).

D&T education gives students, through design, real opportunities to be engaged, to participate, and to be creators of their own knowledge but, it is argued, there are special ways that critiquing plays its roles. In setting these out, it is to be remembered that in the pursuit of critiquing within D&T practice, the students' general education is enhanced. They are practising critique and gaining voice as would-be democratic citizens. This is a strength of quality D&T as a compulsory curriculum component. For D&T's intrinsic richness and its general educational role, critiquing must be taken as purposeful and as a democratic tool of debate, values-weighing, social questioning of technocratic cultures of dependence, and so on.

Critiquing is responsive *to* something that exists or has happened - whether an idea in the mind or a physical product. Critiquing is about questioning rather than answering. Its practice helps clarify ill-defined problems through reformulation and reassessment. Critiquing uses many possible differing questions not one best question. Critiquing is reactive - after the fact. Whilst critiquing is an invaluable tool that enriches designing, it is also something more in itself. Through D&T education it helps clarify needs-wants issues, values issues, highlights the contestable, exposes the multiple effects of technologies and becomes a mirror for productive thought and action.

Critiquing is deconstructive but not destructive. In itself, it has limited problem-solving capacity but it does have excellent problem-finding or fallacy-exposing capacities. Critiquing acts as quality assurance throughout checking and rechecking validity, integrity, worth, accuracy, and fairness. Critiquing may involve looking in the mirror, reflecting alone or together, or placing in the window for public scrutiny.

Critiquing does not have components to be arranged into lockstep sequences – other than understanding the audience for the critique e.g. self, team, assessor, public. Critiquing may lead to a sharper interrogation of assessment criteria and rationales. Critiquing can be used on one's own methodology of practice – on time management, design procedure chosen, or research options taken.

Critiquing aids selection of thinking styles. Thus sophisticated critiquing is a form of metacognition. It is reflective and deconstructive but deconstructive thinking is not destructive thinking. Critiquing may involve discomfort but that is an aspect of critical purpose. The 'discomfort' of self-critiquing is not a matter of positive or negative criticism. It is a phase of the journey to a best defensible compromise. Critiquing as experience-building is the interplay of personal experience and knowledge with others' experience (community, research, opinion etc). The greater the critiquing experience(s) the greater the critical disposition. Critical friendship is an asset. Like risk-taking in creativity and designing, risk-taking in critiquing requires safety nets. Critiquing is done against a frame of reference which may be personal experience, some agreed or public criteria or a design brief. Imagination should not be critiqued.

To return to Paul (1995), critiquing is the articulation of the dialogical *and* the dialectical. We are reminded that 'Critical thinkers critique in order to redesign, remodel and make better.' (Paul, 1995:526). Critiquing is a purposeful and highly defensible aspect of any healthy democracy's education. Importantly, through Design and Technology education, critiquing can find a home as personal learning tool, as stimulus to design activity and as shaper of quality pedagogy. Perhaps this is another way that D&T might lead democratic curriculum change.

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The place of creativity in technological literacy: the role of teaching resources in fostering pupils' creativity.

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Abstract
The paper attempts to justify developing creativity as part of technological literacy. It reviews the importance of creativity as a concept as perceived in subjects, including design and technology, in England. The paper explores ways in which creativity might be achieved through teaching resources such as the QCA/DfEE for Design and Technology: A scheme of work for Key Stage 3 (11-14 years); Royal College of Art Schools Technology Project 11-14 (RCA), Nuffield Design and Technology 11-14 years Project; Key Stage 3 (11-14 years) National Strategy: Design and technology; Young Foresight and Technology and the Enhancement Programme (TEP).

The paper examines the teaching resources for the 11- 14 age range years from the perspective of a three-feature model for creativity previously developed by the author. The model is used as a tool to critique and identify aspects of the resources that support the development of creativity and aspects that are not addressed.

The findings indicated that a significant number of the resources are strong in the domain relevant feature of the model for creativity concerned with technical and constructional creativity but weak in aesthetic creativity. In the process-relevant features problem solving and designing are evident but it is not always open-ended, creative problem solving. The findings are generally disappointing in a number of the resources in the social and environmental features focusing on macro/micro environmental, social and cultural issues. As all three features need to converge to ensure that creativity occurs there are implications for the development of teaching resources aiming to foster pupils' creativity.

The paper concludes by arguing that creativity should be an integral part of technological literacy and makes some recommendations.

Key words: lower secondary pupils, creativity model, importance statements, fostering creativity, teaching resources.

Introduction.
The paper examines the importance of developing pupils' creativity as an aspect of technological literacy described as 'the ability to use, manage, assess and understand technology' (ITEA, 2000, p9). Many people across the age range perceive technology in terms of its artefacts including computers, cars, televisions, toasters, pesticides, flu shots, solar cells, genetically engineered tomatoes (Dakers, 2006). In this paper the development of the abstract concept of creativity within the context of technology education is explored through a range 11- 14 years teaching resources developed in England since the introduction of the National Curriculum for Design and Technology in 1990.

A brief review of the importance statement of subjects in the National Curriculum in England looked at the perceived importance of creativity. It is considered that English 'enables them (pupils) to express themselves creativity and imaginatively' (DfEE, QCA, 1999, p45) and that mathematics is 'a creative disciple' (p57). The importance of science statement sees scientific methodology 'as a spur to critical and creative thought' (p102) and 'pupils use ICT tools to find, explore, analyse, exchange and present information responsibly, creatively and with discrimination' (p143). Art and design 'stimulates creativity and imagination' (p166) and music 'increases self-disciple and creativity, aesthetic sensitivity and fulfilment (p17). In physical education there are opportunities 'for pupils to be creative, competitive and to face up to different challenges as individuals and in groups and teams' (p174). Lastly, but by no means least, in design and technology pupils 'learnt to think and intervene creatively to improve quality of life……to become autonomous and creative problem solvers, as individuals and members of a team' (p134). Subjects that did not to refer directly to creativity in their importance statements are geography, history, languages and citizenship, however the findings imply that creativity is considered to be an important part of a pupils' education.

The three-feature model used in this paper to analyse the potential of a range of teaching resources to foster creativity in pupils aged 11-14 years was developed within another research study (Rutland, 2005). An overall aim was to develop a theoretical model, or framework, that could be used to collect and analyse data to highlight examples of good classroom practice and identify 'gaps' that should be addressed. An international literature review in the field of psychology was carried out to attempt to define creativity, though this proved to be a complex matter. A consensus was that 'big' creativity is when something of enduring value is developed that contributes to an existing field of knowledge and transforms it, whereas 'small creativity', though equally valuable gives a fresh and lively interpretation to an issue (Feldman et al, 1994).

The views of Amabile (1983, 1996) proved to be highly influential as she highlighted the impact of specific social factors and intrinsic motivation on creativity and described creativity as the confluence of intrinsic, or self, motivation, domain-relevant knowledge and abilities, and creativity-relevant skills. The creativity-relevant skills relate to strategies and approaches that the teacher teaches pupils so that they have some tools for being creative. A multi-component approach was taken as it emphasises the importance of the environment as stressed by Amabile (1983, 1989, 1996) and highlighted that creativity only occurs when the three features converge (Csikszentmihalyi, 1994, 1999 and Feldman, et al. 1994).

In the model, or framework, for creativity the three features are:

1. **Domain relevant features** - *a set of practices associated with an area of knowledge, for example design and technology or other subjects such as science, mathematics*
2. **Process-relevant features**- *influencing, controlling the direction and progress of the creative process.*
3. **Social, environmental features** - *macro/micro environmental, social and cultural issues.*

In the domain of design and technology the following four criteria for creativity were identified:

- **The concept or idea** – *has the designer proposed a concept that is original, novel, feasible, useful, will function etc?*
- **Aesthetic creativity** – *has the designer made proposals about those features of the product that will appeal to the senses, for example, sight, hearing, touch, taste and smell? Is there something about these proposals that is particularly novel and attractive?*
- **Technical creativity** – *has the designer made proposals about the way the product will work and the nature of the components and materials required to achieve this? Is there something about these proposals that is novel or elegant?*
- **Constructional creativity** – *has the designer made proposals about the way the product will be constructed and the tools and processes needed to achieve this? Is there something about these proposals that is novel or original?*

The specific criteria listed in each of the three features, as seen in the charts, were evolved from research activities during the original study. If the model was used to analyse creativity in other subjects domain criteria would need to be developed.

Methodology

Teaching resources.

The six teaching resources analysed in this paper for their potential to develop pupils' creativity are:

- *QCA/DFEE (2000) Design and Technology: A Scheme of work for Key Stage 3* The scheme of work provides a long and medium term plan to teach design and technology for pupils aged 11-14 years and gives guidance and suggestions for short-term planning.
- *RCA (1995) Royal College of Art School Technology Project*. Materials include student books in two sections of 'Challenges' and 'Designing skills' for each year group for the secondary age range 11-18 years. This paper looks at the age range 11-14 years. The learning approach is built on three elements; design and make tasks (DMAs), focused practical tasks (FPTs), product evaluation and core designing skills.
- *Nuffield Design and Technology 11-14 Project (2000) www.secondarydandt.org* The materials are based on three teaching methods. Resource Task, or short practical activities, to help pupils learn the knowledge and skills required to design and make. Larger Capability Tasks where pupils can design and make a product. Finally, Case studies or true stories about design and technology where pupil learn about the world outside school
- DfES (2004) Key Stage 3 National Strategy: Design and Technology. A key objective relevant to this paper is 'improving the teaching of designing'. There are six subskills of designing and making: exploring ideas and the task; generating ideas; developing and modelling ideas; planning; evaluating and making high quality products. They are linked to the importance of design and technology statement in the National Curriculum (DfEE, QCA, 1999). The 80 activities for teaching yearly objectives are linked to the Scheme of work for Design and Technology (QCA,DfEE, 2000).
- Young Foresight (2002) www.youngforesight.org Young Foresight is an educational initiative for design and technology that provide an experience for Year 9 pupils lasting about 12 weeks.
- TEP Technology Enhancement Programme www.tep.uk The programme supports over secondary schools with published materials, resources and training programmes aimed to enrich and enhance technology education.

Each set of materials were analysed and mapped against the three- feature model for creativity.

Findings

QCA/DfEE Scheme of work for key stage 3 *and* Royal College of Art (RCA) Schools Technology Project.

Details of the findings are in Table 1.

The Scheme of work was strong in process relevant features and low in domain and social and environmental features of the model. It was a prescribe scheme of work with set units that could be combined in various ways. The curriculum planning information was quite complex but helpful. Unit titles did not encourage open-ended solutions. Links were made with pupils' previous and future learning.

The RCA project focused on a design-based approach to teaching and learning. The project did not highlight the domain relevant features but was strong in process relevant features such as creative problem solving and organisational information for the designing and making activities (DMAs). Case studies introduce pupils to product development and manufacture. Cross-curricular links were made with mathematics, art and science.

Nuffield Design and Technology Project and Key Stage 3 (11-14 years) Strategy.

Details of the findings are in Table 2.

The Nuffield Project was clearly structured and included Resource Tasks to teach the knowledge and skills required by pupils to complete the Capability Tasks or design and make assignments. There were generic and focus area design strategies to develop skills in designing, chooser charts to encourage pupil to make technical decisions and case studies set in real-life contexts. There was a good balance in the analysis across the three-feature model for creativity and a wide range of choice of activities for teachers and pupils.

In the Key Stage 3 Strategy there was a wide range of activities aimed 'to improve the teaching of design' and they were mapped across the specialist areas of design and technology. Pupils' creativity was encouraged though these activities. Pupils' motivation was addressed in the social and environmental feature but how to use the tasks effectively was unclear. The main issue was the need for teachers to audit existing schemes and integrate the activities into their teaching.

Young Foresight and TEP projects.
Details of the findings are in Table 3.

The Young Foresight project was clearly presented and for a shorter allocation of teaching time. It focused on 'designing' and not 'making' and encouraged pupils to be creative and take risks. The focus was not on the domain features and the project was very strong in the process relevant and social and environmental features. Creative problem solving, TV programmes of real-life contexts and links with the world outside school were highlighted.

The TEP project was very strong is the domain features but only within materials technology and electronic communications technology (ECT). It was weak in the process relevant features and the social and environmental features. The wide range of CDs, leaflets and teaching materials and equipment available to schools and teachers focused on the technical and constructional, but not aesthetic, criteria in design and technology. Information on examples of classroom projects was provided.

Discussion
The findings indicate that the three-feature model for creativity was a useful tool to analyse the teaching resources. It is important to acknowledge that the aims and objectives of the resources do vary. Some are clearly a set of resources that are intended for teachers to use in their curriculum planning and classroom practice for pupils aged 11-14 years, another focuses on one year group for a short curriculum invention. One contains a series of tasks that can be linked through curriculum planning to a published scheme of work and/or the planning of the school. Another of the resources has a clear focus on subject knowledge and skills in the domain relevant features of the model, but in a limited range of specialist design and technology areas. It did not score well in the process relevant or social and environmental features of the model. All but one of the teaching resources covered all the specialist subject areas in design and technology in the English curriculum.

Four of the resources included longer DMAs and the skills and knowledge, including designing, required for the designing and making activities were taught through FPTs in all of resources. Case studies were used by two of the resources as a strategy to link with the world outside school. One resource favoured closed FPTs where technical 'kits' were used to develop a product, for example an 'Electric Plane Launcher' and a 'Jitterbug' Another resource, a detailed long-term scheme of work with suggestions for short term planning, was linked to another that is essentially a series of 80 activities. Guidance was given on how they could be used with the long-term scheme of work or with an audit of a schools' existing scheme of work. There is fine balance between 'telling' professional teachers exactly what and how they should teach in the classroom and leaving all the decisions to them. Heavily structured schemes can be rejected by teachers because they are inflexible and inappropriate of individual schools. However, a complete lack of direction leaves teachers without a clear overview of the specific aims, for example to foster pupils' creativity, and opportunities to draw on other colleague's expertise.

The strength of the model is that is helps focus on the three features that need to converge if pupils are to be truly creative in the classroom (Csikszentmihalyi, 1994, 1999 and Feldman, et al. 1994). However, the model is not perfect in that some criteria may overlap two features. For example, the personal criteria in the process relevant features highlight pupils' ability to be imaginative, work in a team and take risks. These has links with motivation in the social and environmental features through intrinsic motivation, curiosity and persistence of pupils fostered by relevant, real-world and open approaches. There is a need for a clear objective in departmental curriculum planning, as found in the majority of the resources, for the pupils to 'learn to think and intervene creatively to improve the quality of life…..to become autonomous and creative problem solvers, as individuals and members of a team' (DfEE, QCA, 1999, p 134). The teaching resources examined in this paper were generally strong on technical and constructional criteria but it is disappointing to see only two who were strong in the aesthetic criteria. This is similar to the recent research findings (Rutland and Barlex, 2007) that unlike design and technology teachers, art and design considered the development of aesthetic knowledge and skills to be as important as technical and constructional skills. If pupils are to be creative there is a need for a balance across three areas of skills (Rutland, 2005).

Designing and creative problem solving are both key criteria in the process relevant features. Not all the resources included strategies to support teaching pupils to design. Two were significantly stronger in this area with both generic and subject specific strategies, though no resource emphasised that some designing strategies may be more suited to some contexts and material areas. Process skills and problem solving was present in all of the resources but it was not always creative problem solving. Units of work were closed rather than open-ended in that pupils did not work in a heuristic manner and were restrained in their outcomes, for example they all made 'a wallet'. This has resonance with similar findings in research exploring creativity in design and technology (Rutland, 2003). One of the resources favoured the more open design and make tasks, for example 'Special effects', and 'Hot comfort' where the range of outcomes could be very varied. In another resource pupils develop their own design briefs but were not expected to 'make'. Restrictions such as timetable allocation, the expertises of the pupils and the availability of resources directly influence how long pupils can spend on designing if they are expected to make in every unit of work. This strategy can be a useful tool to address this issue.

In the social and environmental feature, considered as essential by Amabile (1983, 1996), it was interesting to note that only two of the resources identified links with previous learning in primary school and the later examination years for pupils aged 14-16 years. Cross-curricular links were identified in three of the resources and key skills in four. One specifically, highlighted the importance of decision making, problem solving and planning. Intrinsic motivation, a key criteria for creativity (Amabile, 1983, 1996) was addressed through real-world contexts in only three of the resources, with one suggesting that they optional and another focused on learning from the past and other cultures. Issues of sustainability and environmental design to motivate and interest pupils were mentioned in only two sets of resources and industry by one, though this was implicit in another of the resources. Reference by only one of the resources to the importance of a supportive, rewarding, secure environment conducive to risk taking (Davies, 1999, 2000) was disappointing. One resource stressed the importance for creativity of partnership and collaboration (John-Steiner, 2000) between industry and the teacher to provide an enriched environment. The importance of team work was referred to by five of the resources and one talked of pupils being given the 'can do' approach.

The three-feature model for creativity was originally devised to map the development of creativity in design and technology through direct classroom observation. However, in this paper it has been used successfully as a tool to analyse a range of teaching resources for the classroom. The disappointing findings in the social and environmental features indicate a lack of understanding that all three features need to be present if creativity is to occur in the classroom (Csikszentmihalyi, 1994, 1999 and Feldman, et al. 1994). Subject knowledge and skills without an understanding of the processes of designing, creative problem solving and detailed curriculum planning are insufficient. As important are the abilities of teachers to use transferable knowledge, understanding and skills, help pupils handle outside and some times conflicting constraints and make links with the world outside school. Pupils are then fully involved in and motivated by their learning and teachers can provide a secure, supportive classroom environment that is conducive to risk taking and rewards their pupils' creativity.

Recommendations

1. The findings of the paper indicate that the concept of creativity is considered important for the majority of subjects including design and technology and, in the wider international context, technology. Therefore, it should be an integral part of technological literacy.
2. Creativity as an aspect of technological literacy would provide a sound basis for developing a meaningful, relevant and articulated technology curriculum at school, local and national levels. A curriculum that would encourage active and experiential learning in the classroom by well motivated and interested pupils able to make decisions.
3. As future citizens in a technological society of the twenty first century, all pupils need to develop a basic level of technological literacy including the ability to be creative.

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Criteria	***QCA/DfEE Scheme of work***	***RCA Project***
Domain relevant features		
Concept/idea: is it original; realistic; novel; useful; functional		Challenges establish the contexts of the assignments and explore values. Pupils can pursue what they think is interesting and creative

		and value it.
Aesthetic: *ways in which it appeals to the senses*, for example visual; smell; taste; sound; image; form; colour; texture; pattern; complex or simple; emotional		
Technical: *how it works,* for example knowledge and understanding of materials, technical language; components, structures; systems & control; communication of ideas e.g. writing, graphics, sketching; specification drawing; modelling; finishes	*Units:* *'Understanding materials';* *'Exploring materials';* *'Selecting material';*	
Constructional: *how it is made*, for example tools and equipment used in making e.g. joining and combining; product analysis; focused practical task; design and make activity; prototypes; manufacturing	Units: '*Producing batches*'; '*Using control for security'; Using control for electronic monitoring' ;'Ensuring quality production'*	
Process relevant features		
Designing - an interactive, iterative creative problem solving process, a project based activity that does not have only one possible solution	*'Design and making for your self'; 'Designing for clients'; 'Designing for markets'; 'The world of professional designers (optional)*	Development of designing skills supported by sections in each pupil's book and individual activities.
Creative problem solving: working in an *heuristic manner* e.g. identifying needs, observing; investigating, generating and developing ideas, making decisions; evaluating; synthesising, analysing, testing and validating	Pupils can be encouraged to be creative through using strategies to generate ideas.	The process skills are emphasised in designing and the underlying knowledge and understanding. Routes taken by pupils should match their individual interests and abilities. Developing pupils' designerly' thinking is highlighted.
Organisational: appropriate design briefs, schemes of work, good classroom management skills and choice of teaching strategies used; time management; self-organisation; analysis; convergent, divergent, lateral thinking, time for reflection, good classroom organisation, group collaboration	Contains design and make assignments (DMAs), product evaluation activities and focused practical tasks (FPTs). Units provide medium term plans (term or less) sequenced across Key Stage 3 with progression in knowledge, understanding and skills. Differentiation and links with KS2 (primary) highlighted. Alternatives suggested to rotational courses. Teaching design highlighted. 34 units – 32 provide the basis for a complete long-term plan across KS 3. Unit content A: understanding materials; B: designing; C: ICT; D: control. In Years 8 and 9 E is making and producing quantity. **Examples projects provided***:* Selecting materials: *'specialist diet', 'fold it up', 'a textiles product for a technical purpose'****;*** designing for clients: *'wallets', 'develop a food product range', 'personal light source'****;*** Designing and making for yourself*: 'snacks', 'puzzle in a box',' fashion wear';* 'Producing batches: '*juggling balls*', *'pasta production', 'sheet materials';* Using ICT to support links with the world*: 'corporate identity', 'going public'*.	I-I-E-E model – 4 aspects for each D&A: introduction, intervention, extension and enrichment. Teachers intervene only when it is in the pupils' best interest. The learning is structured so that the skills and knowledge required are taught through FPTs. Challenges set out initial criteria for success. Spiral model of learning. Curriculum model will operate differently in each school structured around learning units. Year 7 *'Ready Steady Go', puppets', 'wall hanging and novelty chocolate'* units acknowledges KS1 and KS2 learning. Units, across focus areas of D&T mapped against NC skills and knowledge e.g. *'creative, salads'; 'door buzzer'; 'puppets'; 'can crusher'; 'electric buggy'; 'Art deco jewellery'*. Some e.g. *'novelty chocolates'* require input from more than one focus areas.
Personal: pupil and teacher imagination; vision; relaxed, confident, willingness to take risk; tolerance; concentration; persistence; curiosity; pro-active; independent; awareness of the needs of others; ability to work in a team.	'*Activities week (optional)'*	Challenges are flexible and allow a spontaneous response so pupils can identify and follow their own purpose. They allow maximum autonomy individually or as teams. Pupils are instilled with a sense of engagement and purpose in what they are doing.
Social and environmental features		
Background: pupil and teacher education,	Scheme builds on pupils' earlier	

previous experiences	experiences in KS1 and 2. 'Transition: building on learning from KS2'; '*Moving on to KS 4 (reviewing and target setting'*.	
Use of external/transferable knowledge, understanding, and skills: recognition of key skills and knowledge; use of key skills and knowledge	Recognition of key and thinking skills. '*Using ICT to support researching and designing'; 'Using ICT to support making'*	Fosters important learning skills
Handling outside/conflicting constraints: class*;* peers; school; parents; society	'*Using ICT to link with the world outside school'*	
Appreciation of alternative ideas and experiences*: cross curricular,* world outside school	Links with language for learning, mathematics and ICT. Social and cultural sensitivity: '*Designing for markets'; 'Designing for clients; 'The world of professional designers (optional)' Activities week (optional)'*	Links with science, mathematics and art, ICT established. Case studies introducing product development and manufacturing.
Motivational: relevant, open, real-world, pupil relevant contexts; intrinsic and extrinsic motivation	Out-of-school activities can enhance learning but the activities week and designing for clients activities are optional.	Challenges are set up to motivate pupils and allow them to make a personal response and take ownership of the task
***Environmental*: a classroom that is supportive; rewarding, secure and conducive to risk taking, peer relationships; use of resources/space effectively	Team planning to transfer learning across materials, provides a common framework. Supports pupil's progress. Examples given. Inclusion: a) suitable learning challenges b) diverse needs of pupils c) overcome barriers to learning and assessment	

Figure 1: QCA/DfEE Scheme of work for key stage 3 *and* Royal College of Art (RCA) Schools Technology Project.

Criteria	***Nuffield Project***	***Key Stage 3 Strategy***
Domain relevant features		
Concept/idea: is it original; realistic; novel; useful; functional	Capability tasks provide open briefs based on 'real' situations, or lines of interest: e.g. '*pet shop parade', 'creative foods', 'hot comfort', and 'masks'.*	Key objective: 'improving the teaching of design'. *Exploring ideas* – 'mood boards'; 'mind maps'; 'learn from the past'; 'a walk around a building'; 'a day in the life of' 'role play'; ' key words'. *Generating ideas:* 'new for old'; 'word and picture board'. *Evaluating: '*ranking'; 'CAFEQUE'.
Aesthetic: *ways in which it appeals to the senses*, for example visual; smell; taste; sound; image; form; colour; texture; pattern; complex or simple; emotional	Pupils asked to make design decisions on the appearance of the product e.g. '**Creative foods'** – *use of nature form as a basis for design: shape, colour and decoration. Use spices to modify flavour, wholemeal flour to modify texture*. Use of designing strategies such as PIES to explore emotional responses	*Exploring ideas:* 'PIES' – people's needs *Generating ideas* – activities such as 'words and picture boards', 'pattern design', *Developing and modelling ideas*: 'building a design',
Technical: *how it works,* for example knowledge and understanding of materials, technical language; components, structures; systems & control; communication of ideas e.g. writing, graphics, sketching; specification drawing; modelling; finishes	Pupils make technical design decisions e.g. **'Novelties incorporated'** *- the properties of materials, degree of precision required for the product, quality of finish. Using image boards, simple shapes and drawing quick 3D views; freehand product analysis; modelling with CAD, spreadsheets.* **Chooser charts***: e.g. metals, plastics, finishes, fabrics, fastenings' fillings,* where pupils make technical design decisions.	Developing and modelling ideas – '*developing and modelling ideas', 'using grids', 'Exploring ideas: 'Using materials'* Generating ideas: *'morphology'* Developing and modelling ideas: *'Improvise, play and experiment',* Developing and modelling ideas: *'three-minute sketching'* *Planning*: *'matrices'*
Constructional*: how it is made*, for example tools and equipment used in making e.g. joining and combining; product analysis; focused practical task; design and make activity; prototypes; manufacturing	Hand-eye co-ordination is developed through the teaching of the precise use of tools and materials. Pupils make constructional decisions e.g. ***'Robots are go!*'** *– the ways parts fit together, which move and which are fixed; how to mount mechanical and electrical components; the placing of the power source; making and assembling mechanisms; using system diagrams;*	Generating ideas*: 'deconstruction'* Planning: '*sequence mapping', 'CAD planning', Planning: 'flow charts' 'sequencing', 'LogoTM production line', 'charting work-flow', 'gantt chart'.* Evaluating*: 'ACCESS FM',*
Process relevant features		
Designing - an interactive, iterative creative problem solving process, a project based activity	26 Capability tasks are open-ended with a line of interest, focus or theme e.g. '*home made or shop bought'; 'creative foods'; 'carrying'; 'display your*	Strategies for designing*: unpacking design tasks; imaging; iterative thinking; raiding and reusing ideas; modeling and prototyping; calculating risk-taking.*

that does not have only one possible solution	*treasures'; 'electronic opportunities'*. The ranges of outcomes are open. 41 Generic design strategies in 6 categories: *investigating a context; stimulating ideas; developing aesthetic capability; modelling and testing ideas; presentation skills; evaluating products*: *e.g. 'brainstorming', 'metamorphosis', 'free-hand product analysis'; 'layout'; using image boards';* Focus-area Strategies: e.g. *'making things look solid'; 'using nets'*	Exploring ideas: '*centring', 'inspirational products',* Generating ideas: *'walk on the wild side'* *Developing and modelling ideas: 'scamper'*
Creative problem solving: working in an *heuristic manner* e.g. identifying needs, observing; investigating, generating and developing ideas, making decisions; evaluating; synthesising, analysing, testing and validating	The project is based on a specific type of learning activities. In Resource Task pupils learn appropriate skills and knowledge. The longer, more open tasks require designing, making and evaluation. They are called Capability Tasks.	Exploring ideas*: 'big and small questions', 'design abacus'* Generating ideas*: 'create some space to reflect', building blocks', 'less is best*?' Developing and modelling ideas: *'4x4'*
Organisational: appropriate design briefs, schemes of work, good classroom management skills and choice of teaching strategies used; time management; self-organisation; analysis; convergent, divergent, lateral thinking, time for reflection, good classroom organisation, group collaboration	The project approach is to select a sequence of Capability Tasks for an entire Key Stage (11-14 years) in which pupils design and make in the required context. In preparation for each Capability Task pupils will undertake product analysis to evaluate existing products and focused practical tasks.	Framework sets out examples of long-term plans for pupils aged 11-14 years. Progression is through the 'subskills' of designing described in the Strategy. Management and review issues discussed. The 80 activities described in the Strategy are link to year groups and are intended to support the yearly objectives of the department. Exploring ideas*: 'reflect on and take action'* 'Planning: '*group planner', 'consequences diagram', 'working in teams'*.
Personal: pupil and teacher imagination; vision; relaxed, confident, willingness to take risk; tolerance; concentration; persistence; curiosity; pro-active; independent; awareness of the needs of others; ability to work in a team.	In the Capability Task pupils will have the opportunity to work both as individuals and in teams. They are given the 'can do' approach to their work	Exploring ideas: '*develop connectivity with other people', 'walk around the building'* Generating ideas: *'take a risk'*
Social and environmental features		
Background: pupil and teacher education, previous experiences	Progression is highlighted through the use by pupils of timed reviews and built in assessment.	
Use of external/transferable knowledge, understanding, and skills: recognition of key skills and knowledge; use of key skills and knowledge	Intention of the project is to foster in pupils the ability to make decisions, plan a course of action and carry it out. It requires both creative and problem solving	Planning: *'sustainable materials', 'product impact'*.
Handling outside/conflicting constraints: class*;* peers; school; parents; society	.	Exploring ideas*: 'observe people and products', a day in the life of'* Generating ideas: *'look to the future'*
Appreciation of alternative ideas and experiences*: cross curricular,* world outside school	Cross-curricular issues highlighted e.g. *'Raindow Radios'* link with science. '*Better weighing'* links with mathematics. 7 Case studies provide opportunities for pupils to link with the outside world and develop an understanding and appreciation of the views of others e.g. *Lara Sparey – designer maker'; 'making jewellery'; 'Covent Garden Food Company'; smart cards'; clothing manufacture'*.	Generating ideas: *'alternative uses'* Developing and modelling ideas: *'get expert help'*, Evaluating: '*six thinking hats', 'compare and contrast'*. Links with DfES/QCA Scheme of work and ICT requirements, NC & Attainment target, Gifted and Talented; NAAIDT; QCA, Creativity: Find it, promote it; DATA
Motivational: relevant, open, real-world, pupil relevant contexts; intrinsic and extrinsic motivation	The intention is that the project provides skills and attitudes useful for the rest of life whatever career. Pupil activities address their own needs and those of others and involve intellectual and practical abilities through open-ended briefs. The real-life contexts and situations for the Capability Tasks are rich in opportunities for the pupils to be self-motivated and interested in their work.	Aim to improve pupils' motivation by: • autonomy • creativity • reflection • skills in group work *Exploring ideas* –' learn from the past and other cultures'
Environmental**:** a classroom that is supportive; rewarding, secure and conducive to risk taking, peer relationships; use of resources/space effectively	A wide range of realistic resources are suggested for both Resource and Capability Tasks. This encourages the development of an environment conducive to risk taking. Sustainable and environmental design introduced in the project.	*Exploring ideas*- 'product footprint' ecology – 'why put it right', the bigger picture',

Figure 2 Nuffield Design and Technology Project and Key Stage 3 Strategy.

Criteria	***Young Foresight***	***TEP***
Domain Relevant Features		
Concept/idea: is it original; realistic; novel; useful; functional	Challenges the orthodox in 7 ways. Pupils design but do NOT make. They work in groups, design for the future and have the support of ambassadors from industry. They use new and emerging technologies, present their ideas to peers and teachers at conferences. Essentially, they develop their own design briefs. Unit 1: *'Understanding the big picture'*	
Aesthetic: *ways in which it appeals to the senses*, for example visual; smell; taste; sound; image; form; colour; texture; pattern; complex or simple; emotional	Unit 2: *'Understanding needs through PIES approach'*. Unit 3: *'Understanding needs and wants'*	
Technical: *how it works,* for example knowledge and understanding of materials, technical language; components, structures; systems & control; communication of ideas e.g. writing, graphics, sketching; specification drawing; modelling; finishes	Unit 17: *'Presenting your ideas'*	Introduces new technologies in schools: smartcard control; PIC programming (Chip Factory); use of modern and smart materials e.g. polymorphy, thermochromic film, shape memory alloy etc. Example projects/kits*:' CNC Torch; 'Jitterbug';'Phone pod''*. Teacher guidance leaflets*: e.g. 'Smart materials'; 'E-modules'; 'electronics'; 'DeskTop Engineering'; 'PIC Technology'*. Multi-media CD-ROMs*: Smart materials'; 'materials selection and processing'*.
Constructional: *how it is made*, for example tools and equipment used in making e.g. joining and combining; product analysis; focused practical task; design and make activity; prototypes; manufacturing	*Unit 16:' New technologies just around the corner'*	Projects: '*Bubble Blower'; Message in a box'* *Teacher guidance leaflets: 'Smart materials', 'Control'; Electronics'; 'Mechanisms'; 'Structures. CD-ROM: Introducing robotics.* Wide range of technical teaching resources e.g. *motors, gears, electronic and optical components, batteries, power supplies, CNC milling machine, bench pillar drill.*
Process relevant features		
Designing - an interactive, iterative creative problem solving process, a project based activity that does not have only one possible solution	Pupils use new and emerging technologies for the basis of their designs. They develop their own design briefs and specifications and justify their designs decisions by group discussions and class presentations. *Setting the scene for a creative response*: DF1 'What's new since 25 years ago?' DF2 The same thing than and now – what's changed?'	Millennium Schools Project – Designing: '*Design Rules'*
Creative problem solving: working in an *heuristic manner* e.g. identifying needs, observing; investigating, generating and developing ideas, making decisions; evaluating; synthesising, analysing, testing and validating	Aim: to improve pupils' designing skills, become more creative, understand new technologies and develop their communication skills. 3 important teaching approaches: 1. Appropriate questioning 2. Modelling ways of working 3. Connected thinking *Designing for the future*: 1 Work in small groups to generate, select and communicate ideas 2 Each group develops, communicates and presents their ideas.	
Organisational: appropriate design briefs, schemes of work, good classroom management skills and choice of teaching strategies used; time management; self-organisation; analysis; convergent, divergent, lateral thinking, time for reflection, good classroom organisation, group collaboration	For Year 9 pupils – approximately 1 term (12 weeks). Pupils work in teams, design products and services for the future. *Tool kit:* a suite of 17 activities to teach pupils the concepts and processes they will need. *6 teaching approaches. Learning is:* 1. Clarified 2. Active 3. Personally relevant 4. Valued 5. Takes place in groups *6.* Involves problem solving	Aim: to enrich and enhance technology education through training programmes and resources. TEP Online Resource Centre: 1 Photocopiable textbooks 2 Projects bring together technology, science and mathematics 3 Special publications e.g. Bit-by-bit controller 4 Partnership network 5 Clip-art library 6 CD-ROM products 7 high technology components 8 Help and support
Personal: pupil and teacher imagination; vision; relaxed, confident, willingness to take risk;	Aims: 1 Pupils will learn to work well with one another and from one another.	Pupils can work individually or as teams.

tolerance; concentration; persistence; curiosity; pro-active; independent; awareness of the needs of others; ability to work in a team.	2 They will exceed their expectations of their achievements. 3 They develop a wide range of communication skills that enhance creativity and improve design ability	
Social and environmental features		
Background: pupil and teacher education, previous experiences		
Use of external/transferable knowledge, understanding, and skills*:* recognition of key skills and knowledge; use of key skills and knowledge		
Handling outside/conflicting constraints: class*;* peers; school; parents; society	Unit 11:*'Getting the most from 'Will it sell'* Unit 12: *'Will these products last into the future?'* Unit 13: *'A matter of choice?*	
Appreciation of alternative ideas and experiences*: cross curricular,* world outside school	Units 4: *'Understanding trends'*; Unit 5: '*Future scenarios for trends'* Unit 8: *'Getting the most from 'Bright ideas for a better world'* Unit 9: '*The story of a tin can'* Unit 10: *'Product life cycle and sustainability'* Unit 14: *'Spot the service'* Unit 15: *'Improving services'* Tetrahedron framework '*Designing for the future': technology, society, people and markets'*	The world outside school e.g. industry is well represented through: Mutimedia/CD-ROMs *'Introducing Manufacturing*' e.g. the electric bicycle, power drills, JCB's backhoe loader and High tech pens. Multi-media CD-ROMs: *'Manufacturing'* e.g. '*developing systems'; controlling speed'; transmitting power'; using components'*
Motivational: relevant, open, real-world, pupil relevant contexts; intrinsic and extrinsic motivation	Aim: Pupils will enjoy D&T like no other subject in the curriculum. Pupil understanding of 'protecting intellectual property rights' Unit 6: *Getting the most from: what where and when'* Unit 7 *'Using the 4Rs of creativity'* 3 TV programmes introduce pupils to new and emerging technologies.	Many pupils will respond well to the 'hi-tec' emphasis of the resources
Environmental**:** a classroom that is supportive; rewarding, secure and conducive to risk taking, peer relationships; use of resources/space effectively	Partnership between teacher and industrial mentor provides an enriched, collaborative classroom environment. Supports pupils to be creative and promotes risk taking	Resources can be bought direct from TEP at a reduced rate for member schools.

Table 3 Young Foresight and TEP project.

Learning concepts through project work
Web based projects for integrated science and technology

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Abstract
An increasing number of schools in the Netherlands recently adopted a radical constructivist approach to learning and teaching. Technology at such schools is integrated in the natural sciences and learnt through large projects. The authors describe the didactical dilemmas associated with these new conditions and the solutions they came up with.

1.0 Introduction
Until recently students in lower classes of Dutch secondary education were taking fifteen different subjects. This resulted in a severely fragmented curriculum. The Dutch government has now compelled schools to reduce this fragmentation. Schools are free to choose from four scenarios. Scenario one is the most conservative option, whereby a school harmonises content matter and skills-teaching in different subjects. Scenario four on the other end of the scale, implies rigorous change. Boundaries between adjacent subjects are broken down completely. Technology is often largely integrated with biology, physics and chemistry at such schools. This area of learning is then called ‘mankind and nature’ or ‘nature and technology’. Most of these progressive schools adopted a view on didactics that can be pinpointed as radical constructivist. This has prompted unprecedented debate about didactical issues throughout all media. Adversaries have criticized schools for giving students too much freedom, leading to low learning outcomes. The authors of this article are at the forefront of developing teaching materials for those schools, in particular for the sciences and technology. They describe their effort to supply schools with exemplary projects that meet the needs of students and teachers. The projects will be described here, with a focus on the didactical features. Since increasing numbers of Dutch teachers engage in the process of constructing integrated teaching aids themselves, we thought it might be useful to describe our dilemmas and solutions.

The five schools involved in this development formulated a number of demands for their teaching aids, the most prominent being:

- Large projects (up tot 30 hours of student work)
- Coherence between subjects in one project
- Possibilities for teachers to adapt the materials to their needs, particularly the levels of choices students have in completing tasks
- Strong use of computers
- Web based materials
- Built-in choices for students
- Emphasis on creativity and arts
- Suitable for cooperative learning

Another striking feature, in the light of the Patt-18 conference, is the absence of a trained technology teacher at many of these schools. This can be explained by the highly stratified Dutch education system, in which schools are either academically or vocationally oriented. These particular schools offer higher levels only, and due to the absence of vocational training and the need for a cutback in the number of subjects, they have not felt the need to employ a teacher with expertise in the field of design and technology. The national curriculum does dictate a number of technology related topics, however (ministry of education, 2007) . That, together with our wish to promote technological literacy, prompted us to encompass technology related topics in these projects. The resulting projects, written by researchers and teachers with high constructivist ambitions, may yield some didactical knowledge for those who engage in the design of teaching aids, particularly in relation to the integration of technology in science projects. Another outcome of our work, that may be interesting in the light of the conference theme, are some examples of contexts in which technology is firmly connected to the arts . This gives students a chance to experience the impact that technologies will have upon their cultural development and to reflect on this experience.

2.0 General didactical structure of projects
Project work as compared to regular 'textbook work', may have favourable qualities for the enhancement of student motivation, particularly if the project is meaningful and challenging.

Four projects were developed within the framework of this article. Themes and topics were chosen by teachers concerned.

1 Design an Alien for a movie. The alien should be able to survive on a given planet with harsh conditions.
2 Make a plan for the technical aspects of a theatre production.
3 Write a brochure about the production of drinking water and the use of it.
4 Design a weather station and compare your measurements with professional data.

Project one is discussed in more detail in this article.

A disadvantage of project work can be the disappointing yield of conceptual knowledge and skills that need rigorous training. Students often emphasise creative aspects of their products and neglect conceptual content. They are focussed on finishing a task and making a beautiful product, rather than acquiring tricky knowledge and skills. Whether or not this is true, teachers do stress this argument, in the educational debate (Kampen, P. van, et al, 2004) This problem may not be severe at most schools, where students engage in project work for only a part of their time, but at our schools teachers wanted to achieve all learning goals through project work.

The solution for the difficulty of learning concepts can be to formulate a demanding set of specifications that students have to adhere to, as they make their product. When, as an example, students make a 'light and sound plan' for a theatre production, the teacher could tell them to use the decibel scale in their product. If these demands are formulated within the assignment the students are likely to be faced with an unattractive and incomprehensible worksheet.
Sometimes teachers resort to the solution of giving workshops when students need certain knowledge and skills. Student motivation for these workshops is often low, because they want to work on completing their product, rather than learning something new. (Van de Velde, 2004)

The four projects mentioned earlier all have the same structure: a basic part and a project part. At the start, the students are made familiar with the final task. At this stage the final task is formulated in a non-specific way, without any new concepts. A sense of curiosity is triggered and students are made aware of the fact that certain knowledge and skills are needed in order to complete the task. This knowledge and these skills are then learnt in the 'basic tasks'. These tasks are all formulated with a focus on the final task. After completing these basic tasks, students proceed to the final task, which is now enriched with the newly acquired concepts. This way the motivating aspects of project work are preserved, whereas in-depth learning of concepts and skills is ensured as much as possible.

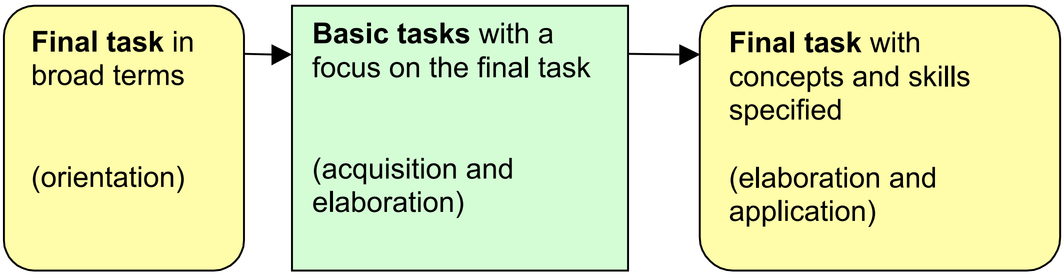


Figure 1. Didactical outline

2.1 The final task as formulated at the start
Let us first look at a few bits and pieces of the introductory text for students. (appendix 1)

This orientation helps students to understand what needs to be done during the upcoming lessons. To give the students an even better idea of the effort that is required, some excellent products and poor products of a previous class can be shown and discussed, with a focus on learning outcomes for the students who made them.

2.2 Basic tasks (Appendix 2)
It is clear from the introductory text that the alien needs very special ears. In one of the basic tasks the student is then given the opportunity to find out how a creature could hear ultrasound and how to determine where the sound comes from.

Enrichment in basic tasks
It is known that students who are given choices, work with more motivation than students who are doing compulsory tasks only. In regular science schoolbooks, the enrichment phase is often placed at the end of a chapter. Many teachers and students forget about these tasks after a while, because the chapter is finished anyway. We therefore chose to give all students the same project task, whereby outcomes can differ quite a lot.

Choices for different activities are therefore mostly situated during the phase of the basic tasks. A few enrichment tasks are situated near the end in order to give extra opportunities to students who are running ahead of schedule. Many enrichment opportunities are made available for teachers and students, all with the aim to produce a better end product. Teachers are encouraged to specify a minimum of tasks to be completed and to specify the different choices they want to give to their students. This can lead to a form of differentiation closely related to Bloom's Mastery Learning, in which units of work are followed up by diagnostic assessment. The assessment outcome consequently leads to either a remedial activity until the content is mastered, or an enrichment activity. Postlethwaite (1996)

A complete overview of all tasks within 'the alien' is given below.

		Basic outline	Enrichment
The Alien (30 hours)	Starting up	Introduction of project	
		Orientation: me and these tasks	
	Basic tasks	Hearing Basics: humans and animals	
		Smell Basics: humans and animals	Can you still smell the same odour after a while?
		Taste Basics: humans and animals	How good is your sense of taste, compared to other creatures?
		Vision Basics: humans and animals	Getting a sharp image: The difference between an octopus' eye and your own eye.
		Touch Basics	
	Project task	Design your own alien	- A design for alien body parts not related to the 5 senses - Let your alien travel to earth: What will he see on his journey?
	Reflection	Reflection: What have you done? What suits you and does that mean anything for your future?	

Webdidactics

In traditional schoolbooks, texts are the primary source of information. The most common sequence is to read the textbook and to answer a number of questions subsequently. In these teaching aids, the students start by reading a task. The student may then decide to grab a textbook for information or a different source. Sources made available include web based video clips, laboratory work as a means to find answers, specified web pages or search terms for the www. This last option is in fact much more durable than giving a specific URL. A well chosen search term still yields good results after many years, whereas URLs change from year to year, or even more often. It does take some time to find a proper combination of search terms that will lead students to a fine selection of sources. To our dismay we have found out, for instance, that even a simple term as 'taste' leads students straight to some rather distasteful websites (in Dutch, that is). The combination of 'taste buds' and 'bitter' on the other hand yields fine results.

Furthermore every piece of text is preceded by a question. This preceding question circumvents new concepts. It serves to evoke an interest in the subject matter and makes the material meaningful and coherent.

After completing the basic tasks, this knowledge needs to be applied by the students when they make the match between the design specifications as formulated by themselves, and their newly acquired knowledge and not in the least their creative aspirations.

2.3 The final task (Appendix 3)

Students who have finished the basic tasks are ready to design the alien. A small piece of the final task is given below.

The students are now ready to apply knowledge and skills learnt, by coming up with solutions for each requirement. Furthermore they are encouraged to be creative and to come up with a unique design. This of course is the fun part of it all. After completing their alien they are asked to present it to their peers. During this presentation they are supposed to legitimate their choices using as much of the concepts learnt as possible.

2.4 Student reflection (Appendix 4)
We started this article by explaining our ambition to promote 'technological literacy'. Students, however, do not always automatically relate concepts and skills to their own identity. Teachers need to help them to do that. One of the tasks to achieve such reflection is given below as an example.

3.0 Conclusion
Teachers who want to construct their own student projects do face some serious dilemmas. On the one hand they may wish to share responsibilities for learning outcomes with their students as much as possible. On the other hand they may wish to specify a number of learning outcomes before the students get to work. Our building block model firmly places the teacher in the role of authority to make those decisions. Teachers highly appreciated this flexibility, but we do feel the need for more in-depth research to stake our claims.

The reader of this article may notice similarities with Problem Based Learning (PBL) in the didactical design. However, if a teacher demands the completion of all basic tasks, we would hesitate to use this label. In PBL students actively identify learning issues and they do generate problem solving strategies themselves (Koszalka T. 2002). Teachers often find it hard to deal with the open ended character of PBL. In the material described, we tried to walk the middle ground in that respect. Teachers who are comfortable with PBL, have used the building blocks of our work in a different way. They gave their students the introduction and subsequently the project task. Students were then free to make their own plan and to make use of the basic tasks by choice. These teachers were quite comfortable with this option, but it must be stressed that they work at progressive schools, where student autonomy is considered even more important than elsewhere.

On the matter of technological literacy we gave some clues on how technology can be interwoven in subjects like the arts. One of the questions remaining is, to what extent science teachers will be adopting learning goals that are inherent to the concept of technological literacy. What was found to be appealing to teachers was in fact a design task that stresses creativity and knowledge of the natural sciences. Teaching 'production processes and procedures', for instance, is far more demanding with respect to technological expertise on the part of the teacher involved. It remains to be seen if and how such learning goals remain intact at these schools in the future. Students have shown great enthusiasm for the approach described, but again, more research is needed.

References
Kampen P. van, et al, 2004 *Teaching a Single Physics Module through Problem Based Learning in a Lecture Based Curriculum,* American Journal of Physics vol.72
Koszalka T. et al, 2002, *Designing Web-Based Science Lesson Plans That use Problem Based Learning to Inspire Middle-School Kids: KaAMS, Eric Digest 463752*
Ministry of education, 2007 *kerndoelen onderbouw VO,* available at http://www.minocw.nl/documenten/kerndoelen_onderbouwvo.pdf
Ploegmakers et al, 1994 *Techniek in de basisvorming*, Coutinho
Postlethwaite (1996) *Differentiated Science Teaching*, Open University Press
Van de Velde 2004*, Op weg naar algemeen vormend onderwijs in technologie,* Artevelde Hogeschool, Gent

Appendix 1, 2, 3 and 4 follow

The people who made King Kong 2005 were able to make such an awesome animation because they were able to combine technical skills with artistic skills and a lot of knowledge of biology.
You are going to design an alien! Universum Studios is developing a high budget movie in which your alien is going to be the star. Another team has already made a design for the planet where your alien lives on: Arulia. So you will be designing the 'Arulian'. You are free to use computer graphics, clay, paper, whatever your teacher allows you to. Have a small taste of 'Arulia' to get into the mood of that weird place in our universe, where your home baked creature will have to survive.

Arulia

Arulia is far away from our own solar system. We therefore refer to it as an '<u>exoplanet</u>' (underlined words contain hyperlinks to the www). A few hundred of these exoplanets are known to astronomers, but because of the distance we know very few details about them. This picture and the written description is an artist's impression.

Figure 2 An impression of Arulia

A human being would not survive on Arulia for very long. The weather conditions are arid and the environment is hostile for humans. The Arulian, however, is quite happy on his homeplanet. He eats green 'crickons' which are nasty looking small insects. Crickons hide in crevices and produce very short high pitched sounds, too high for us to hear. Red crickons also exist but those are highly toxic. Fortunately Arulians can see the difference.

These are a few of the things that you will have learnt after completing everything:

- How to make a design, using a professional method. This time the design is about an alien, but the method is suitable for designing cars, dresses, computer programmes, ……. Etc.
- How the human senses work and how they differ from animal senses: Your alien will need proper senses to survive, remember?
- How the arts are nowadays highly influenced by technology, and vice versa.
- What the universe looks like.

Appendix 1

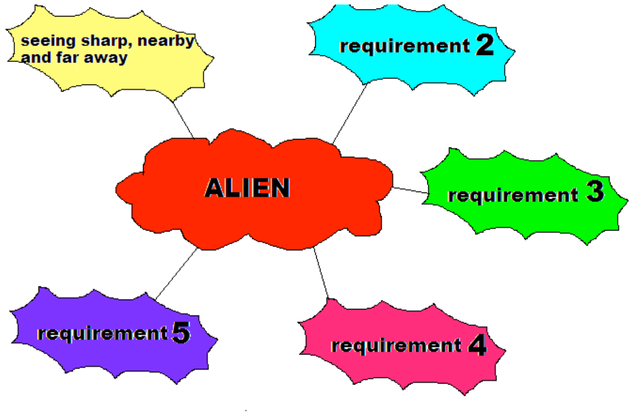
Appendix 2

Owl's ears

You now know a lot about the human ear, but will the human ear be good enough for your Arulian? Let's have a look at an animal with remarkable ears.
Did you know that an owl sitting high up a tree can hear a mouse moving around, underneath a thick cover of snow? Even better: the owl can determine its exact location. Explain why the owl is much better in determining the whereabouts of the mouse than humans are.

Search terms: owl hearing

Requirements
Before you make your alien, you want to know exactly what is required for it to survive. Read the description of Arulia very precisely now and make a diagram of everything that is required. Don't worry about the solutions yet. That will be the next phase. Look at the example, but please do choose your own style.



Appendix 3

Looking in the mirror
In this task you are going to look back on what you did and what you learnt. After doing so, you will take a glance at a possible future.

a) Does it suit me well?
Which of the activities below was most enjoyable for you? And which activities were least enjoyable? Put all activities in the right order.
Most enjoyable

- Finding creative solutions for a problem
- Learning a design method
- Conducting an experiment
- Learning how technology has an impact on the arts these days
- Learning how human beings depend on technology
- Learning about the human body
- Learning about animals
- Learning about outer space
- Explaining something to the other group members
- Doing some calculations
- Working alone
- Working together
- …………..

Least enjoyable
b) Jobs
Write a profession behind each item in the row above. It should be a profession in which that particular activity is carried out regularly.

c) Nice jobs and terrible jobs
Are the jobs you wrote behind the activities also arranged from most enjoyable to least enjoyable? Probably not. An activity may suit you well, but the job in which it is carried out may not be attractive to you at all. Write a short explanation about this. If you wish, you may use the 'starter' below.

I rather liked the activity ………………………… It is carried out a lot in the job…………..
Nevertheless I don't see myself choosing that job in the future because ………………….

I dind't particularly like to …………………… That activity is carried out a lot in the job ……………………. I could still choose that job however, because ………………………………..

The Alien project is now finished. Perhaps you have a test coming up. Good luck in that case! Hopefully you are keen to dive into a number of topics a bit deeper next time.

Systems in shade of the artefact
Content foci of “a systems approach” – an analysis of six national curriculae or guidelines for technology

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Introduction
We all use technological systems in our daily lives. We are also, in a socio-technological perspective, parts or actors in these systems, and most of us would agree on that the world becomes increasingly systemic.
Several national curricula or guidelines mention “technological systems”, “products and systems”, “systems and environments” or similar combinations, thereby showing an intention that the performed curriculum ought to include teaching focussing on technological systems. What are the main educational ideas relating to education about technological systems? How are these expressed? What shall students learn, and why?

Traditionally technology education has focussed on the production of artefacts – including materials, methods, structures and functions – and very little effort has been put into teaching, learning and understanding technological systems in schools. This also applies for the field of technology educational research, although some findings can be made. Williams argues that students should be encouraged to develop a wide range of process based skills.[1] He proposes “a systems approach” as one of five central “processes in which students are engaged when they do technology”[2] together with design, problem solving, invention and manufacturing. In his study of of six countries technology curricula Rasinen outlines ten significant contents, one of which is “the systems and structures of technology”.[3]
Although the rhetoric level on technology curriculum comprises a concordant argumentation for a shift from the heritage of industrial arts, its vocational base and its tool skills into a more problem solving compulsary general education, based on a broader definition of technology[4], recent international research report slow progress in turning technology education into new desired directions.[5]
How are then the concepts relating to technological systems percieved and undertood as educational ideas? Is the construction of artefacts during technology lessons only aiming at the “designing, making and appraisal” of a healthy sandwich, a mechanical puppy or a computer stitched embroidery? Or does this new, general, holistic view on technology education really bring a different value to what Givens and Barlex state:

> Designing and making engages students with thinking about the made world and how they might intervene to change it.[6]

This article surveys and analyses six different nations’ curricula or guidelines for technologically based school subjects. The overarching aim is to elucidate different meanings linked to educational ideas on teaching towards a deeper student understanding of a technological systems approach. A

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[1] Williams, 2000.
[2] Ibid. pp. 53.
[3] Rasinen, 2003., s 45.
[4] Cf. Jones, 2003;McRobbie; Ginns and Stein, 2000;Seeman, 2003.
[5] Cf. Sanders, 2001;Stevenson, 2004.
[6] Givens and Barlex, 2001., p. 137.

second aim is to provide international perspectives to the reading of the Swedish national syllabus for the subject *Teknik* as a part of the compulsory school system.
In the four page short Swedish statutory syllabus for the subject *Teknik* five different perspectives and central question areas characterising the study in *Teknik* are put forward (in parallel to Williams). Four of them focus on "Development", "What technology does", "Construction and operation" and "Technology, nature and society". The fifth concerns "Components and systems":

> Objects with technical functions linked to each other in different ways are almost always components in larger systems. Examples of large systems are networks transporting goods, energy or information, whilst carriages, power cables and computers are components in these systems. Sometimes it is also meaningful to define sub-systems, i.e. intermediate levels in a hierarchical system. By studying individual technological solutions and their incorporation into larger systems, pupils can obtain important insights into the special character and conditions of technology. (p. 97)

Selection
There are always difficulties in studying different countries curriculae. First, school systems are not equally designed. Second, the subject structures range from traditional academic models to more thematic or cross disciplinary learning areas. Third, we have a diversity of guidelines and statutory curricula with a span from syllabus detailed "Lehrplan"-models (e.g. England and New Zeeland) to aim stating "standards"-type (e.g. Sweden, USA, the Netherlands and Scotland) – minding that these categories are not static. Fourth, the technological intensive parts of different countries national curricula or guidelines are labelled in numerous ways. In this study the curriculum character is not a discriminating factor. The multitude of variation is rather a strength in respect to the outcomes of this survey – it is not a comparative study in that sense. The chosen texts for this study can be categorised as Official documents/Curriculum planned and developed by the state or nation, comprising statements on several curricular levels – content level, regulation level, subject level, and intern and extern operational level.[7]
The selected documents represent countries with a developed culture of both technology education and technology education research. However, choosing a range of documents only spanning English speaking countries or documents translated into English is a dilemma for the study, and most certainly leaves out interesting input from other countries and traditions.
The official national curricula or guidelines used in this study are:

USA
Standards for Technological Literacy. Content for the Study of Technology (2000)[8]

Holland
Attainment targets for primary education, 1998-2003[9]
Attainment targets for basic secondary education, 1998-2003[10]

Skottland
Environmental studies; Society, science and Technology; 5-14 National Guidelines, 2000[11]

Nya Zealand
Technology in the New Zealand Curriculum, 1995[12]

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[7] From: Berg, 2003., with reference to Goodlad and Glatthorn.
[8] Technology for All Americans Project and ITEA, 2000.
[9] the Dutch Ministry of Education, 1998-2003b.
[10] the Dutch Ministry of Education, 1998-2003a.
[11] Scottish Consultative Council on the Curriculum, 1999.
[12] New Zealand. Ministry of Education, 1995.

England
Design and Technology in the National Curriculum, 2005[13]

Sweden
National Syllabus for the Technology Subject[14]

Theoretical stance
Roberts and Östman has, within the field of science education research, developed and used the concept of three *companion meanings* in educational texts: curriculum emphasis, nature language and content focus.[15]
In the present study companion meanings are discursive tools used to describe how different ideas are parts of a sedimentation process within the technology subject, especially concerning technological systems. A *content focus* indicates what is seen as important to offer education about, what students are supposed to learn. The *system languages* concern the technological vocabulary and how it is used to bring meaning to the construction, analysis and description of technological systems through the use of central concepts and their context. A *curriculum emphasis* says something about why students ought to learn this or that about systems and the objectives, strategies and rationalities behind. This paper concentrates on the findings of different *content foci* concerning technological systems.

One assumption for this study has been that it would be impossible to identify the curricular parts dealing with education relating to technological systems without having an understanding of how to think about technological systems. In the study philosophies of technology and systems theories have been used as a theoretical lens.[16]
It would be bold to here suggest an ontological definition of *a technological system*. However, there are some significants to the concept of *a technological system* in the literature, and I will here give a brief description how these emerged as tools for the reading of the official documents. I here leave the debate on the ontology of technological systems and concentrate on the more epistemological dimensions – how can we think about systems? What are the characteristics of the concept *a technological system*? This has been vital to the study and needs to be declared, I think.
The first, and maybe most well known, definition of *a system* is that it exceeds the sum of its parts. A system needs *components, connections* and *interaction* between them. These can not be arbitrarily chosen, but should be defined from the idea that they form some sort of interesting whole. This, in turn, demands a system *border* and a *surrounding* to be determined in each case. The surrounding is important to the system. It can not be controlled by the system, but in most cases there is a flux of information, energy and material through the system depending on its openness or closedness. Here the existence of feedback loops is another characteristic. One central idea to *systems thinking* is that it offers an alternative to traditional Newtonian scientific reductionism, and later atomism, by challenging the thought that a phenomenon (in this case a system) can be understood and predicted by examining the properties of a component (on a lower systems level) – changing a part of the system affects the whole system – e.g. we can not put questions to or understand the road transport system while studying the car alone. There may also be emergent properties appearing on a higher systems level. The structure, function and behaviour of the system are interesting properties as are their varying complexity and dynamics.[17]

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[13] Great Britain. Department for Education and Employment. and Qualifications and Curriculum Authority (Great Britain), 1999.
[14] The Swedish National Agency for Education, 2001.
[15] Roberts, 1982;Östman, 1995;Östman, 1998.
[16] E.g. Bertalanffy, 1973;Churchman, 1979;Hughes, 1988;Ingelstam, 2002;Mitcham, 1994;Wiener, 1954;Winner, 1977.
[17] For an parallel, interesting and more ontological debate concerning structure and function on "the artefact level" see Kroes and Meijers, 2002., and following articles by e.g. Hansson and Mitcham in the same issue.

Before presenting the significants used for the study of the texts another question must be raised: how do we discriminate a technological system from e.g. a political, an economical, a biological or a juridical system? Some guidance can be found in literature:

One way to define a technological system is to start out from a *technical core* – the tangibly constructed (which within its construction carries what we would call the technological intention), e.g. the cars, roads, signs, petrol stations etc. Another way proposed is to follow *the system builders* to describe the establishment, expansion and stagnation of large technological systems in a *socio-technical* and *historical* perspective. A third way is to focus on the system's *technological function* (e.g. transporting, storing, controlling or transforming) as the central factor for system definition. Yet other ways are to start out from *technological principles* (like electrical, hydraulical, pneumatical, mechanical or chemical), or from the *general construction* of the system (a physical, a biological/natural or an informational system). Lastly the system definition can emanate from the following of a (natural) *resource* through a chain of production or refinement (like a wheat axe or petroleum).

I do not claim these different ways to be exhaustive, but they seem to cover a large area of possibilities. They can of course be combined in order to direct our interest and help us to outline a systems border. Most of all, however, they indicate that a technological system above all is a mental construct, even if we all would agree that a modern sewing machine is a technological system, and so is a house when we look at its heating. Nevertheless this has to be established in order to proceed with analysis and construction. We thus use a systems approach.

Out of this understanding of how we can think about technological systems, eleven clusters of *significants* were used as tools for the reading. These were:

- components/subsystems/hierarchies
- connections/wholeness
- systems border/surrounding
- relative isolation (openness/closedness) in respect to a surrounding
- control/feedback/flow of information
- system functions (black boxing)
- complexity/scale
- dynamics
- technical core
- socioconstructivistic/sociotechnological perspectives
- conditions for production/innovation systems

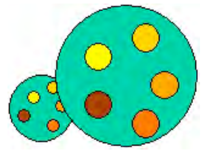
Method
A qualitative text analysis method was chosen where texts are systematically analysed through a theoretically oriented exploration, based on the system aspects above and the theories on companion meanings. The aim is to clarify educational and functional ideas concerning "a systems approach" in respect to how different meanings can be found in the curricular documents as different content foci, systems languages and curriculum emphasis regarding education about technological systems. The method does not only recognise text as a source for the obvious; the manifest ideas. Also what is not written, and thereby excluded, express an idea.[18]

Results
As a result of the analysis five different *content foci* concerning technological systems appear in the curricular texts studied. These are main categories of prescribed educational content relating to – or presented as – ideas of what pupils should learn, how to reach this knowledge and what kind of instruction could be used. Some of these *content foci* have sub-categories. I will here only give brief

[18] Roberts, 1982., p. 245.

descriptions. Quotes are used only to exemplify how these foci show in the texts. Each focus is presented together with a small graphical icon.

Scale/Complexity



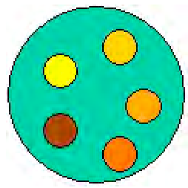
Education focussing on scale/complexity

This first content focus leads the educational concern in two directions: the scale of the system and its complexity. Teachers and students are expected to investigate this complicated relation. It also points towards the problem of finding fruitful examples of technological systems and how to define them in terms of systems borders and surroundings. In the Swedish syllabus complexity is mentioned in the grading criteria for year 9:

> The student describe, on basis of own explorations, in certain detail even the construction and function of more complex devices, where the structural ideas are not obvious.[19]

Two observations can be made throughout the six national documents. Firstly, scale seems dominant in respect to complexity, and grades of complexity are seldom discussed. The systems examples used are most frequently "products" that can be held in a hand, carried or at least be visually covered, even if larger systems like the Internet or a transport system are occasionally mentioned. Secondly, a higher degree of complexity often means that a system's socio-technological dimension is used when defining the system, predominantly to include actors and link the system analysis to production and economical considerations, alternatively to link it to exchange over the systems border and how the system affects the surrounding (environment).
The link between student's understanding of system complexity and the representation of a system's physical and conceptual characteristics in a scale model or a simulation context is a part of this focus.

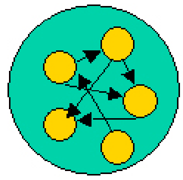
Systems as a collection of components



Education focussing on the components

This *content focus* draws on manufacturing and design, the assembly, joining and combining of components to construct something, rather than being concerned with questions about what the system might be and how the components might interact with each other. The stance of the focus is from the horizon of the components, rather than the system itself. A system is here treated, not as more than the sum of its components, but as the sum – a collection of components. Higher system levels become obscured.
Several examples are found in the curricular documents where subsystems are studied and when the difference between a component and a subsystem is not clear in relation to the intended finish of the process – are we designing a product or a system? Defining the system's border does not seem important and the set of components can sometimes be arbitrarily chosen – e.g. the study of a computer and what it can do as a part of the Internet or of a LAN, without mentioning routers or the language computers use to talk to each other.

Relations between components



Education focussing on the relation between components

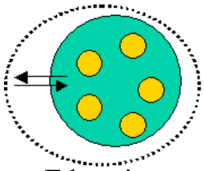
This content focus has two main lines – one connects to information exchange, mainly in electronic but also in hydraulic and pneumatic systems (and combinations), the other is more concerned with the epistemological question "how can we understand a system?". It also balances between "a systems approach" and a touch of atomism, exemplified by statements as "Many times, the

[19] My own translation, since the grading criteria is not yet translated into English by the Nation Education. (Skolverket, 2000.)

best ways to determine what is happening in a system is to take it apart." [20]. Although knowing the relationships between components is vital to system understanding, there might be a tendency so seek explanations further and further down the hierarchy, thereby risking not paying attention to the relations between components or the overarching function of the system itself.
The construction and control of a system by means of its components are the main educational aims in this content focus. The vocabulary attached to this focus is dominated by concepts from control engineering, e.g. input, output, feedback, loop, process, switch, and sensor. If larger technological systems like a power system or a production plant are studied, these are still the concepts used.

Interaction with the surrounding

Viewing technology as increasingly systemic and technology's relation to society as problematic, this focus point out *society* as some kind of surrounding. On the other hand also *nature*, as an environment, seems to be considered a relatively diffuse surrounding. *Surrounding* is a problematic concept; it is often used synonymously with *environment*, which in turn has its own more or less divergent connotations.
Here three interconnected sub foci crystallize, directing the attention towards the system's interaction with its surrounding.



Education focussing on interaction with a surrounding

One way action

How a complex and systemic technology affect its surrounding – seen as the individual human being, the society or the nature at large – is a relatively widespread focus. But what character the influence has is seldom obvious. One passage in the English document can be used as an example. Under the title "Assessing processes and products" for both KS 3 and 4 formulations can be found pointing at students assessment of "…the environmental impact of products…"[21]. Similar statements can be found in the other documents.

Reciprocal action

Human intentions and expectations together with natural or technological conditions or restrictions constitute the background to this content sub focus. As an example the Netherlands writes under "Technology and society", subtitled "Daily life", that the students should be able to

- indicate certain fundamental technological developments and the positive and negative influences of such developments on daily life;
- explain and give examples of the way people and situations can influence the development of new products;[22]

Looking at technological systems' interactive relationship to their surrounding, the surrounding is more often the society or the nature, and less often the made world or the technology itself. Again, the way in which the interaction can be characterized or carried through is not obvious to the reader of any of the curricular documents. If anything, the criteria and constraints of the production of a system (as a complex product) are regarded as delimitations of the possible system.

Socio-technological perspective

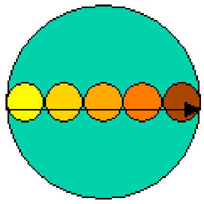
Following the previously chiselled sub foci, several of the curricular documents highlight technological systems as constructed in a social context through subtitling like e.g. "Technology and Society". One impression is that most of the documents embrace a non-deterministic attitude towards technological development. There is, however, a tendency of ambivalence to the question concerning the system border, whether the system refers to the whole society or the whole world, and if man is

[20] Technology for All Americans Project. and ITEA, 1996., p 19.
[21] Great Britain. Department for Education and Employment. and Qualifications and Curriculum Authority (Great Britain), 1999.
[22] the Dutch Ministry of Education, 1998-2003a.

outside the system border or an important component within (e.g. a medical system or the car we travel in).

Production

An often used content focus is the study of the sequence "from raw material to finished product". This is previously touched as a part of the students' production processes, but this time it more concerns the industrial aspects. It is a more or less outspoken rationale behind the different national Technology curricula to provide the counties with an economically and industrially competitive workforce. This is also shown in the choices of educational contexts for the study of technological systems – chemical, electronic or food industry etc. Central concepts for this focus is optimising and trade-offs, viewing a connection between technological capacities or literacy and the finishing of a well designed product – or system!



Education focussing on production

Discussion

The *content foci* parts concerning technological systems are results of the analysis, but the presentation here is neither excluding, nor claiming to be exhaustive. They are aspects of systems approaches which guide the thoughts of what possibilities we have with technology education, as seen from a curricular perspective. Behind these manifest propositions lie ideotypical conceptions and some results can only be briefly discussed here. To a broad extent the content foci include all of the *significants*, although the relation to system theories is not distinct. When it comes to describing the educational content, it seems both decisive and hard finding effective and successful ways to define and delimit systems towards a thought surrounding. Only two *content foci* really operate with the system border and function on a system level: *scale/complexity* and *interaction with the surrounding*. The system's surrounding is mostly seen as parts of the social and natural world, more seldom the made world.

Technological systems c*ontent foci* have been found at all curricular levels – like targets, suggestions for instruction, strategies for co-operation with other subjects or institutions etc. – and not only as titles or subtitles. This is considered as a sign that the study of technological systems is holding a strong position, at least on the formulation arena. The five *content foci* are not equally distributed in the curricular texts, and probably not equally used in classroom practice. This is, however, an empirical question to be further investigated.The made world is to a large extent systemic, and I think a shift in technology education towards a *critical* systems approach would help making the made world understandable to our students.[23] This is a democratic question. By reflecting over what *content foci* we use (and what *systems languages* and *curriculum emphases* we adopt) we might develop both the curricular level and our classroom practice. In that perspective the prevalent strong focus on the design and production of artefacts in technology education could benefit from the complementary use of a broad systems approach. Otherwise the technological systems will still be in the shade of the artefacts.

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[23] Compare to Petrinas' critical technological literacy: Petrina, 2000.

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Digital democracy – A new role for technology education?

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Abstract
This paper outlines a consideration for the future development of technology education. Throughout history various grand narratives have impacted on technology education. In the current post modern era of globalization, technology education continues to struggle for relevance and definition, and takes various forms in different countries, but none seem resoundingly successful. The current development of what some have termed a digital democracy (Web 2.0) provides a relevant context to which technology education could address itself.

Introduction
The relationship between technology and democracy has varied over time. When technologies first developed, accompanying the genesis of civilization as we know it, simple technologies enabled the development of communal democracy. The use of simple tools permitted challenges to existing power structures by enabling those with the technology to exercise their new-found power. Later, increased mobility extended relationships once limited to the family and the tribe into broader communities. This geographic extension of influence spread democratization influences by further challenging power structures.

Throughout different periods of time, technology has both facilitated the development of democracy and has been an impediment to democracy, and this equally applies today. It could be argued, as does Sclove (1995), that the power vested in the technological elite
by the technologies that they control, such as gasoline-powered automobiles, undermines any grassroots based democratic movements that may develop in opposition to their interests. Such technologies inhibit participation in significant decision making and define social orders that constrain self actualization and support illegitimate hierarchies. On the other hand, some technologies are the means of constituting democratic forms of power sharing, such as broadly accessible web based technologies with international and pervasive distribution networks which enable individuals and groups to have a voice and for the voice to count.

Technology Education
In the context of technology education, forms of rationalism could be explicated in a number of ways. During colonial times, the modernist approach could be characterized by the representation of technology education as modern woodwork and metalwork, regardless of significant indigenous technologies related to construction (thatch and mudbrick) or hunting or food preservation or appropriate agricultural technologies. This type of rationalist approach was clearly related to notions of progress, and the determination of a single path toward what was clearly a western conception of progress which had resulted in the superiority of the north (Ullrich, 1993). To this end, the imposed technologies represented anti-democratic forces and were utilized to embed power with the colonizers.

The emergence of rationalist knowledge as an aspect of globalization (Castells, 1998) clashes with the developing postmodern notion of cultural respect and regional independence. As a counterpoint to this force, van Wyk (2002) proposes Indigenous (Technological) Knowledge Systems (IKS) as a framework within which diverse learners may construct knowledge from multiple perspectives which are meaningful to them. Van Wyk presents IKS as a critical framework rather than a term with definitive meaning, which seeks to be inclusive and transformative. It is significant that this thinking about knowledge frameworks emanates from a South Africa which is struggling to develop relevant and democratic forms of knowledge in response to many years in which technologies (and technology education) were a weapon in the armoury of totalitarian apartheid. This focus is supported by Keirl

(2003) in his call for technology education to adopt a critical and creational approach to knowledge development, placing students at the centre of learning and so provide the opportunity to refute what is perceived to be the undesirable aspects of globalization.

A continuing phenomena which may seem inconsistent in a postmodern international education environment is the existence of international curriculum organizations, which, by their very role, imply that there is a universal curriculum applicable to all regardless of national or regional culture or history. International curricula are in some ways the educational equivalent of multi national globalization through their ignorance of the local and the homogenization of cultural values.

As Schostak (2000: 48) argued 'there can be no grand narrative concerning what is good for all. Standardization to create the curriculum is patently absurd in a context of change that is so fast, so diverse and so technologically and culturally creative'. A global curriculum would seem to align more with a colonial than postmodern environment through the promotion of totalizing forms of western knowledge. Even worse (author's bias) is that the recipients pay a significant amount of money for the curriculum, often from a national or school budget which is invariably stretched. Those who can afford the significant costs of adopting an internationally recognized curriculum are often those who least need it as a tool of development and an entré into international educational equivalence.

However, the adoption of international curriculum is rapidly increasing around the globe. The International Baccalaureate is expanding at the rate of about 14% annually. The main reasons for this are directly related to globalization. The forces of globalization encourage the acquisition of educational qualifications that are internationally acceptable. Allied with this is a developing mistrust of locally developed educational curriculum, particularly in the USA. These forces conspire against both a postmodern critique of global developments and a valuing of local culture.

Recent Trends in Technology Education

Very few of the current national and international grand themes of technology education are indisputably successful. A focus on the development of Technological Literacy is probably the most widely touted broad goal of technology education. A part of the rationale for the goal of Technological Literacy is an attempt to attract equitable treatment for technology education alongside the other school literacies of reading, writing and mathematics (Seeman and Talbot, 1995; Williams, 2005). Very little progress has been made in moving toward equity of learning areas, reflected for example in the introduction in Australia of national testing (in a state-based educational system) of students in literacy and numeracy, and the 'No Child Left Behind' Act in the US which also focussed on reading and maths. Even in the UK, where rather than focus on technology as a literacy of equivalent importance, research was conducted on how the study of technology could enhance the core curriculum elements of literacy and numeracy (Stables, Rogers, Kelly and Fokias, 2001), implicitly relegating the place of technology as a means to another end rather than an end in itself.

To a certain extent the US has lead the way in the articulation of the goal of technological literacy with the development of the Standards for Technological Literacy (ITEA, 2000) and associated publications. However, in the US, a reasonable time frame to permit the implementation of these standards has been usurped by a change in direction and a focus on Engineering as the organizational structure for technology education, to the extent that the professional association is now contributing to the development of K-12 Engineering Standards, and many universities, secondary and some elementary schools are implementing engineering programs.

South Africa has developed a national Technology Education curriculum with a social reconstructivist approach that was scheduled to be implemented in 2006. It has technological literacy as its overarching goal for students, and contains some innovative and unique elements such as 'appropriate indigenous technologies' as one of the content areas. However, largely due to the apartheid policies during the history of South Africa, many rural schools have very few resources and it will take many years before all schools enjoy a basic level of technology resources and equipment.

Similarly, China and India are in the process of developing, trialling and implementing a national technology education curriculum. The challenges facing the curriculum developers in these countries are enormous. Not only is there no widespread educational history of technology as a school learning area, and so no school infrastructure or equipment, teachers, and support material; but with over 1 billion people in each country, change takes place very slowly.

England has a multi-faceted approach toward Design and Technology with food, ICT, CAD-CAM and electronics all receiving attention with resources and teacher support material. Recently a number of reports (Design Council, 2006) and some research has had a focus on design and creativity, a duality that is vital given the largely instrumental focus of support for design education. The stimulus for the focus on design has been an attempt to ensure the performance of business and industry rather than a concern for the development of individual students, hence the significance of the accompanying creativity, which does focus on the individual. Despite this comprehensive approach to development, design and technology was recently down graded to a non-compulsory area of the curriculum.

New Zealand is currently undergoing a curriculum review in all learning areas. In Technology, after the first formal curriculum in 1995, the review is focussing on moving away from a conception of technological literacy that is embedded in practice, to one which is equally focussed on understanding the philosophy of technology and developing technological knowledge. The two proposed new strands of ‘Nature of Technology’ and ‘Technological Practice’ replace the former strands of ‘Technological Capability’ and ‘Technology and Society’, with the Technological Knowledge Strand remaining.

In Australia, the birth of contemporary technology education can be traced to the nationally agreed declaration of eight essential learning areas in 1989, one of which was technology. Since then all the educationally independent states have developed technology curriculum, and consequently undergone curriculum revisions. The state approaches to technology vary from traditional to radical. In the latest round of revisions Victoria, one of the states, has reorganized the learning areas to eliminate technology as an independent area. In a context of teacher shortages and scarce resources, this development is seen to potentially set a negative precedent for other states.

So it seems that few national or state approaches to technology education are sustainably successful. Technological literacy as the goal of technology education has appeal because it is multidimensional – it can be related to national economic performance of a literate workforce, it relates to an individual’s level of literacy with the implicit assumption that this will be personally more satisfying, and it can be used to relate to social responsibility in the context of a technological society. Maybe such multidimensionality is problematic in that striving to be all things to all people represents an unachievably broad focus.

An additional more personal critique comes to mind in the context of a generation of young people who are growing up with a familiarity of communication technology unfamiliar to previous generations. In an attempt to classify them, they have been labelled ‘Generation Y’ and born in the 1980’s and 1990’s. Of course such labels are fraught, and there are many variations in terminology and parameters in an attempt to demarcate such demographics, including the Net Generation, Millennials, iGeneration, Digital Natives and MyPods (fusion of MySpace and iPod).

For the purposes of this discussion, a number of the characteristics of Generation Y are relevant as one group of students for whom technology education curricula is being designed, and in an admittedly stereotypical sense, being designed by ‘Baby Boomers’ of a different generation. It is possible that a significant dysfunction arises in curricula that has been designed by Baby Boomers, for the Y Generation. It has been maybe 40 years since there was a real generation gap, when the ‘jungle rhythms' of rock'n'roll merged into the flower power gained from easy sex and drugs. Some see the current school age Digital Natives as the representation of a generation gap between their teachers where the relevant question becomes 'How do we empower and protect our students in an environment that increasingly excludes us?' (McLester, 2007). The existence of this gap is reinforced in the report: *The Digital Disconnect: The widening gap between Internet-savvy students and their schools* (Arafeh & Levin, 2003) in which students reported a significant disconnect between their use of the internet in and out of school.

In the last few years a new set of values have arisen, resulting in a barrier between generations. This generation (Y) was the first to witness and use a broad range of technologies from an early age: the internet and broadband, digital cable, cell phones, HDTV, digital cameras, digital pets, camera phones, social networking, GPS, online gaming and touch screens. Of course other generations use these technologies, but they did not grow up with it and integrate it into their lifestyle to such an extent.

Until these developments, much modern technology mitigated against the opportunity to democratically engage in civic life and its associated politics (and of course still does): shopping malls, spreading suburbia, automobilization and a vast array of home entertainment options, for example. While they may continue to work against the democratic sharing of power, they do not preclude it, and in the face of a more powerful range of technologies, exercise diminishing influence.

A New Direction

I would like to suggest the consideration of a more focussed approach to the goal of technology education. This came to me when I realized I was awarded TIME magazine's Person of the Year for 2006. The rationale for this decision was the great power that I have to contribute to democracy and to shape the future, and the evidence that I have provided over the past few years of this potential. The medium for this power has been dubbed Web 2.0, the people version of the World Wide Web, relegating Web 1.0 as the paper version.

The initial promotion of the term Web 2.0 is generally ascribed to O'Reilly (2004) and refers to a perceived second generation of Web-based services which are characterized by open communication, decentralization of authority, freedom to share and re-use, user's ownership of data and an effectiveness that develops as more people use them.

I both learn from and contribute to Web 2.0, whereas I could only learn from Web 1.0 – it was only the experts who could contribute. I now review books on Amazon.com, I blogg on about political candidates and have an effect; I podcast things I am interested in to absorb them later at my leisure; I participate interactively in car design competitions; I make movies on my phone and a week later 100,000 people have viewed them; if I am in the right spot at the right time I can film a paparazzi's dream and distribute it myself; I have my research available in the world's largest encyclopaedia without having to worry about peer reviews. I have seized the reins of the global media and founded the new digital democracy, I have beaten the professionals at their own game (Grossman, 2006).

Journalists feel usurped by what I am able to do with my blogging, and scholars suspect the authenticity of my research in Wikipedia. I am an amateur and now have the means to challenge the professionals, who of course decry my new-found power as the end of quality and professionalism.

My means include LiveJournal and MySpace, Wikipedia, LastFM, Netflix, Facebook and del.icio.us, Flickr and outside.in. But YouTube is probably the most significant means I have, and it is not just one medium, but several in one. As Poniewozik (2006) explains, it is:

- A surveillance system – millions of people, through their mobile phones, have the power to quickly and easily send any happenstance image around the world, from the London train bombing to celebrities in unguarded moments and politicians in compromising positions.

- A spotlight – users have the capacity to find significance in events that the mainstream media may ignore. Programs and advertisements made for TV have been rejected and then reborn after being uploaded to YouTube.
- A microscope – while TV news is constrained by budgets and time, not so YouTube. Extreme close up video diaries from Iraq, Israel and Lebanon convey the confusion, humanity and reality of war zones.
- A soapbox – anyone's ideas can spread instantly, cheaply, democratically and anarchically.

Even if technology education is addressed only to the development of technological literacy, then this phenomenon of digital democracy must be a part of it. But I think it should be more than that: it can provide the basis for a student centred approach to technology education that would not only equip students with the skills to participate, but provide them with the technological understanding they need in order to be able to participate in an ethical, socially responsible and informed manner.

There is some danger in promoting this approach. Williams (2006) warns that participation in Web 2.0 is simply a celebration of self, a narcissistic infatuation. It is now possible to go about your day and consume only what you wish to see and hear, '…television networks that already agree with your views, iPods that only play music you know you like, Internet programs ready to filter out all but the news you want to hear' (Williams, 2006). The problem with this is that there is a lot of information that individuals in an informed democracy need to know, with the consequent danger that '… we miss the next great book or the next great idea, or that we fail to meet the next great challenge … because we are too busy celebrating ourselves and listening to the same tune we already know by heart' (Williams, 2006).

One could respond by questioning the basis of 'need to know', and whether individuals actually have the resources and power to decide and then access what it is that they need to know, or whether the current media organizations make those kinds of important decisions. In the latter scenario in which the quality of 'newsworthy' is ascribed by media organizations, the individual power to bypass these business decisions and access information that 'feels' relevant and important through the Web 2.0 system of opportunities would place the individual in a powerful, self determining position. Generally, that assumption of power is accompanied by a level of responsibility, and unless the responsibility is felt and active, the possession of power wanes. For example in the influential areas of politics, education or the media, irresponsibility results in implications at the ballot box, in tenure or in ratings. However, in the case of the power that accompanies participation in Web 2.0, responsibility can be abused without the loss of power. Fiction can parade as fact, respect for others is not an assumption, character assassinations are tolerated and the unimportant is promoted.

Developing fundamentalist groups from neo-Nazis to al-Qaeda provide all too imminent evidence of the negative aspects of the democratization of communication technologies.
The global counterpoints proposed by Barber in 1992, prior to the recognition of Web 2.0, provide an exemplar of opposing tendencies related to democracy, power and responsibility. In 'Jihad vs McWorld' he explains these forces as having '… equal strength in opposite directions, one driven by parochial hatreds, the other by universalizing markets, the one re-creating ancient subnational and ethnic borders from within, the other making national borders porous from without. They have one thing in common: neither offers much hope to citizens looking for practical ways to govern themselves democratically'. Both these forces have found an affinity in Web 2.0; a clear indication that its use is diverse, and that an ethically based technological literacy is an important prerequisite for participation. So, given that entrée into this electronic participatory democracy is freely available, and there is no system of checks and balances on the power that is derived from participation, a question arises as to the development of responsibility.

A technology education approach that addresses the development of technological responsibility through a democratic information-technology medium (Web 2.0) would be an appropriate focus for technology education. It is not a radical departure from the goal of technological literacy or creative and innovative design, but more a recognition of the dynamism of both the process and the content of technology. The increase in the power of the individual that accompanies Web 2.0 and the consequent increase in responsibility provides a context for a renewed focus in technology education on the social and ethical nature of technology.

The psychology of 'thinking and doing' as the mode of learning in technology education resonates with the interactivity of Web 2.0. The web based resources available provide stimulus for both developing ideas and doing something with those ideas. For example one of my assessment tasks for students is to have them develop a digital representation of the essence of design and technology education. After developing a statement of this essence, they do something with those ideas by searching for and developing a series of digital representations. Having collected the representations they consider how they can be best utilized to represent their statement. They then act again on their ideas and iterate through that process until they have a digital representation with which they are satisfied. They then post that on YouTube[1] and use that platform as the structure for a round of peer assessment. Any YouTube comments that are made about their movie are included in their final portfolio.

A postmodern and enquiry based narrative of technology, which pays mutual attention to both the local context and impinging global developments would seem to provide an appropriate framework for the development of technology education. A personal relevance type of curriculum design may be the most appropriate in this context. It is based on humanistic theory and so the emphasis is consequently on personal growth, integrity, autonomy and uniqueness. The goal of such a curriculum is to produce a self actualizing, autonomous, authentic, healthy happy person (Petrina, 1992) through an integrated focus on the cognitive, affective and psychomotor areas of development.

McNeil (1981) isolates a number of concepts which form an essential basis for personal relevance curriculum design:
1. All individuals participate in the curricular and learning processes.
2. There is integration of the material being learnt and integration in the humanistic approach taken.
3. The subject matter is emotionally and intellectually relevant to the participants.
4. The person is the object of the learning.
5. The goal is to develop the whole person within a social/technological context.

A humanistic approach to technology is appropriate in this context given its integrative potential and the individually autonomatic balance it provides to the potentially deterministic forces of technology. Children's feelings and morality about technology have a significantly higher level of potency when they are channelled through the mechanisms which have become Web 2.0. Specific teaching techniques are implied in this approach to curriculum. They would be those which encourage planning and spontaneity, expression, insight, and reflective thought. Students can access data from a broad range of sources and work in teams to collaboratively produce at a distance. The notion that education only occurs at school can be broadened in the sense that students can engage in design and technology processes from a broad range of locations.

Relevant content knowledge in technology is defined as that which is needed in order to progress a student's thinking and action toward resolution of a problem. The source of content then is determined by its relevance to the individual student's environment and their immediate concerns. In the context of Web 2.0 students are able to locate, organize and evaluate information from a broad range of sources and so are more likely to access information appropriate to a specific task.

With the incorporation of Web 2.0 resources, learning in technology could more easily be organized with an emphasis on unity and integration, for example organized in themes rather than discrete material or process oriented subjects. Learning can more easily encompass deeper cultural understandings and global awareness through unmediated contacts with individuals and groups in other cultures and countries.

Students can more easily be exposed to technological processes with which they may not usually come in contact. For example the remote observation and control of rapid prototyping processes such as stereo lithography will broaden students comprehension of tangible and virtual technologies.

The basis of the learning process is more amenable to authentic problems and significant questions due to the ease of research and communication available. The collection of relevant data and the use of multiple processes to explore alternatives is readily available to students.

Throughout the processes of designing and making, opportunities are presented to focus on responsible citizenship aspects of technological literacy through the safe and responsible use of information and a positive attitude toward technologies that support collaboration and learning.So this scenario involves utilizing, as another tool, the technologies of Web 2.0 in designing and making processes in order to maintain a relevant and responsible type of technological literacy as the ultimate goal of technology education.

Conlcusion

Technology is of course not the only factor determining the efficacy of a participatory democracy, either through impairing it or facilitating it; there are many others well beyond the influence of schooling. Elements of the argument of this paper, that one focus of technology education in a postmodern age should include a preparation for engagement in a participatory democracy may be contestable, but certain facts remain:

- The current approaches to technology education in a range of countries have limited success;
- Web 2.0 enables a level of individual participation heretofore unavailable, and provides a medium of personal relevance to students.

Many technologies are the substance of public controversy and increasingly consume media attention and political preoccupation. Consider power generation, the causes of what used to be natural disasters, telecommunications and security systems, defence and weapons systems, hazardous waste disposal and resource exploration. Powerful political actors dominate the discussion and control of significant technological issues – politicians, government administrators, corporate leaders and representatives of special interest groups. This current system of discourse and decision making is inadequate because it:

- excludes lay citizens from anything but a trivial role;
- often raises questions after many of the most important decisions have already been made;
- evaluates technology on a case by case basis rather than having a philosophical starting point as a basis for decision making;
- focuses on a few high profile technologies at the expense of the mass of emerging and existing technologies;
- directs attention to material issues rather than the often more important social and cultural issues;
- excludes discussion of the influence of technology on democracy (Sclove, 1995, p240)

Left to current patterns of control and decision making, the world is not going to get better. But this degeneration is insidious, standards of democracy, personal freedom and well being are diminished in small steps which neither make big news nor become the focus of attention. So life progressively becomes more technologically determined without attracting attention to the trend. The thesis of this paper is that if people are informed about technological issues after having studied technology education at school, and the mechanism is available for them to express their beliefs, then the move toward a more democratic technological order is possible.

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Revitalizing Technology Education with Apprenticeship Studies

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Introduction: Return to Culture of Training

Technology education, as an area of study, has been offered to both male and female students in Newfoundland and Labrador schools. It had grown out of the industrial arts movement that prevailed well into the 1990s and during the most recent decade had seen piece-meal upgrading to accommodate the changes in digital technology and the introduction of computers. The technology upgrades were widely deployed in other curricular areas as well. However, the base of technological education has been, by and large, the only access high school students have had to a technical-type offering after the removal of vocational courses from the Provincial high schools in the mid 1970s. What has existed for the last twenty years has been a generalist-introductory technological type curriculum, largely void of skills training.

Now, decades after the dismissing vocational training from secondary public school education, Provincial authorities and educators have sought to reinstate vocational-type skills training through a study of apprenticeship approaches. This paper describes the rationale for to this reversal of policy, looks at how other Provinces in Canada are asserting apprenticeship skills training in their high schools, and summarizes the invariable issues related to this latest introduction of utilitarian vocational education activity into an academic-type curriculum base.

The Rationale For Introduction of Apprentice Skill Training

In an attempt to control a perceived growing rate of poverty in the Province of Newfoundland and Labrador, and provide a curricula base that was somewhat similar to that offered in other provinces, the Government of Newfoundland and Labrador stuck a long list of comprehensive measures that targeted Province's high schools (Government of Newfoundland and Labrador, 2006).

The issues of trade skills shortages, poverty, and high unemployment were not an uncommon concern to the Province's educators, school administrators, trade representatives and elected official. Additionally, an acute need for a skilled workforce that was being depleted through retirement of an aging workforce and changes in immigration practices drew attention to where training in Canada could be best deployed (Government of Canada, 2004).

Recognizing that Newfoundland and Labrador had Canada's second highest poverty rate and in need of revitalization of trade education in its Provincial schools, officials sought a strategy that would alleviate, not only these above concerns, but also a growing sense of uneasiness over whether youth were provided with effective instruction that would enable them to career choices. The view that there was a missing element of skills awareness among youth was mitigating the decisions they were making regarding whether to complete their high school education, enter the workforce upon completion of high school, or seek additional post secondary education beyond their high school completion. A general enhancement of direct links to post-secondary education to future employment was deemed as needing (Industry Canada, 2007).

Practical hands-on courses had long been perceived as the best way to deploy a utilitarian type of curriculum that could serve to improve the career choice opportunities for students, particularly those students who would drop out because they did not see the relevance of the courses that were available to them in high schools (Barron, 2007).

As well, there was the on-going attention to the low participation rate of females in skill trade areas that need to be a component of any new apprenticeship initiative. At the time of the new policy in announcement Newfoundland and Labrador, female participation accounted for as little as three percent presence in skilled trades occupations (Barron, 2007).

A general renewal of skills training and technology was therefore seen as an obvious response and what was needed was a strategy.

A New High School Apprenticeship Initiative
The main features that comprise the Province of Newfoundland and Labrador undertaking essentially amounts to a reinstating of vocationalism through a study of apprenticeship activity. The following are the main components of the initiative.

- The initiative was to be a long-term approach.
- There would be 1.5 million Canadian dollars in 2006/7 made available to fund skills training in high schools. This would be expended to augment high school holdings of tools, materials, and associated needs. All would be related to apprenticeship and skill training.
- A group of high school pilot courses would be developed to augment the existing group of Technology Education courses.
- An additional of allocating an annual expenditure of two million serve to further develop skills training programs.
- Specific provisions would be undertaken to alleviate inequity that exist between rural and urban schools
- All provisions would pay greater attention to the needs of gender inequity in all training programs.
- Similarly all provisions would need to address the unresolved training issues that affect aboriginal students.
- Community partnerships in training would be stimulated.
- There would be greater involvement of federal government, business, and labour in all the training initiatives.

Where Had Skill Training Gone
The reintroduction of skills training in the Province's high schools has adjusted the focus of technology teachers in Newfoundland high schools. By the end of the last century skills training had not been a significant component in high schools at all. It had become the main work of the post secondary education system, both public and private in the Province (College of North Atlantic, 2007).

Skills training have had much iteration in Newfoundland culture. It ranged from local community morning mentoring where women would teach local girl the skill of sewing while the local boys were taught to fish, to more formal activity undertaken by benevolent church groups, and even later instilled in both high schools for a short period of time and then into postsecondary community colleges, both private and public.

Shortly after joining into confederation with other Canadian Provinces vocational schools were built throughout the new Canadian Province of Newfoundland (McCann, 2007). However, skills training and vocational education was not maintained in high school curriculum and it was placed into a newly developing system of post-secondary community colleges by the late 1970s. The benefit of federal funding that would underpin post-secondary training was the deciding factor for this move. Viewed as too expensive to install and to maintain, shop faculties where skills training could be undertakes were a struggle to say the least. Only the larger schools in the Province had working facilities and these were too few. Hence, the majority of smaller schools had not been able to offer any form of skills training. With the elimination of vocational courses from high schools by end of the 1970s the burden of maintaining skills training high schools had been largely done away with. Only a small number of larger schools chose to maintain the few shop facilities that had been in put into place. These were to be turned over to Industrial Arts programs (Hache, 2007).

With a shift of vocational training to the community college system, high schools were left with only a struggling industrial arts program. These continued to thrive and although some integrated skill activity into their curriculum, most maintaining a generalist approach. When industrial arts was modernized to reflect the general global movement to technology education, trade training was further diminished. The new approaches in Technology Education would see substantial computer use, introduction to greater amounts of problem solving-type teaching strategies, but lesser emphasis on skills that were formally associated with trade training. Thus skill training had been largely eliminated from of high schools in the Province, for the better part of two decades (Sharpe and Hache, 1991).

Skills Training In High Schools In Canada

In Canada each Province has a strategy of its own high school strategy, and consequently approach to skill training at that level. By and large some degree of skill training has continued to exist in a myriad of technology education type programs, and vocational programs throughout Canada (Sharpe & Hache, 1992). A number of these have been linked to industrial arts while others have retained their vocational school underpinnings. Enhance activity related to making a career choices, developing problem solving ability, improve general home maintenance knowledge, exploring the functions of industry, introducing tools of technology, are among the many approaches that have deployed in a host of differing formats seen throughout Canada.

Not withstanding the existence of Technology Education type programs in Canadian high schools, that in many programs taught some skills, there has been growing support to either expand employment training programs that teach skills, or reinstating more focused skills training where it had not previously existed. Recent developments in several Provinces have established more aggressive apprenticeship-type training schemes in seven of Canada's Provinces (Hache, 2007).

- **British Colombia**

  A program of apprenticeship is offered as component of courses that lead to high school graduate requirements. It has been fashioned to heighten awareness among students to trade occupations and better prepare them for later entry into apprenticeship trade training which has been the essential work of post secondary schools, both private and public in the Province.

  Details of the program are available in the following link.
  http://www2.news.gov.bc.ca/news_releases_2005-2009/2006EDU0123-001443.htm

- **Alberta**

  Apprenticeship training is offered in Alberta high school to students while completing their general high school course work. These programs can be started as early as grade 10 and students can earn up to 40 credits towards their diploma. More than 50 designated trades and occupations are available for students to explore while in full time participation in the program.

  Details of the program are available in the following link.
  http://www.nextgen.org/Programs/TradesandTechnologies/TradesRegisteredApprenticeshipProgram/tabid/590/Default.aspx

- **Saskatchewan**

  Saskatchewan Youth Apprenticeship (SYA) is designed to promote apprenticeship to high school students in Grade 9 to 12. The program was piloted in seven schools in Saskatchewan in 2005-06. Due to a high interest, the SYA has been implemented province-wide in the 2006-07 school year.

  The purposes of the program are to:
  - Introduce apprenticeship and the trade certification process;
  - Create awareness of apprenticeship programs and opportunities; and
  - Make connections between high school programs and skill.

The program is structured to include formal registration with the area apprenticeship board, formal contracts between participants, and systematic review practices.

Details of the program are available in the following link.
http://72.14.205.104/search?q=cache:2c6Nj-ImFiwJ:www.saskapprenticeship.ca/siteimages/Links_Book_2007_part_2.pdf+trades+in+high+schools&hl=en&ct=clnk&cd=10&gl=ca&client=firefox-a

- **Manitoba**
  High school students in Manitoba can participate in skills type apprenticeship programs starting at age 16 (upon completion of grade 10) and acquire high school graduation credits for the same. The Manitoba Senior Years Apprenticeship Program (ASYO) has students seeking and finding an employer to host the apprenticeship participation, and submit an apprenticeship agreement that is reviewed by their school and in collaboration with the area apprenticeship certification board.

  Details of the program are available in the following link.
  http://www.gov.mb.ca/tce/apprent/future/syao.html
  http://www.gov.mb.ca/fs/bird/SkillsTrain/

- **Ontario**
  Ontario has maintained skills training in their high schools throughout the last century and has had components of apprenticeship allied to their vocational programs, also referred to as Technological Studies in recent decades. The Ontario Youth Apprenticeship Program (OYAP) opens the door to apprenticeship in a wide range of careers. The renewed emphasis would feature additional teacher recruitment, interface with other programs such as cooperative education and vocational education and Technological Studies.

  Details of the program are available in the following link.
  http://ogov.newswire.ca/ontario/GPOE/2006/08/31/c9806.html?lmatch=&lang=_e.html
  http://educ.gov.on.ca/eng/6ways/
  http://www.edu.gov.on.ca/skills.html

- **New Brunswick**
  New Brunswick Youth Apprenticeship has been conceived as a two-year, two-phase program for students in grades 10-11. It is based on educational outcomes that include up to 180 hours of skills training under employer supervision. Participation in the program is also linked to continuation of apprenticeship progress in a post secondary college upon completion of the high school component.

  Details of the program are available in the following link.
  http://www.gnb.ca/0000/progs/curric/youthapp/index.asp

- **Nova Scotia**
  Youth Apprenticeship in Nova Scotia provides high school students with an opportunity to earn graduation credits while in a cooperative education type program that is allied to a hosting employer who provides skills training.

  Details of the program are available in the following link.
  http://www.ednet.ns.ca/pdfdocs/skills_learning/skills_action_plan06-07.pdf

Underpinnings Rationale and Pilot Implementation

National and Provincial research information indicate that there will be dramatic increase in the need for skill trades workers throughout Canada. As work in skilled trades has always been a viable career path for students to pursue upon high school graduation there has been concern voiced over the extend to which students are aware of these looming opportunities there have been few opportunities in high schools to provide readiness courses that have an focus on skill trade occupations (Hache, 2007).

The programs that have existed have been largely void of practical experiences related to the requirements of workers in trades occupations. Acquiring hands-on experiences on these have been viewed as a means to better inform students to the opportunities in skilled trades careers and additionally provide a chance to experiment with some of the techniques utilized and tools and implements used in selected occupational areas. With the launch of the Futures in Skilled Trades and Technology program, Newfoundland and Labrador students have been presented with an expanded base of high school offerings designated to fill a curriculum void that had existed in their high schools. Presently thirty skill training pilot have been instilled in Provincial high schools. It is anticipated that an additional six will be added in the fall of 2007. It is also anticipated that pilot programs will be designated as full implementation program at that time and that skilled trades courses will be available throughout the province in high schools by 2010.

Courses that are featured in the pilot programs are as follows:

- Skilled trades
- Design and Fabrication
- Integrated System
- Residential Construction
- Energy and Power
- Communications Technology
- Production Technology

Incorporated into these courses are craft trades of carpentry, electrical installation, plumbing and small engine repair and others. It is anticipated that ten high school courses will be available and a number of these will be additionally expanded to include computers and robotic devices and increased information on engineering opportunities.

To better harmonize the low participation by female) in the 24% during the current pilot project deployment of the program) specialized courses women in science technology and trades are anticipated (Barron, 2007). At the moment the age requirement for admission to n apprenticeship program is 19 year and some beyond high school years. However, a Career Development course 2201 is also part of the package and this will include apprenticeship information and it is anticipated that credits toward apprenticeship work will be a future addendum to the program (Barron, 2007).

Challenges and Conclusion

After a review of the many of programs that have become available to Canadian youth that focus on apprenticeship one is left with a number impressions. In the context of recent changes in the Province of Newfoundland and Labrador that would seek to revitalize skill training and introduce apprenticeship one can make a number of observations and can draw a series of recommendations(Hache 2007).

- Deployment of skills training programs that are void of strong philosophical, contextual, and procedural underpinnings is risky. Deploying a skills training program in any region where it has not previously existed and has not been parcel to on-going and sustained development present a number of challenges.
- The choice of which skill area to use that would provide a basis to better understand apprenticeship is controversial. The selection of the skill base onto which to develop a skill course needs to be reviewed in the context of available resources that would support a students trade choice. One cannot presume that students enrolled in any particular trade course will readily transfer skill to other trade areas. Similarly, knowledge pertaining to employment expectations is not similar across all apprenticeship fields. Providing too few courses from which to select, or designating inappropriate courses to offer, risks having students take up courses without fully understanding the skill area that they are entering; they can be forced into the wrong courses. They unknowingly make risk decisions in their career selection. (Torjman, 1998)
- A host of standards regarding skills training, particularly those that have reference to production related careers, need to be fully rationalized. This has long been recognized by the profession of

vocational trainers who have sustained such curriculum for most of the last century. Generalist teachers are generally familiar with occupational standards among the skill trade grouping.

- Typically, qualified tradespersons are recruited to teach vocational and trade skill courses. Compelling or recruiting unqualified generalist teachers to teach trade skills, particularly those that implicate public and personal safety, provides risk.
- The culture of skill trainers needs to be reviewed. International standards, recognition of the many associations and professional groups that purvey training in occupations have long been part of vocational training culture. Generalist teachers are largely void of this information. Few have had the practical experience in a trade.
- Inter-provincial mobility of students in relation to the particular training options that exist in any of the many Provincial apprenticeship models designated for implementation in Canadian high schools needs to be fully rationalized.
- Securing area apprenticeship employment has risk for students participating in apprenticeship training. The apprenticeship resources that are available in any particular geographical area challenges the claim that an apprenticeship program that can be equitably deployed.
- A mechanism that would systematic monitor the deployment of training to better address the needs of aboriginal groups and female participation in apprenticeship involvement needs to be full defined.
- All provisions of training are generally "budget-hungry". Recent move to instill training into high schools where there had not been previously available provides a risk to the initiative itself, particularly in cash strapped schools that seek funds to sustain other curricular needs.

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A neo-darwinian view of technological literacy: a curiosity gene, technicity and 'learning by doing'

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Abstract
Langrish's 5 basic requirements for Darwinian evolution are explored in the context of product development, particularly guitars. Thistlewood's three categories of designing – artefactual, evolutionary and historicist – are discussed and the constant probing at the boundaries of the guitar and other musical instrument families is noted. Doyle's concept of technicity as a potential explanation for such restlessness is examined. Evidence supportive of Doyle's concept from Loughborough University's 'polymer guitar project' is included. The paper concludes by discussing the validity of a product evolution analogy and the implications of a neo-Darwinian perspective for design and technology education. 'Learning by doing' is discussed and the view that the ultimate goal of design and technology education is bridging the gap between technological literacy and technological capability is suggested.

Introduction
In a 2004 paper, Langrish discussed the ideas associated with a Darwinian interpretation of product evolution and at the *2006 Design History Society Conference* concerning *Design and Evolution* presented the five basic requirements shown in Table 1. At the same conference, Norman (2006) discussed the strength of the product evolution analogy in the context of the development of the guitar and concluded that Doyle's (2004) concept of technicity might provide a fuller explanation for the associated human behaviour. These concepts, as well as Thistlewood's (1990) observed categories of designing, are explored here in order to provide a neo-Darwinian[1] perspective on some of the key issues concerning design and technology education.

1. The existence of variety – different kinds of things having mixtures of differing properties held in varying amounts
2. A competitive selection system which picks 'winners' from the different things, properties, amounts of properties or combinations of these
3. A system which replicates the 'winners' or some proxy for the winners. (e.g. male animals may compete but real competition is between the properties of the animals and only those properties which are linked to replicators get passed on). Preferential replication gradually replaces the 'losers'.
4. There has to be a system for the generation of new varieties because the above three on their own lead simply to a steady state (including oblivion as an extreme steady state). New varieties take us back to 1 and the continuation of the process.

To which it is necessary to add a fifth:

5. Even with the addition of 4, the system of change would slow down through diminishing returns, unless we have a fifth feature viz. changing the rules of the competitive selection system. Without changes in the environment or some other form of rule change, evolution would stop.

Table 1 Towards a general theory of Darwinian change: five basic requirements (Langrish, 2006:9)

Thistlewood's classification of products

[1] The term neo-Darwinism follows Langrish's use ie 'to mean Darwin's natural selection plus genes (which were discovered later). It is not suggested that design is somehow genetic. Design evolution is the evolution of ideas, and the Darwinian evolution of ideas is called "memetics" from the concept of self-replicating ideas called memes by Richard Dawkins (1976)' (Langrish:2004:4-5)

When discussing the classification of products, Thistlewood (1990) identified three types: archetypal, evolutionary and historicist. Archetypes are products which have developed through the generations and where 'significant departure from these characteristics leads at best to less-fit artefacts and at worst … to retrograde mutations' (*ibid*: 14-15). Musical instruments are one of Thistlewood's examples of archetypes in daily use and the others he lists are bowls, jars, tables, chairs, traditional water-craft and age-old instruments, like spades, hammers and cutting blades. In discussing the possibilities that designing archetypes presents, he comments as follows.

> They represent a phase of human design enterprise before authorship was celebrated. The contemporary designer's contribution to their re-presentation consists in attending to secondary features such as materials, colours and decorative treatments: essential forms have ceased or virtually ceased evolving and are correspondingly non-negotiable. (*ibid*: 14)

Archetypal forms of guitars have undoubtedly developed and many examples of current makers addressing such secondary features can be found (eg early classical (parlour) guitars, steel-strung acoustic guitars based on the Martin designs and electric guitars based on the Fender Stratocaster).

Torres and the Spanish guitar: an 'evolutionary' step?
Thistlewood's second category of designing refers to evolutionary steps, which …

> … obliges the designer to invent new forms that invalidate all their predecessors. Electronic typesetting has invalidated hot metal. …
> …
> 'Evolutionary' designing compresses (and in this sense emulates) the centuries-long processes of development that have produced 'archetypal' artefacts. Much of this emulation is effected by means of 'accelerated use' – by subjecting artefacts to harsh regimes of durability-testing and programmes of mechanical wear-and-tear. This is pragmatic research and development. Much else, however, is achieved by imagining desirable but currently impossible outcomes - the opposite of pragmatism. (*ibid*:15-16)

Such a remarkable step took place in guitar making in Spain in the nineteenth century.

> The instruments played by Sor and his famous contempories – Dionisio Aguado (1784-1849) and Matteo Carcassi (1792-1853), for instance – were, however, far inferior to the guitars at the disposal of today's players. All that changed – with a quantum jump in the development of classical guitar construction – at the hands of a carpenter from San Sebastian de Almeria, Antonio de Torres Jurado (1817-1892). Better known simply as Torres, he was without a doubt the most important figure in the history of guitar design and construction. Musicians who played his guitars immediately discarded those of other makers. Throughout Spain luthiers adopted Torres' designs. In fact, to this day, classical guitar makers still construct their instruments in the manner of Torres (Denyer, 1982:42)

The Torres construction guitars came to dominate the design of the Spanish guitar because of their superior musicality, but also because they were initially played by Francisco Tarrega – "the Chopin of the guitar" (Bonds, 2001:66); then by Andrés Segovia, who recorded their sound, thereby introducing the cultural power of exposure via mass media (Huber, 1994:12) and because they offer luthiers security for their reputation, established know-how and some flexibility (ibid:40-41).

The cultural influence is evident from the development in the USA of the only real alternative to the Torres construction guitars. Christian Friedrich Martin (1796-1873) brought his knowledge of European practice to America when he arrived in 1831, having been a foreman in Johann Staufer's shop in Vienna. The early guitars he made in America maintained their European influences, but over a period of 15-20 years his own designs emerged, most notably the cross- or X-braced top. 'The great majority of Martins from 1850 onwards have some form of X-bracing' (Gruhn and Carter,1993:18).

The search for volume: historicist designing

The third category of designing which Thistlewood identified was historicist, in which …

> … the designer is conscious of working within an historical continuum. Buildings are the most obvious manifestations of this tendency … They are compared with antecedents that are still evident in the world around them, which in effect constitute a museum of architecture and building. Although houses have a familiar symbolism and of course an archetypal function – shelter – they have no essential form … (*op cit*:15)

The emergence of the electric guitar is a long and fascinating story, but it is noted here as an example of Thistlewood's historicist designing. The sound of the electric guitar is largely determined by the pick-ups used, the weight of the body, and to some extent the type of wood selected, but there is no essential form. A huge variety of designs have emerged, including of course the Gibson Les Paul, the Fender Telecaster and Stratocaster, but there are many others. They appear in different colours and materials eg wood, of course, but also bronze, aluminium, acrylic, polymer foams etc

An interim discussion

So within one product family, it is possible to identify all three of Thistlewood's categories. Artefacts which have essentially ceased to evolve and where at least some designers have re-presented familiar forms. Clearly, some humans are not satisfied with simply reproducing artefacts, but wish to 'leave their mark' or to give the product something of their individual character. Evolutionary steps are constantly being sought and when no essential form is required (historicist designing) abundant variations ensue. When Dasgupta was considering whether creativity could be considered to be a Darwinian process, the lack of randomness in the ideas which emerged was a key argument in his rejection of the idea (2004). He examined three case studies from the histories of natural science, technology and art[2] and concluded:

> … a fecundity[3] in the generation of variations on which the selection is supposed to work according to the variation-selection model is not evident in any of the examples. In none of the case studies presented here is there any evidence whatsoever of blind variations being generated. On the contrary, the cognitive process in each instance was goal driven and knowledge driven. (411-412)

Certainly much of the evidence presented in relation to guitar development (see Norman, 2006a for more detail) supports Dasgupta's findings of goal-directed, rather than random activity, but there is also some support for designing which is more analogous to the concept of 'random mutations' (eg some electric guitar designs). The analogy is stronger when looking at a whole product family than particular case studies of individual design activity.

For guitar development, Thistlewood's concept of evolutionary designing can be seen as related to periods of static technology and fixed goals. It is interesting to note how the emergence of new materials technology has re-awakened some innovative ambitions. Carbon fibre has been explored by Greg Smallman (in collaboration with the guitarist, John Williams) as a material for Spanish guitar components in order to improve the soundboard response. It has also been explored by the Rainsong company in order to make complete steel-strung acoustic guitars. The 'polymer guitar project' at Loughborough University has been seeking to develop guitars using expanded polycarbonate soundboards, resulting in the business venture, Cool Acoustics (www.coolacoustics.com). There is comparable experimentation in the violin family (Revkin, 2006).

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[2]The case studies were in natural science, Jagadis Chandra Bose (1858-1937) and his 'Monistic Thesis'; in technology, James Watt (1736-1819) and his 'Separate Condenser'; and in art, Pablo Picasso (1881-1973) and his 'Picture from Afar' (Guernica)).

[3] Within biology or demography fecundity refers to the ability of an organism or population to reproduce

The 'natural evolution' analogy: technicity
The development of the guitar seems to be characterised by issues relating to 'technical and cultural lock-in' of particular designs, but with a constant probing at the boundaries of the guitar family. Whether it is re-presenting archetypal designs, seeking new evolutionary steps or generating more historicist possibilities it seems impossible to stop. Why do designers re-examine the existing boundaries of the guitar family? Certainly the reality that at least some of them do provides supporting evidence that the first of Langrish's five basic requirements for a Darwinian model can be met, but can this be explained by anything more fundamental than some perceived dissatisfaction with some aspect of a product's performance? (Petroski, 1993). It is possible that Doyle's concept of 'technicity' (2004) can help to move the argument on. This term might be seen as one of many expressions of a similar concept eg 'graphicacy' (Balchin,1972), 'technik', (Fores and Rey, 1979), 'designerly ways of knowing' (Cross, 1982), 'technacy' (Seemann, 2006), or indeed Archer's concept of 'cognitive modelling' perhaps (1981). It is not appropriate to review and distinguish these concepts here, simply to note that 'technicity' is but one expression of a number of related ideas.

Technicity

> Technicity might best be characterised by a creative capacity to:
> a) deconstruct and reconstruct nature, and
> b) communicate by drawing (Doyle, 2004: 67)

At DATA's 2004 international research conference, Doyle explored this concept of technicity as the fundamental driver for human evolution.

> I make no apology for borrowing a term from philosophy and bending it to my purpose. Design and technology, unlike traditional academic fields, seems to lack an intellectual core: it's all about making things. For longer than I care to think, this has concerned me. Our technical capacity has transformed our planet and ourselves, and continues to do so. On an evolutionary timescale these changes have happened instantaneously. Developed over the last two decades, the field now called 'evolutionary psychology', offers interesting insights into how we came to be. Unfortunately, neither this new field …, nor its academic precursors …, has anything to say about how we are able to make things…
>
> In this paper I hope to do two things:
> 1) Tease out and clarify 'language' as an evolutionary adaptation.
> 2) Draw out the core of modern human behaviour: our ability to create and innovate
> (ibid: 65)

The polymer guitar project
At DATA's 2005 conference, Norman and Pedgley reported an analysis of Loughborough University's innovative polymer acoustic guitar project in terms of this concept. This project was established as a case study to support a PhD research programme exploring the role of knowledge in design decision-making (Pedgley, 1999). A secondary focus was the establishment of a complete chronological record of a design innovation. The patent that resulted from the work is evidence that innovation did indeed occur (Norman *et al*, 1999). This chronological record also provided research evidence against which the technicity hypothesis, namely that 'innovation is to be expected [and that] technicity is its intellectual driver' (*op cit*:71) could be tested.

The chronological record of the polymer guitar project
During the polymer guitar project, various uses were made of 2D and 3D modelling media to assist with product design and development. Over the course of the project, these built-up into an archive including sketch sheets, logbooks, card and foam models, and working prototypes, as is usual for product design activity. Unusually, however, a detailed diary of designing was kept (Pedgley, 1997) in parallel to the product design activity, to satisfy the research objective of generating documentary

evidence of designers' decision-making in relation to materials and manufacturing processes. The diary was generally completed at the end of each day's designing and often made specific references to design thinking embedded within 2D and 3D media. The resulting catalogue of diary entries comprised a chronological 'running commentary' of designing, spanning 227 project days over approximately two and a half years, with over 500 individual entries. For Owain Pedgley's PhD, the catalogue was analysed to track various aspects of materials and manufacturing decision-making, including the nature of cognitive modelling and information searches (Figure 1) For the 2005 conference paper, the diary catalogue was re-analysed for evidence of technicity.

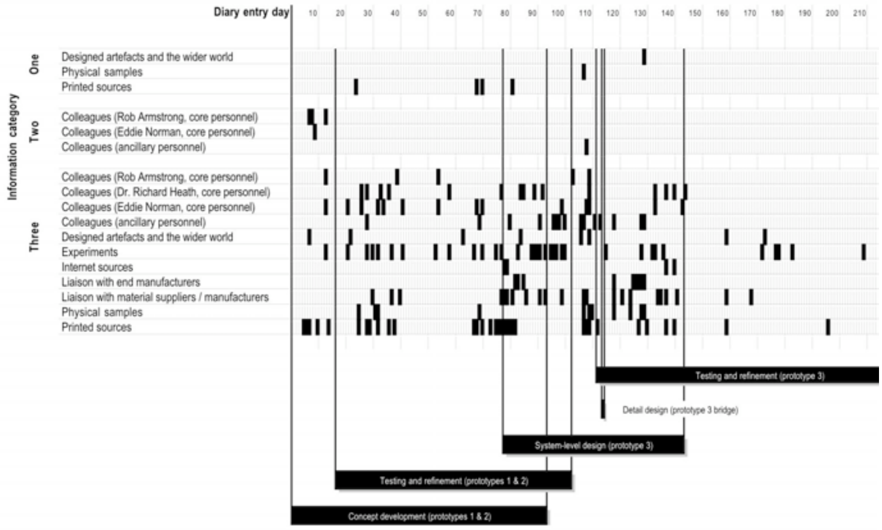


Figure 1 Materials and manufacturing information searches for the polymer acoustic guitar (Pedgley, 1999:231)

Mining for evidence of technicity

Table 2 shows some characteristics of technicity identified from Doyle's paper (*op cit*, 2004) grouped under three headings: language, deconstructing and reconstructing, and drawing.

Grouping	**Technicity characteristic**	**Page**	**Comments**
Language	an organ of social cohesion	68	'Creativity is not in language, though creativity co-opts language'. (70)
	intentionality	68	… related to our theory of mind
	shared memories	68	… essential for meaningful descriptions
Deconstructing and reconstructing	identifying different making strategies	69	… described in terms of making a ring
	rehearsing alternative scenarios	69	… linked to imagination and the human theory of mind
	a secure cultural foundation	69	… historical evidence is cited suggesting that this is a requirement for innovation
	blindingly obvious	69	… a characteristic of 'creative leaps' in retrospect
Drawing	use as an external memory system	69	… part of the construction process

	development to serve a novel application	70	… sketching styles relating to particular aspects of deconstructing and reconstructing?
	use of drawing instruments	70	… indicated as drawing tools, but would clearly extend to CAD

Table 2 Ten characteristics of technicity identified from Doyle's paper

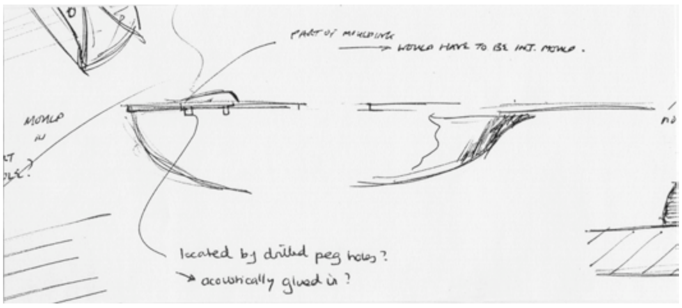
Many of the entries in the diary catalogue could be identified with one or more of the characteristics of technicity listed in Table 2. The following diary entries (Figure 2) illustrate some of these characteristics (for more examples see Pedgley & Norman, 2005:134-137).

1. *Language: shared memories*

Date 13.6.96	Day 7	"Continuing product analysis exercise at the moment. → formulating ideas/getting to know 'guitars' rather than specifically designing a new one …"

1. *Deconstructing / reconstructing: rehearsing alternative scenarios*

Date 28.10.96	Day 20	"To have bridge interconnecting with soundboard (i.e. 1 mould) would be tricky. Bridge= reasonably intricate = std. moulding with non-reinforced plastic (i.e. a different material to the soundboard, so, therefore, could not be integral). Fibre reinforced would not allow for such intricacies (also, means soundboard is no longer a flat 'sheet' which could, if appropriate, be cut out - a lot cheaper than moulding)."

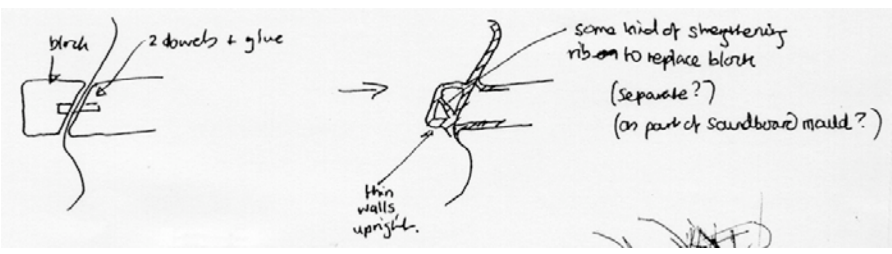


2. *Deconstructing / reconstructing: a secure cultural foundation*

Date 16.7.97	Day 39	"[Meeting with Rob] Rob explained to me how I should go about building the top-plate, and gave an indication of the materials to use, giving me confidence and a 'green light' to go ahead with building something that he was happy with. It had been a long time since I had seen Rob, so I wanted to get his 'stamp of approval' on the work done and the direction now being taken, especially concerning what materials to start with. It had been up to me though, to find a design direction from the conflicting ways of working of a crafts-designer client (Rob) and a materials specialist (Dick)."

3. *Drawing: use of an external memory system*

Date 27.4.98	Day 143	"I used this left-hand drawing to remind me of how the prototype will be constructed around the neck. It led me on to thinking about the same in the mass-manufactured proposal… the block was providing stability, and rigidity in particular - how could this be achieved in the mass manufactured version, using lay-up/moulding? A web of walls I thought, rather like strengthening ribs in injection moulded components… The idea was then superseded on DS55 main."



Use of an external memory system

Figure 2 Entries from the diary of designing supporting the technicity hypothesis (Norman& Pedgley, 2005)

A neo-Darwinian perspective on design and technology education: learning by doing
Is it plausible to take the 'technicity hypothesis' view that to be human is to be innovative and, if humans engage in activities of this nature, then innovation is inevitable? Human decision-making is an expression of the art of making judgements based on incomplete information about existing factors and future consequences. This is the essence of design activity, and hence then of the existence of products and their associated technology. In the same way that each game of chess is highly likely to be different, so with product design dependent on a multitude of sequential decisions, the designs will inevitably be different. So, in some respect, every resolution of a design problem could be seen as innovative, in the sense that with respect to some factors it is a 'better fit' for the design intentions than its predecessors. It is a matter of judgement as to whether the better fit is of more value than other better fits. So, on the view that technicity can be understood as the capability underlying human decision-making in the face of uncertainties, perhaps innovation can be interpreted as inevitable and product evolution considered the survival of the most valued. The constant probing at the boundaries of the guitar family could be seen as a demonstration of technicity, perhaps a 'curiosity gene', or, given the potential planetary consequences, even a 'self-destruction' mechanism. Much recent research by Baynes has focused on understanding the behaviour of very young, pre-school children when designing (1992, 1994, 1996)[4]. The playful behaviour of the young of a species is often strongly indicative of what the adults must do to survive, and the exploratory behaviour of young children demonstrates the fundamental nature of 'learning by doing'.

Learning by doing is one of the ways in which designers develop the 'recipemes', a form of memes (Dawkins, 1976) which Langrish describes as transmittable ideas about how to do things' (2004:17). He uses Abu-Risha's concepts (1999) in order to describe designing in terms of the 'purposive pattern recognition (PPR)' between the recipemes and the 'selectemes', which are 'ideas about the sorts of thing you want to do. Selectemes are involved in making decisions between alternatives. They provide motivation; they are values' (*op cit*: 17). As Langrish noted both recipemes and selectemes can 'sometimes be transmitted without formal language' (*ibid*:17), and this view of designing is supportive of Doyle's analysis of technicity as the essential human characteristic which has led to human domination of the planet. Some of the replicators of product evolution are the products themselves, which embody the thinking of their designers, and hence the importance of museums for design education. Similarly, other replicators are embodied in the skills and know-how which are passed from one generation to another through 'teaching by showing' (Norman, 2000).

Langrish also describes a third type of meme.

> … the "explaneme," must be added because of the human propensity to ask "why?" As long as humans have had a language, they have told stories, and good stories get replicated. If someone discovers a new recipe, people will ask why it works. Explanemes ar the ideas that provide the basis for answering the "why" questions. They range in sophistication from simple stories to complex mathematical concepts, but they have two things in common, they offer an explanation and they need a language to be transmitted."
> (2004:17)

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[4] These 'Orange Series' publications are dowloadable from Loughborough's Design Education Research Group website at www.lboro.ac.uk/idater/

The designers' judgements (Norman 2006b) and the discipline of the market provide Langrish's second basic requirement for a competitive selection system, and design and technology education can be seen as providing the third ie a system 'which replicates the 'winners' or some proxy for the winners'. However, what view emerges of the role and shape of design (and technology) education, should such a neo-Darwinian perspective be taken?

Probing at product boundaries and the generation of alternatives can be seen as inevitable consequence of human behaviour. No design 'strategy' or process, singular or plural, is needed for this to be the outcome, and design education can perhaps be best seen as taking the form of 'sports coaching'. Sport for all' programmes from which the most talented emerge, and the recipemes available to these few are gradually increased until the 'PPR' associated with highly skilled designing becomes routine. Technological literacy is largely about the understanding of the selectemes that enable participation in a democratic society. Technological capability, if this concept is interpreted as the ability to intentionally bring about a specified outcome, requires 'PPR', and bridging the gap between technological literacy and technological capability could be considered to be the ultimate goal of design (and technology) education. Explanemes are the province of science, and on such a neo-Darwinist view, they are not an essential feature of designing or product evolution, and consequently neither are formal languages a requirement.

Returning to guitar development, many people have relevant selectemes which could define worthwhile goals (literacy), a small minority have the recipemes required to do anything about them (capability). Science provides few explanemes and their foundations are not secure (Norman 2006b). That is why luthiers exist, and at Cool Acoustics we work with Rob Armstrong, who has now made around 750 instruments, all successful and all different, and nobody gets lucky that many times in a row! Rob Armstrong believes in self-enlightenment and learning by doing, and, although guitars are but one product, they nevertheless illustrate the potential strength of the case for taking a neo-Darwinian perspective on design (and technology) education.

The optimistic outcome of such a view is the steady-state that Langrish predicted: a guitar perceived to be perfect. So, perhaps a key aspect of design (and technology) education should be minimising the changes in the product environment that lead to innovation and the related over-consumption of the world's resources. Products that are 'eternally yours'[5].

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Indigenous technology in the south african curriculum: a unique feature

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Context

Since 1994, education in South Africa has undergone fundamental transformation. The new curriculum, known as Curriculum 2005 (C2005) and developed in 1997, was the first single curriculum for all South Africans and it was the pedagogical route out of apartheid education (Chisholm 2003). The first nine years of schooling, known as the General Education and Training Band (GET), became compulsory and it was in this band that Technology was introduced as a new learning area. The revised National Curriculum Statements (NCS), developed in 2002 for grades R – 9, were the result of a process of revision designed to strengthen and streamline the original curriculum statements.

The guiding philosophy of C2005 was 'outcomes-based education', a controversial philosophy with links to the 'competency-based' approaches found in the vocational and work-based training areas (Stevens 2005). The whole educational system is based on twelve critical and developmental outcomes, whilst each learning area has its own 'learning outcomes' achieved by attainment of specific 'assessment standards'. Of interest to this paper is Learning Outcome 3 for Technology (NCS) which requires learners to demonstrate an understanding of the interrelationships between science, technology, society and the environment. The inclusion of this outcome is in line with curriculum revisions undertaken in other countries such as New Zealand (Jones 2003) and the United States of America (USA) (International Technology Education Association 2002), which acknowledge the interrelationship between science, technology and society. It is noteworthy that the South African curriculum has added the aspect of 'environment' in the exploration of these interrelationships. Of particular interest is the first assessment standard for this outcome - 'indigenous technology and culture'. This was a new inclusion and one that is seemingly unique to South Africa. The other two assessment standards concerning the 'impact of technology' and 'bias' have been consistent throughout the revisions and are found in other technology curricula. With the unique inclusion of 'indigenous technology and culture' to the curriculum, technology teachers and learning material developers now have to contend with issues such as:

- what is meant by the interrelationship between science, technology, society and environment;
- what is 'indigenous technology'?;
- the link between technology and culture;
- what this means in terms of 'technological literacy'.

The Value of Indigenous Knowledge Systems

Defining Indigenous Knowledge

Various definitions of indigenous knowledge exist and one of the more inclusive definitions is that given by Dei, Hall and Rosenberg (2000:19) , which states: *"Indigenous knowledges are unique to given cultures and societies and they reflect the capabilities and values of the communities that use them"*. Woodley (2003) suggests that indigenous knowledge systems should be studied in terms of space and time, emphasising the importance of context. He further states that the spatial dimension of indigenous knowledge is the embedded, holistic or 'place-based' aspect of knowledge at any one point in time, and that to understand knowledge as embedded in place needs an understanding of the social norms, values, belief systems, institutions and ecological conditions that provide the basis for the 'place' where knowledge is derived. Indigenous knowledge encompasses technology, social, economic, philosophical, learning and governance systems (Seepe 2001).

Renewed interest

Up until the 1960s, colonial powers used education as a tool to disseminate the metanarrative form of civilizing culture perceived to be utopian during these times (Boyne & Rattansi 1990). Metanarratives are stories a culture tells itself about its practices and beliefs. Lyotard (cited in Klages 1997) suggests that the perceived order maintained in modern societies is through the means of these 'metanarratives'. Colonial administrators viewed western science as the ultimate authority for interpreting reality and indigenous knowledge was perceived to be simplistic and vague. As a result, African and other knowledge systems were marginalised with adverse consequences for the people who were colonised (National Research Foundation 2002; Pitika Ntuli 2002). In regards to education, most countries in post-colonial Africa inherited a curriculum that was largely irrelevant to their own circumstances. This is partly due to the fact that learners were (and still are) often confronted with sets of world views, knowledge and attitudes that were not their own. Education in most parts of Africa tells children from a traditional culture that their future is rooted not in the knowledge of their parents and grandparents, but in the knowledge imported from a Western pedagogical tradition. This results in views that indigenous knowledge systems are obsolete (Aikenhead 2002; International Council for Science 2002; Kunnie 2000).

However, in the last two decades, these perceptions and views have been changing. The great majority of the world's populations rely on indigenous knowledge for their survival: in South Africa it is estimated that it is 80% of the population (Ngulube 2002; Snively & Corsiglia 2001; World Bank 2003). There is overwhelming evidence, the result of careful research from many countries and sources, that illustrates the great range, validity and usefulness of indigenous knowledge (Chambers 1995; McGovern 1999). Lyotard (cited in Boyne & Rattansi 1990) suggested that social development in the postmodern era can no longer be seen as fulfilling some metanarrative, but that it should be a pragmatic matter of inventing new rules. The validity of these rules will reside in their effectiveness rather than in their compatibility with some legitimising discourse. So, in the social development field, less emphasis is being put on the transfer of technology and more on learning from and with indigenous peoples (Chambers 1995; Massaquoi 1993). As people and governments across the world become more concerned with environmental issues and sustainable development, sensitivity to the value of indigenous knowledge grows (Warren, Slikkerveer, & Brokensha 1995). In the agricultural development field, recent studies about indigenous knowledge are having an effect. Policy makers and planners are starting to recognise the need to understand existing knowledge systems and decision-making processes (Warren & Rajasekaran 1993). The renewed interest in indigenous knowledge is evident in documents such as Agenda 21, the main text to come out of the Earth Summit held in Rio de Janeiro in 1992 (UNCED 1992), and in conferences such as the World Summit on Sustainable Development held in Johannesburg in 2002. Essentially, indigenous knowledge affects the well-being of the majority of people in developing countries. It is therefore a valuable resource for the traditional societies from which they originate as well as for scientists, technologists and development agencies. Warren and Rajasekaran (1993) suggest that, in the social development field, it is feasible, efficient and cost-effective to move towards an interactive technology development from the conventional transfer of technology approach.

In South Africa there has been a broad approach to the recognition of the value of indigenous knowledge systems. As well as playing an important part in biodiversity, agriculture and sustainable development, indigenous knowledge systems are seen to be important in fields such as government (languages, traditional authorities, constitutional reform, land reform, indigenous peoples) and education (languages, science and technology, environment and multicultural education) (Crossman & Devisch 2002). It is a critical research area supported by the National Research Foundation and both the ministry and the parliamentary portfolio committee for arts, culture, science and technology are now championing indigenous knowledge systems. Indigenous knowledge systems are now starting to form a part of university and school curricula.

Indigenous Knowledge and Western Science
The comparison of Western scientific knowledge and indigenous knowledge usually creates a dialectical opposition (Shava 2006). Shiva (2000) points to the dichotomising impact of Western scientific research on local knowledges which, through processes of inclusion and exclusion, creates boundaries of power. She points out that *'Western systems in agriculture and medicine were defined as the only scientific systems'* (2000:vii). Yet the agricultural practices of most farmers in Africa rely heavily on traditional know-how and this sometimes proves to be far more productive than imported techniques (Hountondji 2002). Indigenous knowledge proponents can also create an oppositional logic of 'us' and 'them' – the subjugated 'us' and privileged 'them' (Dei cited in Shava 2006). There is now a growing realisation that these knowledge systems are not necessarily oppositional - they can be complementary. This has implications for the ways in which these knowledge systems are recontextualised into learning materials. The historical, political, social, cultural and environmental contexts in which a technology emerges, develops and stabilizes, and the interrelationship between the two knowledge systems needs to be explored.

Different approaches to technology
According to Mitcham (1994), the philosophy of technology has two traditions: the engineering philosophy tradition which emphasises analysing the internal structure of technology and the humanities philosophy tradition which is more concerned with external relations and the meaning of technology. In other words, most theories distinguish between technology as artefact and technology as social ideas, values and needs. Technology education curricula in the past have focused primarily on the engineering philosophy tradition, perhaps due to the roots of the discipline being in the technical curricula of the industrial arts subjects, such as Technical Drawing and Metalwork. The humanities philosophy tradition is more recent and its influence is evident in curricula revisions in some countries, such as New Zealand (Jones 2003), the USA (ITEA 2002), the Netherlands (Eijkelhof, Franssen, & Houtveen 1998) and South Africa.

Philosophical and sociological perspectives have prompted an extensive debate about the nature of technology (Hansen 1997). The debate seems to run along two continuums: the extent to which technology is viewed as autonomous or human-controlled, in other words technology's relation to human powers; and the extent to which technology is viewed as neutral or value-laden (Feenberg 1999). The following diagram illustrates these two continuums and the placement of the more well-known theories of technology on the two continuums:

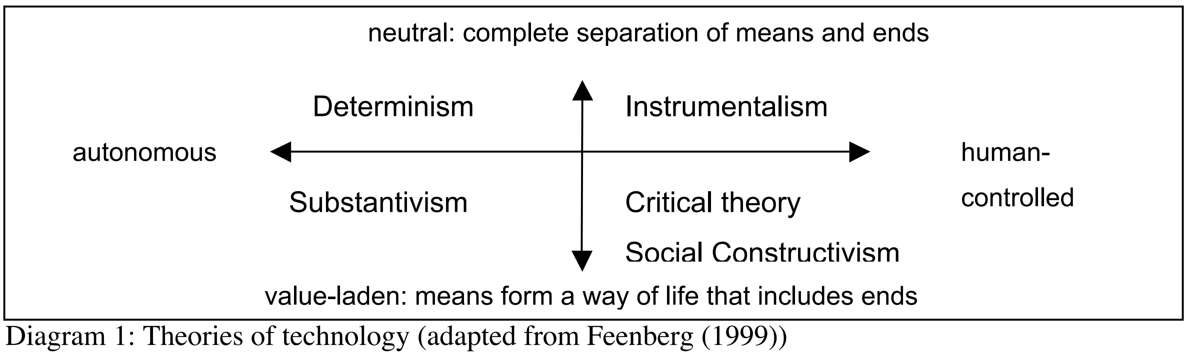

Diagram 1: Theories of technology (adapted from Feenberg (1999))

The two theories of determinism and instrumentalism perceive technology as a set of neutral products detached from values. Determinists believe that technology controls humans and in doing so, it shapes society to the requirements of efficiency and progress, as in classical Marxism (Feenberg 1991). This view of technology has contributed to a simplistic and inflexible view of the relationship between technology and society (Pannabecker 1991) and it has reinforced the idea that technology is an autonomous entity developed according to an internal logic which has determinate impacts on society (Russell & Williams 2002; Williams & Edge 1996). Instrumentalism is based on the idea that technologies are tools that are used to provide the means for the realisation of independently chosen ends (Feenberg 1991). In other words, technology is viewed merely as an instrument of progress. These two theories ignore the influence of contexts, including indigenous knowledge practices.

Theorists such as Feenberg (1999) and Ihde (1990) claim that technology can never be removed from a context and therefore can never be neutral. The non-neutral approaches suggest that attention be given to relationships as well as objects. While the scientific principles used in engineering might be value neutral, the emergence, implementation and impact of a technology are embedded in historical, aesthetic, political and cultural meaning. Substantive theory views means and ends as inseparable: our tools form our environment and therefore who and what we are. Substantivists view technology as a culture of universal control from which there is no escape. Substantivist theories of technology draw attention away from the practical question of what technology *does* to the hermeneutic question of what it *means* (Feenberg 1999). Substantivists suggest that once society goes down the path of technological development, it will be dedicated to values such as efficiency and power; traditional values will not survive this challenge. This approach has been criticised for its apocalyptic and dystopian view.

Unlike most other theories, with critical theory there is no assumption of progress. Similarly to the substantive view, critical theory argues that the technical order is more than a sum of tools but, like instrumentalism, it rejects the fatalism of the substantivists. In choosing our technology we become what we are which then shapes our future choices. According to Feenberg (1991), critical theory argues that technology is not a 'thing' in the ordinary sense of the term. Rather, it is an ambivalent process of development suspended between different possibilities. This ambivalence attributes a role to social values in the design and not just the use of technical systems, thereby distinguishing it from the neutral thesis. Critical theory replaces the conventional distinction between artefacts and ideas held by determinism and instrumentalism by a holistic view in which technology reflects the dominant ideologies of the culture in which the technology emerges. It suggests that technology embodies the values of a particular civilisation and can be interpreted as a cultural phenomenon (Hansen 1997).

Social constructivism is the dominant theory of learning embodied by the National Curriculum of South Africa and should be placed on the horizontal continuum next to critical theory. Social constructivists argue that technology is largely socially determined. It has sharpened reflection on *who* makes the technology and *why* and *how*. Like substantivism, constructivism attempts to understand more than technical function by exploring the construction of networks of people and things within which functions emerge. It confirms the link between means and ends and contingent development (Feenberg 1999). Faulkner and Runde (2005), Klein and Kleinman (2002) and Williams, R. (2002), emphasise the role of human agency as central to the process of technological advance. Faulkner and Runde (2005) propose that the technological identity of an object emerges jointly from that object's physical characteristics and the function collectively assigned to that object by society. This identity is internal to those communities in which those identities have currency.

The South African curriculum for Technology states *"All technological development takes place in an economic, political, social and environmental context. Values, beliefs and traditions shape the way people view and accept technology, and this may have a major influence on the use of technological products"* (Department of Education 2002:9). The emphasis on context and the recognition of the effects of values, beliefs and traditions on technological development means that the view of the nature of technology is that technology is human-controlled and value-laden. It is the interrelationships between context and technological development, linked to the value of indigenous practices, that now need to be made explicit in learning materials.

The relationship between culture and technology

The term *culture* is used in a variety of contexts and is therefore difficult to define. Allen (2000:443) stated that:

> Culture consists of patterns, explicit and implicit, of and for, behaviour acquired and transmitted by symbols. The essential core of culture consists of traditional ideas and especially their attached values. It is a complex and ambiguous concept as it cannot be thought of in isolation. It has multiple associations and it can be valuable if it directs our attention to the interconnections between things.

The acknowledgement of the influence of human agency on technological development and use suggests that there are inextricable links between culture and technology. A definition of technology needs to reflect these links. A suggested definition is: Technology is a socio-cultural process that is manifest in a product by applying technological literacy and capability in the mitigation of risks. It is the ongoing development of technology that has created new ways for humans to live in the world and it is the human-technology interface that has changed the way in which human beings interact with their environment and with each other (Dakers 2006). The social and cultural development of human beings has a strong correlation with their technological development. Indigenous knowledge systems, influenced by experimentation and external systems, are rooted in personal experience and local culture, and the intrinsic value of indigenous knowledge systems is illustrated in the high use of these systems by local communities. The aspects that link technology and culture need to be examined and explored in the technology classroom.

Implications for the classroom

What teachers know, what they deem to be valuable knowledge and various dimensions that influence their choices (historical, spatial, political), will impact on the way in which 'indigenous technology and culture' is introduced in the classroom. Rowell, Gustafson and Guilbert (1999:48) state that:

> "While curriculum developers set out the orientation of the school subject in documents mandating the goals and content of the instructional program, teachers interpret the program with a focus on aspects congruent with their personal views and interests".

Teachers' conceptualisation of 'technology', 'technology education', 'indigenous technology and culture' and 'the interrelationship between science, technology, society and the environment' will effect the extent to which they introduce and engage with the inclusion of 'indigenous technology and culture' in their technology lessons. In other words, their view on the nature of technology will influence their teaching. Regarding the introduction of 'indigenous technology and culture' in the technology curriculum, teachers and authors of learning materials will have to deal with issues such as *what* knowledge to use and *how* to recontextualise this knowledge. Most indigenous knowledge practices are transmitted orally from generation to generation and therefore very few examples have been recorded. The challenge remains for educators to identify indigenous technology practices and then recontextualise this knowledge into meaningful learning contexts. This is a process that is beginning in South Africa as educators start to implement the revised curriculum.

Conclusion

Dei (2000) says that educators are having to confront some critical questions about their work in the academy, and one of these questions is 'how do we ensure that learners are informed by the complete history of ideas and events that have shaped and continue to shape human growth and social development?'. He continues by saying that it is encouraging that so many educators, parents, learners and community workers are now questioning the modes of conventional knowledge production which 'privilege some knowledge forms and set up a hierarchy of knowledges'. The omission of non-European knowledge forms during colonial times did not allow learners to be informed by a 'complete history'. Learners and educators must start to offer multiple and collective readings of the world. Educators need to find new paths that emphasise complementary and interconnected aspects rather than duality when dealing with indigenous knowledge and western science. Learners must be given opportunities to understand and engage with the diverse histories, cultural narratives and representations from different cultures. They must be encouraged to develop a critical perspective by seeing that there is more than one way of understanding reality (Giroux 1997; Irzik 2001; Nieto 2000).

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Enhancing teachers' PCK through the use of planning frameworks in primary technology

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Abstract
This paper explores the ways in which assisting teachers in their planning can clarify their pedagogical content knowledge (PCK), and enhance their classroom interactions. It reflects the work of the Classroom Interactions in Science and Technology Education Project. PCK is predicated on the notion that it is an active process where subject knowledge and practice have a symbiotic relationship, rather than being a simple combination of the two. There is an important distinction between teachers knowing a subject and knowing what to activate subject-wise for classroom teaching and learning. Teachers employ an intellectual process to translate their content knowledge into a form that is learnable for particular students. The use of planning frameworks can impact on this intellectual process. This paper traces teachers' use of planning frameworks in technology teaching and the impact on PCK and classroom interactions.

Introduction
This paper makes a case for the role of teacher PCK and how it influences, and is influenced by, planning. Planning frameworks were first developed in 1999 in response to teachers' difficulties in teaching primary technology, a new subject in New Zealand schools. The frameworks were artefacts that served as learning frameworks in a professional development research project and were used to help teachers develop their technology PCK. Further development of the technology frameworks was undertaken in 2005 and 2006. This paper traces the development of technology planning frameworks, and how their use impacted on teacher PCK and classroom interactions.

Investigations into the knowledge needed for teaching have illuminated the complexity of the knowledges teachers bring into play at the moment of teaching (Hiebert, Gallimore & Stigler, 2002; Shulman, 1987). The realisation is that teaching is a complex practice that cannot be dichotomised into knowledge and action (Boaler, 2003). PCK is concerned with how teachers shift from knowing subject matter/content to being able to translate and communicate that content so their students can learn it. This translation act is an active process where content knowledge and knowledge of practice have a symbiotic relationship (Rodrigues, Marks & Steel, 2003). A teacher needs to understand subject matter and be able to clarify subject matter 'in new ways, reorganise and partition it, clothe it in activities and emotions, in metaphors and exercises, and in examples and demonstrations, so that it can be grasped by students' (Shulman, 1987, p.13). Black and Wiliam (1998) identified distortions to classroom interactions, when there is minimal in subject knowledge and gaps in how that subject knowledge is represented and developed for students.

For teachers to teach technology in a manner that supports and extends student learning, they may need to develop new understandings and make changes to their current practices. Just like learners, teachers need supports to help them learn. Educative curriculum materials have potential as vehicles to support such learning (Ball & Cohen, 1996) as they offer representations of concepts, tasks, procedures and teaching approaches and can be used over time in classroom contexts (Schneider & Krajcik, 2002). Teachers' beliefs about subject areas, teaching, their students, and the curriculum materials influence how teachers interact with curriculum materials (Gunckel & Vandenbelt, 2006). As part of our project, science and technology curriculum materials for planning have been developed that are educative for teachers. In this paper data pertaining to technology are highlighted.

Background to the InSiTE project

This paper is mostly focused on the Classroom Interactions in Science and Technology Education (InSiTE) Project, which aims to explore primary (year 1-8) teachers work in science and technology classrooms during 2005, 2006 and 2007. An interpretivist research methodology is being employed. Data generation methods include classroom observations, student and teacher interviews, teacher workshops, and samples of teacher and student work. Teachers and researchers jointly contribute to the analysis to develop mutual understandings of classroom interactions, student learning, and teacher PCK. Teachers each teach a science unit and a technology unit of their choosing each year. At teacher-researcher meetings we have introduced and developed the planning frameworks.

Using a subject-specific planning framework as a learning tool for teachers is not a new technique for us. In the Learning in Technology Education (LITE) Project (Jones, Moreland, & Northover, 2001; Moreland, 2003) we designed planning frameworks reflective of the technology curriculum (Ministry of Education, 1995) with primary teachers. The LITE project was undertaken between 1998 and 2000 with 18 teachers when technology was a new subject in New Zealand schools. In 1998, teachers could identify technology tasks, but had difficulty identifying suitable technological learning outcomes and associated technological knowledge. Teachers focused on students completing practical tasks, so it was almost impossible to provide feedback to enhance learning at the conceptual and procedural level. In 1999 and 2000 we helped teachers develop their understandings of, and practices in, technology education. The intervention process was centred on using technology-specific planning materials for the articulation of technological learning outcomes (Figure 1).

Figure 1: Planning for learning outcomes in technology

<table>
<tr><td colspan="3">Task definition:</td><td>Technological Area/s:</td></tr>
<tr><td colspan="4">Overall dimensions of technology:</td></tr>
<tr><td>Conceptual learning outcomes:</td><td>Procedural learning outcomes:</td><td>Societal learning outcomes:</td><td>Technical learning outcomes:</td></tr>
</table>

Defining the main task and the particular technological area and/or areas helped teachers discern the overall direction for learning nested within a specific technological area. Teachers specified learning outcomes in four categories: conceptual, procedural, societal, and technical. As well, teachers considered how learning outcomes might coalesce and be put into practice holistically. An iterative planning process was required where teachers moved back and forth between defining the main task, articulating learning outcomes, and conceptualising and bringing together the technological practices embedded in the main task. This kept the categories coherent, interconnected and consistent. Teachers also completed another planning sheet that outlined the activities students would undertake in order to accomplish the main task and the intended learning. This also included assessment aspects such as key questions to ask students and aspects for summative assessment.

These frameworks proved to be useful for LITE teachers identifying what they needed to know to teach a topic, and the associated ideas, skills and attitudes. They prompted a subject-focused articulation of learning outcomes, and an identification of a main task to develop particular technological conceptual and procedural aspects, rather than just providing activities. We used the planning frameworks as ‘learning frameworks’ in our workshops. They became focal artefacts for discussion between teachers, and between teachers and researchers, and for fostering teacher development.

Findings of the InSiTE Project

In 2005 we concentrated on finding out about teachers existing knowledge and practices in science and technology. For technology, we introduced the LITE learning outcomes planning framework. All teachers used it alongside their customary planning. Though the planner helped them to focus on technology leaning outcomes, they were unwilling to totally discard their previous planning practices. Teachers' technology PCK translated into providing their students with activity-based, hands-on learning experiences. PCK was represented by their skill in locating, defining and refining tasks to take account of, and build on, students' knowledge, experience and interests (Wine, Moreland, Jones & Cowie, 2005).

The work in 2006 provided us with opportunities to introduce and refine the frameworks in the light of teachers' experiences and reflections, and researchers' observations and reflections. Because it was a challenge for teachers to plan in this detailed and subject-specific manner they required time and support. Conversations were important for helping to tease out the essential technology learning outcomes and linking these with appropriate pedagogical approaches. All teachers completed their planning for teaching technology using the frameworks. Though they acknowledged that it was difficult, they stated that collegial and researcher support, and opportunities to talk about their progress were key factors for successful use. Our findings from 2006 are presented in two sections: first, the development of the frameworks; and secondly, teachers' reflections on their developing PCK.

- Developing the frameworks

Since the technology learning outcomes framework was successful for the LITE teachers, we made no changes to it. However, we did work together on the accompanying lesson outline sheet. It links the pedagogy with the content. It now includes meso and micro tasks, focal artefacts, planned interactions, and key outcomes. We have helped teachers think more carefully about the activities they were planning, so that they maximised opportunities for students to achieve the learning outcomes. They recorded the focal artefacts that helped to structure lessons, focus attention, and introduce and develop ideas. The possible interactions they could have are itemised. These anticipate what to say when activities are introduced and worked through. Key student outcomes are listed, so that teachers run through how students might respond before they begin teaching. This lesson outline sheet helped teachers anticipate possibilities and undertake a dress rehearsal before classroom teaching. Jenny's lesson outline is shown in Figure 2. It details three of the nine technology teaching tasks she planned for her Year 5/6 class for designing and making percussion instruments.

Figure 2: Lesson outline

Teaching Tasks					
Macro	**Meso**	**Micro**	**Focal Artefacts**	**Planned Interactions**	**Key Outcomes**
Task: To plan, design and construct a musical instrument from materials used on the farm.	1. Introduce what musical instruments are.	1.1 How do instruments make sound?	Range of instruments. Pictures.	Brainstorming Share prior knowledge.	Confirm knowledge about sound.
		1.2 Why are instruments used?	People – DJ, Musician. CD player – CD's.	Discussion and sharing of favourite music.	Know that instruments play a role in society through entertainment/work.
	2.Investigate different materials used to make musical instruments.	2.1 Compare different materials and how they make sound.	String instruments. Metal instruments. Shakers. Recording sheet.	Groups with one instrument. Record sounds and share with class.	Know that specific materials make different sounds.
		2.2 Compare the same instruments made from different materials.	An instrument. Comparison sheet.	Partner discussion and share back with class.	

	3. Identify the features of a musical instrument.	3.1 Compare and label features of selected instruments.	Worksheet – • Features • Similarities • How they are used Instrument pictures	Share and justify choices. Why does that feature help the instrument to make noise?	Know what features are needed in order for their instrument to make noise.

Jenny's lesson sequence outline for creating a musical instrument was divided into nine lessons. Each lesson was unpacked into meso and micro tasks in order to achieve a match to the learning outcomes and planned interactions. Figure 3 shows three lessons and their division, focal artefacts, planned interactions and the key outcomes to look for. The division of the macro/main task into meso and micro tasks helped Jenny use her PCK to structure lessons so that links between lessons and within tasks were promoted (Moreland & Cowie, in press). The articulation and linking between focal artefacts, planned interactions, key outcomes and tasks indicated that Jenny had thought about ways to communicate what she knew about making musical instruments to her students in forms that were learnable.

Considerable skill and knowledge were required for planning in this way as teachers needed to be able to design and match the learning outcomes with the appropriate pedagogical approaches. Practice contributes to skills becoming more automatic, so teachers had more than one opportunity to trial the frameworks, and discuss the impact on their teaching.

> Planning together meant our units were more thought through, so therefore it was better for the students. (Jenny)

However, planning this way takes time to complete and is a difficulty with the model. Despite this limitation our teachers believed that the benefits outweighed any negatives.

> I haven't got the time to always plan like this. But my in-depth planning in technology produced the best teaching I've done all year. If I went in that depth for everything, my teaching would be better. It helps me know exactly where we're going, what to do and what questions to ask. (Jenny)

At the end of 2006 teachers acknowledged that they understood the frameworks better and their use had impacted on their technology teaching. There was a commitment to using them again in 2007.

> Last year (2005) I was not ready for this. But now I am. I want to try them again next year. (Carol)

- Teacher reflections on developing PCK

Teachers made several observations about how their PCK was developing for teaching technology. These were related to their enhanced ability to plan and enhanced classroom practices.

Enhanced ability to plan

They commented on how they planned more thoroughly, were better at discerning what they needed to know themselves before teaching, and were better able to outline student achievement goals.

> It has reinforced to me the importance of clarifying ideas before teaching and thinking ahead to what the children may think at each step to help with preparations. They are different and more thorough ways to plan science and technology units. (Brenda)

They were more concerned about planning to develop students' content ideas.

> It made me think about the correct terminology to use, that I then expected the children to use. (Carol)

They were now cognisant of the importance of planning in an inter-related way, and were able to select appropriate tasks and resources for developing particular ideas.

> Planning with macro/meso/micro tasks and the focal artefact helps focus teaching and learning into bite-sized chunks for both the teacher and the students. (Grant)

Including their interactions and key outcomes in planning was a new planning technique. They commented on the worth of thinking through these aspects and the impact on their subsequent classroom interactions.

> It made me think through each stage thoroughly instead of always having to think on my toes, which can often mean missing good opportunities, or not choosing the best way to do something. (Brenda)

As an advance organiser, the subject-specific planning frameworks focused teachers on identifying what they wanted students to learn and the pedagogical approaches to help students learn those aspects. Teachers synthesised the planning of learning outcomes and how to help students achieve them.

Enhanced classroom practices

Teachers acknowledged several gains in their science and technology classroom practices. They talked about how they used their plans as props while teaching.

> I often had the plan beside me when I was teaching. I used it a lot. It clearly marked where I wanted to take the children with their learning and what I would need to get them there. (Lois)

Teachers maturing PCK meant they developed the confidence to craft their interactions around science and technology ideas. Their confidence that they had the requisite PCK proved crucial to teachers being willing to engage in effective classroom interactions with students.

> Some things, concepts need to be deliberately taught, or brought to children's attention. You need to know what you want your children to know. Yes, it made me clarify what exactly were the technology ideas, so that I was better able to help the children. (Lois)

They thought about the barriers students might encounter and how they would deal with them. However, detailed planning did not restrict what they did in classrooms. Rather, because they were so prepared, they felt confident to depart from their plans in response to learners.

> With this planning I feel quite prepared, but I changed direction to suit children's needs and I might then present ideas differently than planned to establish learning. (Jo)

Teachers became clear about student learning goals and because their planning and interactions were focused, their students were also more aware of what was to be learned.

> Lots of discussion to clarify the task helped develop common goals. It is important to develop vocabulary, so that all children have an understanding that they can achieve. (Glenda)

Teachers' developing PCK meant that they knew what their students had learned. They described changes in their students' technological understandings, skills and attitudes.

> Overall the unit was a success. For the children this was their first introduction to food technology. All the children have learnt about prototypes and production lines and they know how to formulate their own prototypes and production lines. (Lois)

Finally, teachers commented on the benefits of developing their PCK through being involved in a community of learners. Working over time with other people on common problems was valuable for their learning.

> It has been great to discuss issues with other teaching professionals who are interested in science and technology. I have gained a lot of confidence. … My teaching, interactions and planning are more purposeful. I can see the bigger picture of these two subjects as not just being an extra to the core curriculum, but an integral part of children's learning.

Concluding comments

Improving teachers' planning as a means to enhance their PCK is not a simple matter. Change happens relatively slowly, and through sustained programmes of professional development. Both projects highlighted the importance of working with teachers to describe and build on their existing practices. The joint-development and use of curriculum materials as learning materials influenced teachers' knowledge and practices. The teachers needed to identify and plan for specific learning outcomes rather than just activities. Designing and using subject-specific planning frameworks were essential for helping teachers evoke and extend the PCK they needed to interact with students in ways that extended learning. These curriculum materials were educative, as they embedded guidance on reform-oriented teaching. The development of teachers' technology PCK is being achieved through an active process of developing subject knowledge and practice together in a symbiotic relationship. Since planning, and planning frameworks are dependable components of school culture from a teacher perspective, technology-specific planning frameworks can be valuable tools for introducing technology into classroom practice. The planning frameworks described here served as effective tools for supporting professional dialogue to help teachers identify task demands, appropriate pedagogical practices and to develop a language to discuss the complexity of student learning and assessment in technology.

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Didactic aspects on the education of entrepreneurship

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Abstract
It is essential to society, if we want the children of today to become the entrepreneurs of tomorrow, to increase the knowledge about *how, when* and *why* individuals take an interest in entrepreneurship. When children (or adults) are faced with entrepreneur-oriented tasks or problems, the actions that follow – what the individual does – are of great importance. To learn in different ways how to understand why pupils do what they do is, therefore, an important task for teachers and educators who teach entrepreneurship to children/youngsters.

One way for teachers and educators who teach entrepreneurship to find ways of adapting their teaching to the situation and environment in which their pupils find themselves, could be using analyses of one's own pupils' actions as a starting point for obtaining knowledge (and understanding) as to why pupils "do what they do. The explanatory model that I present in this paper – a pedagogical application of Georg Henrik von Wright's theory of logic-of-events (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 "entrepreneur-oriented" situations.

Initially, some results which are based on Swedish studies in regard to the attitude on the part of teachers and students vis-à-vis entrepreneurship are shown. Following this account an easy-to-grasp report is presented on a research- and evaluation project concerning teaching entrepreneurship in the municipal entrepreneur- and technology-oriented school system. Finally I argue that logic-of-events interpretations could be a useful pedagogical tool in the teaching of entrepreneurship.

Introduction
During the autumn of 2003 Nutek, having been commissioned by the SCB (The National Bureau of Statistics), carried out a survey about attitudes among young people in regard to entrepreneurship. The survey identifies several interesting connections in terms of young people's attitudes in regard to entrepreneurship. It seems that the willingness to become an entrepreneur is connected to whether or not there is someone close to you who is an entrepreneur. The number of those who could consider becoming an entrepreneur is greater among those who have family members, relatives or someone who is a close friend who are entrepreneurs in comparison to those who do not. The survey also posed questions regarding to what degree the school has provided them with knowledge about entrepreneurship and if the young people feel that the school encouraged them to become entrepreneurs. The results show that the number of young people who could consider becoming an entrepreneur is greater among those who were given information in school about what it is like to run a business, when they were compared to those who did not get a sufficiently good idea.

Another aspect of the study brings up is the issue about how young people perceive their entrepreneurial capacity, i.e. if they think they are capable of starting their own companies. The results show that those who have a strong faith in their entrepreneurial capacity respond, to a greater degree, that they are willing to use their knowledge and attempt starting their own businesses. Using the results of the SCB-studies as a starting point a number of *key factors* can be identified where each factor in and of itself, as well as when taken together, seem to benefit the development of someone's interest in entrepreneurship:

- Knowledge
- Experience

- Role models
- Self confidence

Entrepreneurship in the school
When commissioned in the summer of 2005 by Vetenskap & Allmänhet, (Science and the Public) Temo (a Swedish polling organisation) did a series of interviews[1] where 700 teachers (teachers in the 9-year compulsory school and comprehensive upper secondary school, headmasters and student teachers) were asked how they view the concept of entrepreneurship. The results show that most teachers perceive entrepreneurship as something that has something to do with running one's own business, being an entrepreneur. Among teachers in the 9-year compulsory school and student teachers one particular branch – the construction business – stands out as being connected to entrepreneurship.

The authors of the report summarize their results with the following statement:

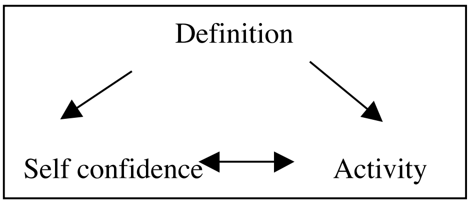
> All in all there seems to be a need for a more active communication in regard to what entrepreneurship is, as well as different kinds of support for teachers, a more active collaborative effort between the school and the world around it, and also improvements in teacher education.

The need for definition
The way in which teachers in their teaching define areas of knowledge, as well as concepts, to a great degree affects the content and working methods of education and training and thus, by definition, the students' experiences in regard to the issue in question.

In my research about pedagogical aspects of technology (Skogh, 2001) I have, in regard to how the students' define the area of knowledge related to technology, been able to ascertain that the choice of technological definitions is dependent upon and mirrors the students' earlier experiences of technology (or the lack of such experiences). The definitions chosen by the students also mirror the students' attitudes vis-à-vis technology and, therefore, will mirror the student's willingness to enter into the field of technological/technical studies. (Figure 1)

This constitutes a very important relationship for the school and the educational system. Knowledge about how individuals and groups perceive and define an area of knowledge can and should be used as a starting point for formulating strategies for development and intensifying of not only the definition of the actual area of knowledge but it should also be based on the interest in the area of knowledge in question and, thereby, (as a result thereof) also be based on the experience and the competence in regard to that area of knowledge.

Figure 1 The relationship between definition, activity and self confidence



I believe that there are grounds for asking the question: is this connection between the definition of technology, technological self confidence and the tendency to engage in technological activities also important to the development of an attitude vis-à-vis entrepreneurship? The area of entrepreneurial knowledge (as well as the area of technological knowledge) is "close" to the world of children and young people – so close in fact that it can be perceived as self-evident and therefore not too interesting to familiarize oneself with. Children and young people encounter many forms of entrepreneurship of

[1] Teachers on the subject of entrepreneurship. VA-report 2005:2, NUTEK & Science and the Public

so many kinds – they encounter it all the time and everywhere. It is far from an easy task for the schools and the educational system to make this “self evident” phenomenon in our daily lives visible and interesting.

The spirit of entrepreneurship

The image we have of what an entrepreneur ‘is’ is far from unambiguous. Just as with the concept “technology”, we all carry around images in our minds that are influenced by our earlier experiences. The fact that different players provide different images of entrepreneurship and running a business is understandable, but no less problematic.

Questions of what students need to learn in order to develop and become good entrepreneurs and businessmen/women have been discussed and can be discussed further. Entrepreneurship is given a shape or form in activities such as Open for Business and Young Entrepreneurship (Ung Företagsamhet) through programs where young people in upper secondary school levels are given the opportunity to run their own “companies” and in a program like “*having a flash of genius*”, which is geared towards younger students, the ambition to stimulate young people’s joy of discovery and creativity, is combined with the ambition to create in children an interest in technology. Even though these activities are different in many ways there is a common denominator in the fact that entrepreneurship, when being a part of these activities, has a clear connection to actions taken.

The importance that these activities, or businesses, attach to the actions of the individual in terms of development of the ability of entrepreneurship is given support by Professor Bengt Johannisson, who is Sweden’s foremost researcher within the area of the science of entrepreneurship. Johannisson has spent many years researching this issue, and his research highlights different aspects of what we might call the “spirit” of entrepreneurship.

Johannisson (2005), too, connects the entrepreneurial process to the entrepreneur and his/her actions: Entrepreneurship is, therefore, very much about recognizing the fact that as a human being you are special and that, because of this, you have to become an active participant in the social circumstances that shape the identity…Self-realization is about living in the here and now without taking it for granted but still believing that together with others you can do something in every situation, as well as about every situation. (a.a. page 346)

The fact that Johannisson puts such great importance to the actions of the individual in the entrepreneurial process is interesting and has consequences for those teachers and pedagogues who teach entrepreneurship. If it is of central importance, teachers need to learn to understand how and why students act the way they to when they encounter the concept of entrepreneurship.

Evaluation study

Currently an initiative financed by Nutek is in place in four of the country’s KomTek Centres (Örebro, Örnsköldsvik, Härnösand and Halmstad), where the emphasis is on entrepreneurship and running businesses. I was given the task to evaluate these activities during the spring of 2005. Primarily I had to evaluate how well each KomTek-Centre had fulfilled the targets in relationship to the targets they had set for themselves, as well as in relation to the targets described by Nutek; pedagogical aspects were also highlighted in the evaluation.

The issue of *what* students need to learn in terms of running a business and entrepreneurship is observed by various players in society. Several concepts for education and training as well as study materials have been produced by many different players (e.g. the above-mentioned Young Entrepreneurship, Open for Business). There has rarely been a focus on pedagogical research in the area of entrepreneurship in regard to *how* this is best carried out and how it is done.

In this paper I attempt to highlight the '*how aspect'* by presenting the explanatory model that I have used in my evaluation study of the entrepreneurial activities in the four KomTek-Centres.
The logic of events – a theoretical model for explaining actions

Since I have, for so many years, been working in the field of research on the pedagogical aspects of technology there are, as I have previously pointed out, many parallels between the areas of knowledge concerning entrepreneurship and those concerning technology. Apart from the obvious fact that when you work with both entrepreneurship as well as technology, you encounter at least one, but more often several parts of the processes of idea/innovation _ technology/function _ design _ production _ marketing, and you will then find that there are other similarities. In all these areas of knowledge there are other factors such as knowledge, experience, self-confidence and role models, which are all of great importance in terms of how the attitude towards the respective area of knowledge develops.

When I had to decide on the choice of a theoretical starting point for my analyses of the KomTek Students way of acting in entrepreneurial situations it became natural for me to use the same theoretical model which I had previously used in my research on pedagogical aspects of technology – Georg Henrik von Wright's theory on the logic of events. In what follows I am giving an overall view of von Wright's model of thought, which I have developed (Skogh, 2001), and the pedagogical application of his theory.
In the essay, Determinism and the Study of Man (1983) Georg Henrik von Wright formulate his theory about the logic-of-events. Logic-of-events interpretations are based on the fact that we can learn how to identify determinants of individuals (their intentions and epistemic attitudes 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 a pupil in an entrepreneur-oriented situation. von Wright identifies four different intentions:

- The intention *wants* refers to what the individual wants and/or considers him or herself in need of. In a teaching context, the teacher has to convince the pupil that the knowledge and experience the teaching is aiming at is in accordance with the needs and wishes of the pupil.
- The intention *duty* refers to the individuals "internalised" expectance to act in accordance with a defined role – to behave in a certain way.
- The concept *ability* refers to the pupil's individual characteristics in the classroom situation. A pupil's ability is limited both by inherited (intelligence, memory, health, physical strength) and by acquired (learnt) qualities.
- The intention *opportunity* refers to the conditions governing the situation – expectations, resources and the balance of authority.

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 or 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. The 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" the individual (here the pupil) to act, that the intention curiosity is introduced as an intention of its own. _

In addition to the intentions mentioned above, the pupils' perceptions of demands of the situation – their *epistemic attitude* – are also included as an internal determinant.

An individual's 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 or her role as a pupil – is of decisive importance as to how the pupil will "succeed" in the 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 or her epistemic attitude.

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 external logic of an individual's behaviour. In order to understand the external logic of a pupil's behaviour in "entrepreneurial" situations, we need to know as much as possible about the conditions of the current events – the current "entrepreneurial 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 this subject.

Logic-of-events interpretations a pedagogical tool in the teaching of entrepreneurship
By systematically analysing pupils' actions, acquire a deeper knowledge about their pupils which makes it possible to relate the teaching of entrepreneurship 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 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 in formulating successful strategies for the future of teaching entrepreneurship.
The systematic structure of the model makes the teacher/pedagogue aware of aspects in the pupils' behaviour (which can form possible pedagogical points of connection for the teacher/pedagogue) which otherwise might go undiscovered and unutilised. Further, every logic-of-event interpretation encompasses the fact that the teacher/pedagogue takes a stand in terms of how the actions of the pupil relate to all "categories of intention" – not only those he/she judges to be the most probable, but also other possible interpretations. The intellectual and mental preparedness which this provides opens up to sensitivity towards not only the individual pupil in the actual situation, but also to other pupils in similar situations. Logic-of-events interpretations of pupils' actions can, thus, be said to increase the awareness of the pupil as an individual but also of the pupil as part of a larger context – of the complexity that influences every teaching situation. Insight into this complex issue can be said to constitute a valuable basis for the pedagogical work.

Notes:

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

_ 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.

_ 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.

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Transferring Design Rich Ideations within the Technologies

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Abstract.
Many believe Irish culture is 'design impoverished'. A country's culture generally defines its people. A school culture profusely defines its students. Is the school culture within the Irish Education system hindering or developing students "designerly ways of thinking" [1]. Are the classroom design activities fully promoting student creativity?

Design is 'something' that can be taught. Design is an activity that requires aptitude, skill, creativity and innovation. Aptitude can be gained, through appropriate experience. Skill can be developed with time. Innovation is the extent to whether design is a success or failure and depends on the creator's or student's ability, which is something that is influenced by nature and nurture [3]. However design can be taught. Students do not have to succeed at everything, they simply must discover and enjoy. Design is in our everyday lives from our waking to sleeping moments. Education should be about life long learning, developing skills to aid us in life and creating a better quality of living. However design pedagogy is not sufficiently encompassing these significant factors.

Discovering the way one prefers to learn, whether by reading, writing, seeing, hearing, doing and so on, needs to significantly influence design teaching. The practices occurring in second level education are mainly didactic, which do not appeal to the majority of the student cohort. The effect of acknowledging ones preferential learning style (PLS) will increase learning and understanding and also make the teaching profession more interesting and rewarding. However the teacher cohort in the second level education sector needs to be aware of PLS and focus pedagogy towards the PLS. This paper discusses issues relating to design pedagogy and how strategically implementing a pedagogy focusing on students PLS can create an improved and more productive learning environment for design activity within the Technologies.[1]

Design as a 'process'.
When the term design was observed in a dictionary many different meanings were identified. "*Design is first of all a process*" [14]. Lawson *et al* reinforce this idea by stating "*the design world would argue that design is itself also a process of discovery, of learning and even a form of research."* [4] According to PATT research pupils who have had no exposure to technology usually associate it with products/output rather the process to achieve an output. [8] So the activity of designing normally ill-defined as a 'design process' is not something many agree upon. However for the correct description of practice as occurring in Second level education, the activity of designing will be referred to as a 'design process' in this paper.

A 'design process' used in most educational systems is linear however this contradicts the reasoning behind why one 'designs'.

> "*The design process is not linear; it is rather a complex activity similar to a game's strategy but strangely it is a game where the rules are continuously changing and that is what makes it so fascinating and mysterious."* [13]

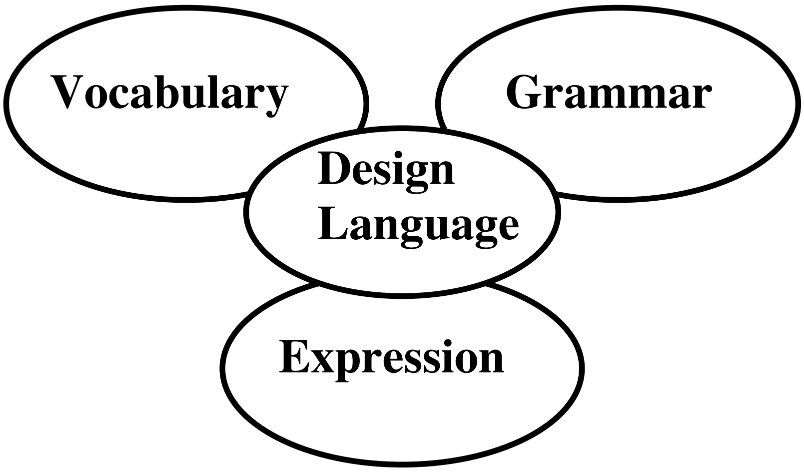
[1] 'The Technologies' in the Irish Second Level Education system consist of Materials Technologies, Technology, Design and Communications Graphics, Architectural Technology, Engineering Technology.

A design process evolved primarily as a problem solving process due to a problem. Design on the other hand does not occur due to a problem but rather due to ill-defined problems. [18] However the design process is being used to design in a problem solving methodology in education systems, which is causing difficulty. This 'design process' being used has not been proven in its effectiveness or its existence in practice (in industry / the 'real world') As Papanek described "*all men are designers. All that we do, almost all the time, is design, for design is basic to all human activity. The planning and patterning of any act towards a desired, foreseeable end constitutes the design process.*" [16]

Highlighting the dilemma of Design Pedagogy in the current Education System.
In the design core of the Technologies, within the Irish second level education system, a barrier is evident between design pedagogy and a problem solving process. Teachers partake in intensive training to become qualified as professionals. However in our ever-changing world, needs and society are changing. Buchanan highlights that "*Others will argue that the problems of the 1990's require new ideas and new knowledge to supplement natural talent: the design profession must respond in new ways to the changed environment.*" [5] The same could be said of the teaching profession. At present significant changes are occurring within the Technologies. With these changes a stronger demand is being placed on education. Four new design based subjects are being introduced both as a reformation of old syllabi and also creating new syllabi. All of these subjects have a design aspect. However there is no defined pedagogy in place to aid teachers or effective communication to build the areas of ambiguity. At present design is predominantly taught to assessment and design projects are executed to meet the needs of this assessment. This research project highlighted that the majority of both teachers and students do not fully understand the activity of design in the present Irish education system. Practioners of design in both industry and education were interviewed to compare the activity of design between the educational institutions. The results highlighted a diverse understanding and ability to teach design on a practical level in one of the institutions. So why is this major dilemma occurring. One fault is the basic understanding of what is the language of design and also what constitutes this language.

The components of a language.
Our first form of education, language, consists of the primary elements for future learning. This involves vocabulary, grammar and expression. Vocabulary starts with the alphabet, each element having its own distinct sound. Merging these and developing the understanding we can progress to grammar. Everyone can be taught vocabulary and grammar. The ability to use the vocabulary and grammar creatively and with intuition shows a person's expression. These three elements of language; vocabulary, grammar and expression; can be present in all forms of learning, whether it is learning music or dance, they are all made up of their own 'language'. This language does not have to be present in words to be understood. It can be conveyed through symbols or illustrations. The most important thing about a language is that is conveys meaning and evokes its principle. So what are the components for the language of design? (Figure 1)

Figure 1: The components of a language.



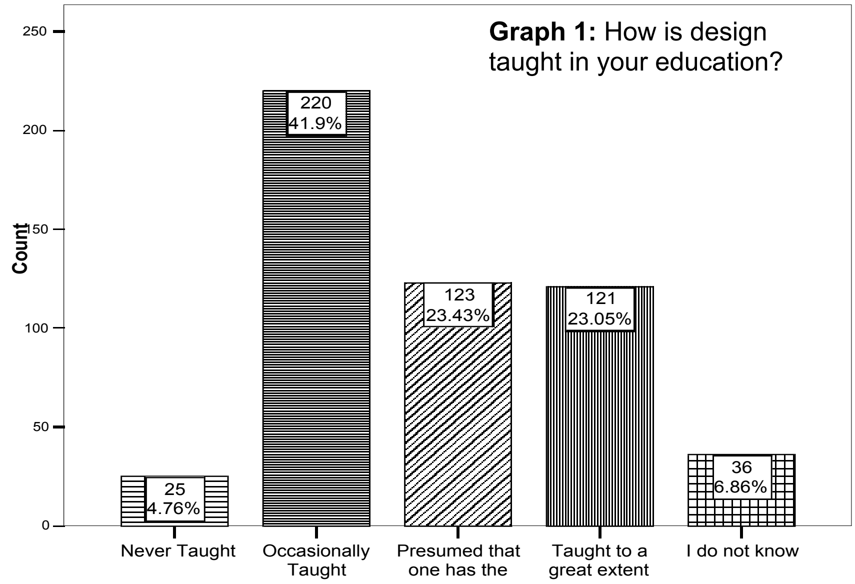
The language of design.
What is the vocabulary of design? Designs' vocabulary is generally seen as a process. The appropriate process or strategy is what forms design. Each element of a process has its own distinct function and purpose, each being an ultimate necessity to designing. However with so many processes available confusion begins to occur. Although many excellent designs and solutions are accomplished intuitively and without a defined structure. Nevertheless one can identify a similarity between the various processes. The common elements of these similarities include:

- Identifying the problem.
- Research into how to remedy the problem.
- Create a solution.

What is the grammar of design? In terms of the English language it constitutes the ability to amalgamate the vocabulary into a form, which shows understanding and aids understanding. The same can be described in the case of design. 'Grammar' is putting together an entire process of designing to arrive at a solution. However the success or failure of this solution depends on ones expression. Expression deals with ones skill. Using the language of design uses this skill to produce a successful product, system etc. However it is believed by some that expression cannot be taught wholly but can generally be a developed skill is as a result of knowledge and practice. The necessity to understand the language of design is urgent. Design pedagogy cannot occur without a clear understanding of what is being taught. The entire make-up of design needs to be established in a manner that can be transferred to a level that can be adapted to the design activities within the Technologies.

Establishing pedagogy to design language.
Can the language of design be introduced into the pedagogy of design and at the same time take cognizance appeal to the preferential learning styles of students? Understanding, enthusiasm, innovation and motivation are some of the necessary abilities or skills required in developing the meaning of design. A meaning of why one needs to teach design must be established. The forefront to this is the history of design. The history of design evokes understanding and reason to the purpose of design. With a clear purpose our reason for doing becomes a lot clearer. This purpose needs to be established amongst teachers. Also the actual practice of designers needs to be structured and used to aid designing in the classroom environment.

Instructional design has potential in the implementation of a structured approach to design practice within our education system. The advantage to instructional design is, in reality, that the designer is constantly looking back to ensure all the subject matter is accurate and in accordance with theories and principles. This practice is necessary in terms of successful design. This practice was described at The Dyson Story and Design Methods symposium held at the University of Limerick (April 2006), which gave an insight into the actual professional practice of designing. The presentation comparatively and practically outlined the actual practices occurring in industry, which contrasted significantly with current practices in Engineering and Technology education. Aled James, a Dyson design engineer, described their professional practice to designing in which "*a 2-Dimensional sketch is the initial stage to any new product, which is followed by prototype modeling"*, using cardboard or another material. All the detailing is done on the cardboard model. *"After this critical modeling then a CAD version is composed."* (Aled James). This methodology does not occur in second level education for many reasons; resources, time, materials, skill and funding to name a few. These shortcomings are causing design to be an abstract topic within education. For example there is often a tendency to compare the expense in the design, so as to quickly arrive at a solution. Supplementary reasons, such as the pedagogy used, highlight the malpractice occurring in terms of design education. This became evident due to the responses by students involved in the study when posed with the question "How is design taught in your education?" (Graph 1). A mere twenty-three percent believe that design is 'taught to a great extent'. No more than a quarter of students in the study[2] believe how design is taught is 'unsatisfactory.' Another alarming figure is the response to 'occasionally taught' with a mere forty two percent.

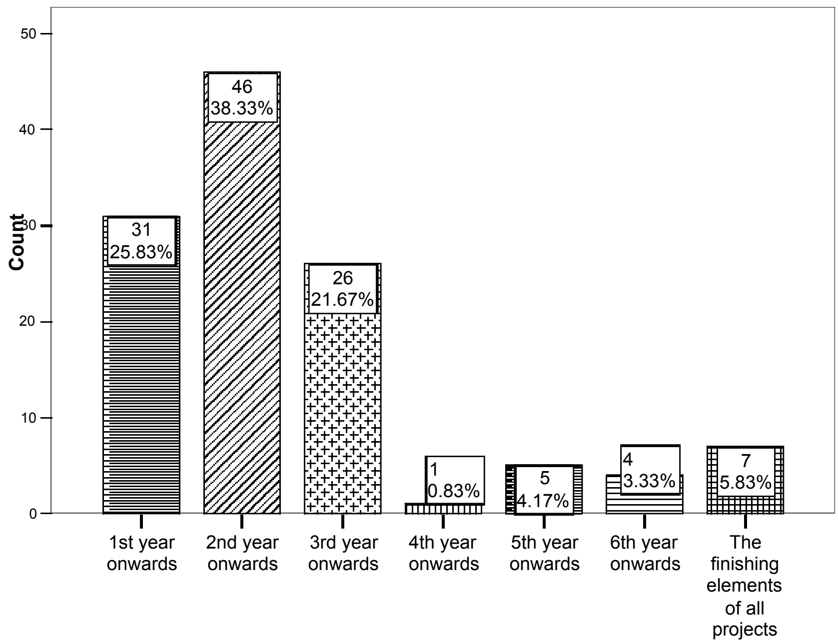


Graph 1: How is design taught in your education?

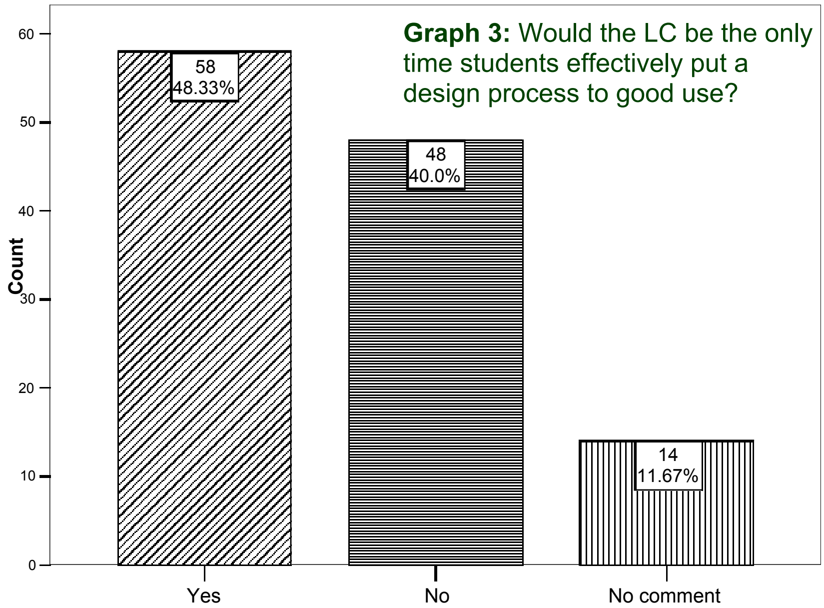
However in the 'never taught' response category nearly five percent of students believe that design is not taught in their education, which is huge and shows the imperative need for design pedagogical strategy to be developed and implemented.

[2] The study cohort comprised of students ranging from Junior Cycle to Senior Cycle (equivalent to the O levels and A levels), which is an age bracket 12 to 18.

Importantly the thought process for designing should not be linear, which is the predominant system implemented by teachers within Engineering and Technology education. According to Cross "'Designerly' *way of thinking and working"* are not systematic [2]. The detrimental factor, which would allow design to be systematic, is whether design is determined or indetermined. If the design is determined this allows for a definite set of conditions. The 'wicked problems' approach caters for indeterminacy. Students develop their *"own idea in a short span of experience"* [6] which they consequently use to aid their designing. Rittle was the first man to initiate the idea of 'wicked problems' of which has ten properties. He believed that designing could not be a systematic process but rather unorderly. [5] Determined design is the predominant practice occurring in design education for first and second year groupings. (Graph 2)



In terms of the Leaving Certificate[3] (LC) teachers were asked 'is the LC the only time that students effectively put a design process to good use' and nearly half (48.5%) said "yes". (Graph 3) This is a very huge figure for LC students who will either progress to industry or further education, and yet must effectively design with minimal tutorial intervention.

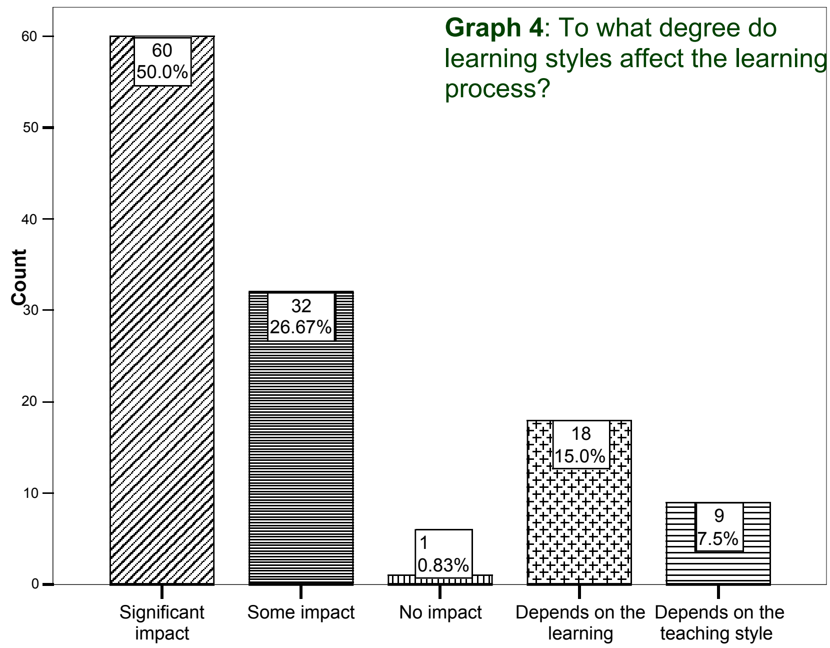


At present there is no established pedagogy in place for design within the Technologies. This pedagogy is becoming more urgent with the upcoming implementation of the new syllabi in the Leaving Certificate. If a design pedagogy, which underpins the educational objectives, is not established the same problem will continue to persist as described by Churchman with a *"significant proportion of teachers who doggedly persist with a craft skill based curriculum and who refuse to engage with the concept of technological capability."* [7]

Preferential learning styles are elementary to establishing a clear understanding the language of design.

If a design pedagogy is to be established, then it is essential to understand and learn how students take in information best. If the teaching style is harmonised with the student learning style it improves the learning and understanding for the student at all levels. Though at the same time varying ones teaching style helps students develop learning styles in addition to their PLS that will benefit them further on in life. According to Felder, "*Students whose learning styles are compatible with the teaching style of a course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject*." [9] This finding is supported by the work of Silverman [10] and Seery et al. [17]

[3] Equivalent to High School Certificate or O levels and A levels.



Currently in schools the pedagogy is aimed toward one (maybe two) specific type of learner, verbal and sequential. Only 50% of the teacher cohort surveyed believes that learning styles have a 'significant impact' on the learning process (Graph 4). This figure acknowledges the urgent need to make learning styles an integral part of all aspects of education.In 1991 Felder and Soloman developed an indicator to try and establish students PLS. After which, Felder and Silverman then designed the Index of Learning Styles (ILS), which has been established in relation to the four dimensions of the Felder –Silverman learning style model. [11] The Felder Silverman ILS was used in a study relating to this research (May 2006) to determine the PLS of the students involved in engineering and technology which was used parallel to the design impression of students.

Table 1, composed by Felder and Brent [12], consists of all the reported PLS studies. Table 1 has been used as a comparison for the results gained as a result (Table 2) of the study, which consisted of approximately 530 students.

Table 1: Reported Learning Style Preferences.

POPULATION	A	S	Vs	Sq	Reference
Iowa State Materials Engr.	63%	67%	85%	58%	Constant (1997)
Michigan Tech, Env, Engr	56%	63%	74%	53%	Paterson (1999)
Oxford Brookes Univ., Business Internat. Students	64% 85% 52%	70% 86% 62%	68% 52% 76%	64% 76% 52%	De Vita (2001)
Ryanson Univ., Elec. Engr.	53%	66%	86%	72%	
Students (2000)	60%	66%	89%	59%	Zywno (2001)
Students (2001)	63%	63%	89%	58%	Zywno (2002)
Students (2002)	38%	42%	94%	35%	Zywno (2003)
Tulane, Engr.					
Second Year Students	62%	60%	88%	48%	Livestay (2002)
First Year Students	56%	46%	83%	56%	
Universities in Belo Horizonte (Brazil)[b]					Lopes (2002)
Sciences	65%	81%	79%	67%	
Humanities	52%	62%	39%	62%	
Univ. of Limerick, Mfg. Engr.	70%	78%	91%	58%	Seery (2003)

Univ. of Michigan, Chem. Engr.	67%	57%	69%	71%	Montgomery (1995)
Univ. of Puerto Rico-Mayaguez					
Biology (Semester 1)	65%	77%	74%	83%	Buxeda (1999)
Biology (Semester 2)	51%	69%	66%	85%	
Biology (Semester 3)	56%	78%	77%	74%	
Elect. & Comp. Engr.	47%	61%	82%	67%	
Univ. of Sao Paulo, Engr.[a]	60%	74%	79%	50%	Kuri (2002)
Civil Engr.	69%	86%	76%	54%	
Elec. Engr.	57%	68%	80%	51%	
Mech. Engr.	53%	67%	84%	45%	
Indust. Engr.	66%	70%	73%	50%	
Univ. of Technology Kingston, Jamaica	55%	60%	70%	55%	Smith (2002)
Univ. of Western Ontario,	69%	59%	80%	67%	Rosati (1999)
Engr.[a]	66%	59%	78%	69%	Rosati (1996)
First Year Engr.	72%	58%	81%	63%	
Fourth Year Engr.	51%	40%	94%	53%	
[a] Data collected with Version 1 of the ILS (All other studies used Version 2.)					

Table 2: PLS of students in design in the Technologies.[4]

A	S	Vs	Sq
67%	**43%**	**88%**	**37%**

From comparing the findings on Table 1 and the results from Table 2 it is evident that the students in Engineering and Technology conform to the other engineering studies around the world. In terms of the engineering student average (Table 2) two figures from the research do not conform to the "norm". The data was checked to see if it was normally distributed, the normality tests used where the Kolmogorov – Smirnov and the Shapiro – Wilk. Both tests indicated that the data was not normal. However the students involved have yet to complete their post-primary education which should cause further developments and advancements in their present PLS's. Also significant differences occurred between student gender, school cohort gender and school type. As the data was proven to be of non-parametric nature and the experimental design was unrelated, the Mann-Whitney U Test and Kruskal-Wallis H Test were chosen to analyse the differences between the independent and dependent variables.

Table 3: Influence of Gender, School Type and School Gender on PLS.

	A	**S**	**Vs**	**Sq**
Student Gender[A]	0.84	0.237	.054	0.925
School Type[B]	0.032	0.043	0.258	0.509
School Gender[B]	0.011	0.097	0.285	0.291

[A] – Mann-Whitney U Test
[B] – Kruskal-Wallis H Test

For the Mann-Whitney Test results (P-values) which are not less than or equal to 0.05 are not significant. Therefore there is no significant difference in the PLS of males and females (Table 3). However for the Kruskal-Wallis Test, if the significance level is a value less than 0.05 then one can conclude that there is a statistically significant difference in the continuous variable (PLS) across the groups. In the Kruskal-Wallis Test for the significant difference between PLS and school type, two PLS showed a significant difference (Table 3). These PLS were 'A' and 'S' and inspecting the mean ranks for the school types suggests that the Community School[5] had the highest A scores, which signifies the preference for the active and sensing style of learning. Whereas surprisingly the Vocational School[6] reporting the lowest ranking shows its signicant preference for the reflective and

[4] A-Active (Reflective), S-Sensing (Intuitive), Vs Visual (Verbal), Sq Sequential (Global) – See Appendix 1.

[5-8] Community School, Vocational School, Comprehensive School, Secondary School–See Appendix 2.

intuitive learning styles. In the other PLS there is no significant difference in the PLS of the Comprehensive School[7] and the Secondary School[8]. The significant difference between PLS and school gender, three PLS showed no significant difference and the A showed a significant difference (Table 3). In terms of the mean ranking the female school showed the highest 'A' scores, which shows the significant preference for the reflective style of learning. On the other hand the co-educational school reporting the lowest mean ranking, highlighting the significant preference for the active learning style. As the findings of the study shows that differences are evident between the various school types and school gender. As a result the need for varied strategies in terms of the implementation of suitable design pedagogies further highlights the need for reform and redress the current practices.

Conclusion.

People who practice design are from a variety of backgrounds, which makes 'design processes' and strategies difficult to define. A definition may have to be replaced by a generic description of activities both cognitive and practical. The many processes in place have been simplified, however are they bypassing the true activity of design? Or is the methodology used in implementing a process creating the ambiguity? Teaching is a complex activity. What works for one teacher may cause the opposite effect for another. A deeper understanding of what is design is required, how it works, and how students and teachers can make it work for them. As the research progresses strategic design taxonomy combining with preferential learning styles appears to be informing best-practice design pedagogy. In order to discover what strategy is suitable for both teachers and students we need to establish the pedagogical style and preferential learning style which will suit each individual in terms of transferring design rich ideations. This strategy must have extreme parameters in so far as to adapt to the various teaching styles and learning styles, which vary for each individual and for each activity. However this strategy is possible with the correct positive attitudes from teachers to reform and create the suitable learning environment with a clear understanding to the meaning of design and its principles. From current practices it is evident that the pedagogy practiced in design activity is not fulfilling one of its aims *"to facilitate the development of a range of communication skills, which will encourage students to express their creativity in a practical and imaginative way, using a variety of forms: words, graphics, models, etc."* [15] An emerging pedagogy must provide a learning environment, which will be significantly flexible to combine teaching styles and student PLS's to the benefit of all concerned.

Appendix 1: Preferential Learning Styles.

Active: Retain and understand information best by actively doing something with it.
Reflective: Think quietly about the new material.
Sensing: Like learning facts. Solve problems using well-established methods. Practical. Careful.
Intuitive: Prefer discovering possibilities and relationships. Innovative. Dislike repetition. Fast worker.
Visual: Remember best in what they see-illustrations. (Majority are visual learners.)
Verbal: Get more out of words.
Sequential: Gain understanding in linear steps, each step following logically from the previous one.
Global: Learn in large jumps; absorb material randomly without seeing connections until suddenly.

Appendix 2: School Types.

Presently in the Republic of Ireland there is a range of educational institutions varying in ethos, modes of instruction, subjects, and management structure. The school types include voluntary secondary, vocational schools, community schools, community colleges, and comprehensive schools.

Voluntary secondary schools are the most popular, providing for fifty five percent of students. Traditionally secondary schools have provided a more 'academic' education however in recent years they have introduced practical and technical subjects. Secondary schools are privately owned, were originally managed by religious communities, but most are now run by laity appointed Boards of Governors or by individuals.

Vocational schools hold twenty nine percent of students and are administered by vocational education committees, which are statutory bodies. The main focus was in terms of the development of skills and vocational training. Nowadays, however, the full range of second-level subjects is available. Vocational schools are also the main providers of adult education and community education courses.

Community schools make up nearly eighty schools in Ireland. A Board of Management manages community schools. These schools offer a broad curriculum embracing both practical and academic subjects. They also provide facilities for adult education and community development projects. These schools are entirely funded by the State through the Department of Education and Science.

Comprehensive schools combine academic and vocational subjects in a wide curriculum. A board of management representative of the diocesan religious authority, the Vocational Education Committee of the area and the Minister for Education and Science manages these schools. The schools are financed entirely by the Department of Education and Science. These were set up to give recognition to a compromise between Secondary and Vocational Schools. Their numbers are few, amounting to ten schools of post primary schools in the country.

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Comparison of depictions by middle school students elicited in different contexts

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Abstract

Drawings are important in design and are a major part of technological activity. This paper presents analysis of drawings produced by Indian middle school students in different contexts: while designing in a D&T task, translating textual information to depiction, and while depicting the solution to a problem stated in text. The tasks included drawing of simple and complex, static and dynamic objects. In all tasks students used exploratory sketches and several strategies to translate their ideas of 3-D objects on to paper (2-D): perspectives, graphical symbols (lines, circles, etc), selective abstraction, X-ray drawings, etc. Depictions of assembly had more annotations than depictions of static and assembled objects. Explorations in the design context were more than in any other context. The findings suggest that design and technology education units could encourage activities in school curricula, which can enrich students' drawing and visualisation skills.

DRAWINGS IN TECHNOLOGY AND EDUCATION

As part of our everyday activities, we manipulate and maintain technological objects. This offers scope for visualisation of relations between structures of artefacts and their functions. We refer to artefacts in our interactions using verbal and non-verbal communication modes, which may include talking and gesturing, verbal descriptions, reading and making drawings. Such communication and thinking with drawings and pictures has been an essential strand in the intellectual history of human development in general and technological development in particular (Ferguson, 1977).

Visualization and externalization of objects

We often understand the diverse objects around us through our knowledge about their spatial and functional distinctions from other objects. It is known that expressing ideas in a visuospatial medium, such as drawings, photographs, models, etc., makes comprehension and inference easier than in a more abstract medium such as language (Tversky, 2002). Drawings aid in the development of reasoning and problem solving skills, and cut across disciplines.

Drawings are preferred over textual representations for externalising and sharing of ideas among designers, architects and engineers. Whereas text is serial in nature, drawings explicitly preserve information about object geometry and topology (Ullman, Wood and Craig, 1990). Besides, they can be used to convey the dynamics of objects and their assemblies (Hegarty, 2004). Literature reveals that adults use sketches and drawings as an aid to thinking (Suwa and Tversky, 1997; Scrivener, Ball and Tseng, 2000). For children, drawings are a spontaneous form of expression (Ramadas, 1990). Designers have been noted to make sketches that are tentative, vague and incomplete (exploratory sketches). Like designers, students also use drawings to think, visualize and reflect on their ideas, especially when engaged in problem-solving (de Bono, 1972) and design (MacDonald and Gustafson, 2004; Hope, 2000). Preliminary design ideas are explored by students through sketches. Students' drawings give us insight into the strategies used by them to visualize and manipulate their ideas of objects and assemblies in different tasks. Anning (1997) has emphasized the role of graphicacy as a tool for learning and recording thinking in classrooms. However, present teaching practices from the primary through high school, either in drawing as a subject or drawing as an aid to learning other subjects, fail to encourage drawing as a mental (cognitive) engagement.

Drawings of objects and assembly in different contexts

Drawings based on oral or textual descriptions may differ from those that emerge from contexts such as design, where drawings emerge without reference to an already existing tangible object, drawing or textual description. Drawings may be of simple objects, symmetrical shapes, or complex objects as in a multi-component dynamic system. In the design context, there are no right or wrong drawings: sketches represent explorations of ideas, while drawings represent the visualised design. Reasoning about assembly and dynamic mechanical systems involves visualisation of the location of objects, their shapes and spatial connectivity (Hegarty, 2004).

Students' understanding of a concept of an object like a pair of scissors is based on their judgements of its structural and functional attributes, and their own experiences. Their depictions may reflect the associations that they spontaneously make with the term (Natarajan et al, 1996). Drawing an assembly of objects based on textual descriptions and cues involves verbal understanding and its translation to spatial depiction, in which both spatial and verbal abilities play important roles. The description could have all the details of artefact(s) to be drawn in the textual form and require students to interpret the text, visualise and depict the artefact on a paper. The depictions may match the description to a lesser or greater extent, reflecting students' textual comprehension, imagery and depiction skills.

Objectives

The study is based on middle school students' paper-pencil productions in two experiments carried out at different times that explored middle school students' representations of simple and complex, static and dynamic objects in three contexts. The following questions are addressed here:

1. How do different kinds of objects and contexts influence exploratory sketches?
2. What aspects of the description do students represent in their drawings and what ideas do they use to depict an object?

METHODOLOGY

The data used in this study comes from the productions of students in two experiments given below.

Experiment 1 – Design context

The trials of a Design and Technology (D&T) unit required groups of students to design and make a windmill model that can lift a given weight. Details of the trials are discussed in an earlier paper (Khunyakari et al, 2007). Students worked collaboratively to design their group's windmill model for about 2.5 hours, making exploratory sketches (tentative and incomplete), technical drawings (dimensioned finished product) and procedural maps (plan of making).

Experiment 2 – Depictions from textual descriptions

The experiment involved two tasks set in different contexts (see Figure 1): (i) *depicting objects based on textual description* followed by (ii) *depiction of a solution to a problem stated in text*. The tasks were completed in 1.5 hours. Students could use as many sheets of paper as needed for making exploratory sketches (tentative) and final drawings. The responses to the first task were collected before administering the next.

Sample

This study was in a socio-cultural setting, where students had different home languages and English as medium of instruction in school. Within the setting, students' willingness to participate in the study, the proximity of the school to researchers' institution and the existing rapport with the school management influenced the selection of the school and sample.

The sample for the design activity in Experiment 1 was 19 students (9 girls, 10 boys), who had just completed Grade 6 (about 12 years). The activity involved students working in 6 groups: 2 groups of girls, 2 of boys and 2 mixed sex (boys and girls) groups.

The sample in the second experiment on depicting objects from text consisted of 60 students (21 girls and 39 boys), who had just been admitted to Grade 8 (about 13 years). Students responded individually to the two tasks set in this context.

Task 1: Ramu is a car mechanic, who has studied only till Class 3. One day, his supervisor gives him a list of items, which he has to buy or assemble. Ramu shows you the list and asks you what is written in the list. Make drawings of each item in the list for Ramu, so that he can know what to bring and assemble.

Item 1: One 100 mm long solid metal cylinder of diameter 20 mm

Item 2: One 150 mm long hollow PVC pipe of inner diameter 25 mm and outer diameter 30 mm

Item 3: The solid metal cylinder (Item 1) has been placed inside the hollow PVC pipe (Item 2).

Task 2: On her way from the vegetable market on her bicycle, Lata's bicycle chain suddenly came off. Lata started to walk home. Imagine that she met you along the way and asked you about the assembly and working of a bicycle chain. Draw a diagram to explain to Lata the assembly and working of the chain and pedal arrangement in a bicycle.

Figure 1: The two tasks in Experiment 2

ANALYSIS

Students' responses on Experiment 1 and the two tasks of Experiment 2 were in the form of paper-pencil productions. The following aspects were used to analyse and compare students' productions in the three task contexts.

Visualisation and meanings

- *Extent of explorations:* The number of students' explorations for parts and assembly in each task was recorded and compared across tasks.
- *Spatial attributes:* For Experiment 2, space was provided for the date and student's name at the top of each rectangular sheet of paper in the portrait mode. Students maintained this orientation of the page in their drawings, which served as reference for vertical orientation of their productions. Depictions of objects and assemblies in vertical (longer dimension perpendicular to the baseline), horizontal or along any other direction were recorded.

Graphicacy skills in depictions

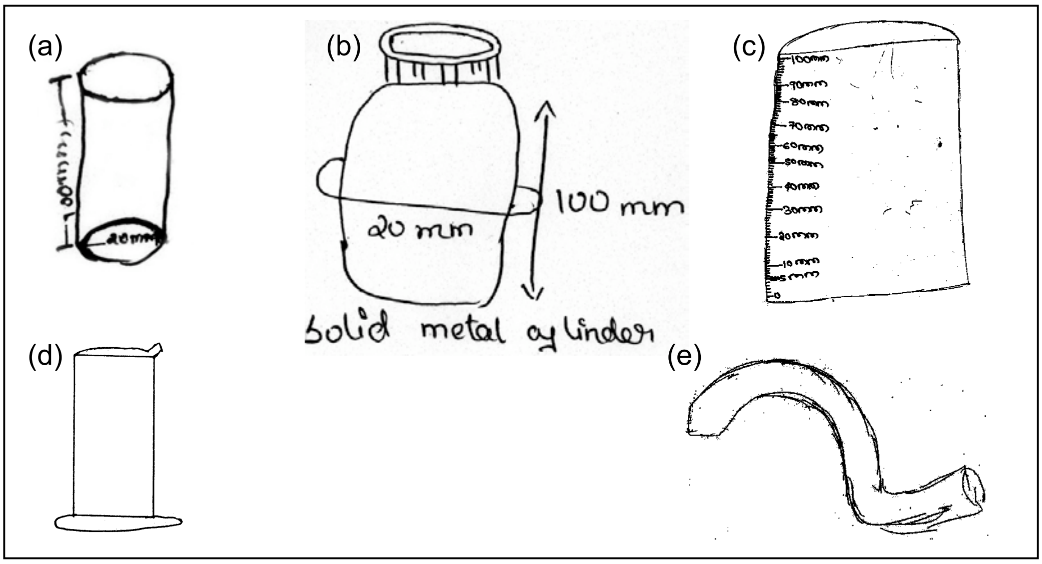
- *Dimensions and drawing conventions for static and dynamic objects:* Labels, annotations or conventions like leaders, arrows and end lines to depict dimensions in drawings were noted as well as the students' depictions reflecting the relative dimensions given in the text (length, diameter, etc.) and relative proportion of assembled parts (spiked wheels, cylinder and pipe, etc.). It was important for students to include dimensions in their technical drawings and procedural maps in the design context and in Task 1 of Experiment 2. Dimensions were not relevant to drawings in the bicycle chain problem in Task 2.
- *Perspectives and translating from 3-D to 2-D:* Strategies and perspectives used by students to depict 3-D objects in the two experiments are compared qualitatively. Students' choice of perspectives in the design task gave an idea of the richness of strategies used by them for depicting 3D objects. For the tasks in Experiment 2, perspective was less relevant and was only noted for its variety.

VISUALISATIONS AND MEANINGS

Students' visualisation of space is seen through the depiction of 3-D objects on paper. Though all the three task contexts concerned geometric objects and their assemblies, different contexts stimulated different strategies for visualisation and depiction. In the D&T unit, students conceptualized and designed the windmill model that they would later make. As their design progressed, the object became intimately familiar to them and they engaged with the details of the assembly. All groups drew one or more drawings to show the 3-D aspects of their windmill model.

For the task on cylinder and pipe, the dimensions and materials were given in the text. They were contextualised and students had to visualise the object descriptions for someone else. Students' drawings corresponded to the object described in the text – a dimensioned solid cylinder in Figure 2a – or an imagined one not corresponding to the description (e.g. a cooking gas cylinder).

Figure 2: The phrase "a solid metal cylinder" triggered association with (a) a geometric object, (b) a



cooking gas cylinder, (c) graduated vessel and (d) measuring cylinder (e) shows a student's depiction of "hollow PVC pipe"

A fifth of the sample in the cylinder and pipe task spontaneously associated meanings and attributes of familiar objects with the textual information. The word "cylinder" triggered depictions of a cooking gas cylinder (Figure 2b) or a measuring cylinder (Figure 2c) among these students. A "150 mm long hollow PVC pipe" was drawn as a long thin flexible pipe (Figure 2e).

A few students spontaneously used analogies while depicting objects, especially in problem solving contexts, which came up both while designing the windmill and in the bicycle task. In the windmill design, the structure of star inspired the vane assembly, or a tripod was refined to the tower. In the bicycle task, an annotation described "…the chain works like a rope".

Extent of explorations

In the design context, groups negotiated the design problem and discussed potential solutions. Groups had to think of the structure, assembly and functional aspects of their windmill model, decide materials, and estimate dimensions. Complex assemblies of components involving a number of parts elicited more exploratory sketches than did simple components. Perhaps, visualizing a non-existent artefact intended for making required students to explore the details of parts and their assembly. Students used sketches as a means to ideate and visualize these details.

While translating textual descriptions to depictions in the cylinder and pipe task over half the students (34 out of 60) made exploratory sketches of objects and assemblies, possibly because of the unfamiliarity of the task and the abstract object referred. Correspondingly, there were fewer exploratory sketches (26 out of 60 students) in the bicycle chain problem solving context. Though it involved a complex dynamic assembly, the artefact and its textual reference were both familiar and unambiguous. Unfamiliarity, abstraction and complexity seem to trigger exploratory sketches.

Spatial attributes

Did students have preferences in orientation for depicting objects of different shapes and in different contexts? In the context of design, the orientations of parts of the windmill model were decided by their place in the assembly: a cylinder or tube was shown horizontal when used as an axle and vertical when used for support. However, while translating textual information into drawings, students tended to depict the solid metal cylinder as vertical (45 out of 60) and PVC pipes as horizontal (36 out of 60).

When faced with the challenge of depicting an assembly of these two items, the largest number of students (27 out of 60) showed one object suspended inside the other with no physical contact between the two. Some (6) chose to depict the solid metal cylinder projecting out from the hollow pipe, sometimes at both ends, not taking into account that the cylinder was shorter than the pipe.

GRAPHICACY SKILLS IN DEPICTIONS

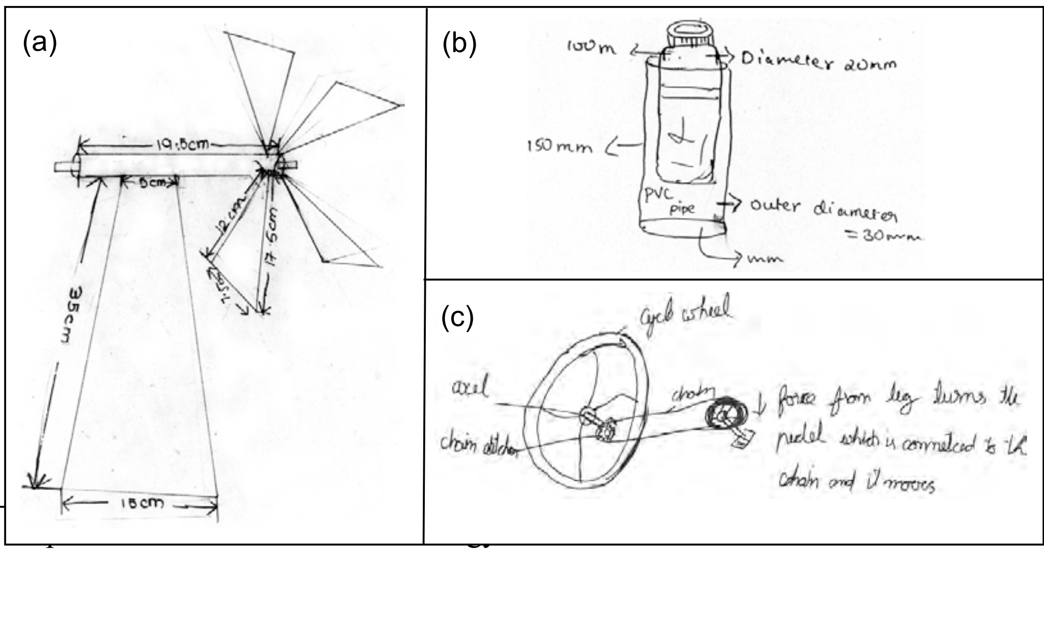
Graphicacy involves the use of skills to represent ideas or objects, which is studied here in terms of the dimensions and conventions used in depictions, as well as perspectives and strategies used for translating 3-D objects to 2-D. The exploratory drawings were rich in graphical symbols and elements used for multiple purposes. While designing, students used graphical symbols to represent different structural and functional attributes. For example, circular lines were used around vanes (see Figure 4a) or wheels (Figure 4c) to show motion and to isolate parts from the rest of the drawings.

Dimensions and conventions in depictions of static and dynamic objects

Drawing conventions and dimensions were relevant to the technical drawings and procedural maps in the design task as well as to the drawings in the cylinder and pipe task. Students, who participated in the D&T unit trial, had been exposed briefly to techniques and conventions for depicting dimensions and units. A majority of groups (4 out of 6) included dimensions and units using conventions in the depiction of their windmill model. Besides, they chose to make drawings proportionate to the dimensions shown (Figure 3a). This was possibly because they intended to make, and hence had visualised the details relevant for making.

Students participating in Experiment 2 were not given an exposure to the conventions of showing dimensions in drawings. While translating the detailed descriptions of a cylinder and pipe into depictions, the given dimensions were reproduced as textual labels (Figure 3b), if used at all. In depictions in Task 1 (Experiment 2), a few students indicated the process of assembly using a dotted line and an arrow (Figure 4b). Dimensions and units given in the text were crucial for the assembly to be depicted as in text. Yet, proportionality of length and diameter in the drawings were triggered only among a fourth of the students. Students seemed to be guided by the relational word, e.g. “inside”.

Figure 3: Students depict dimensions and units (a) using conventions in the windmill design, (b) as



labels in the cylinder and pipe task and (c) use annotations in bicycle chain assembly task.

Solving the bicycle problem in Task 2 (Experiment 2) required students to engage in mechanical reasoning, of putting the chain on the spiked wheel and rotating the pedal slightly. Two thirds of the students showed this in their drawings. About a third of students (17 out of 60) supplemented their drawings with annotations (Figure 3c); at times they annotated the procedure at each step. About a third chose to draw the entire bicycle. Showing the relative proportion of parts in an assembly was relevant to the tasks in Experiment 2. Of the 33 students who drew the 2 spiked wheels of a bicycle chain assembly, 24 showed them in the proportion as commonly seen in bicycles in India. At times, students enlarged features like the pointed tooth of the spiked wheel to highlight it. Students variously depicted the chain by lines, wavy lines, unconnected but closely arranged circles or circles connected by small lines. Among the 60 students, 14 tried to indicate motion in the assembly with the help of lines and arrows. In some cases, an arrow or icon of a hand over the pedal indicated the direction of force.

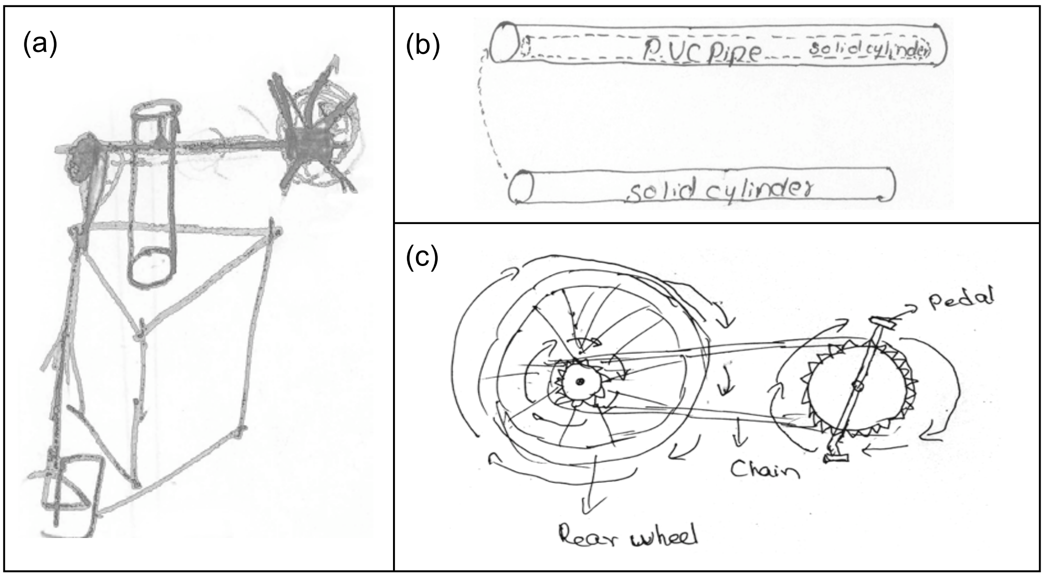
Perspectives and translating from 3-D to 2-D

Perspectives as a strategy for depicting the 3-D nature of objects on a 2-D paper varied with the nature of the object – simple or complex structure, symmetric, composite, etc. – and nature of the task context.

In the design context, where students had to visualise a non-existent complex dynamic object in 3-D and represent it on 2-D, students made choices of different perspectives while they explored, made technical drawings and procedural maps. They used a variety of strategies like dotted lines or X-ray drawings of occluded parts, and icons for those parts that obstructed, showing details of assembly (selective abstraction of axle and vanes in Figure 4a and chain in 4c). A few groups showed the windmill design details by depicting the front, lateral and back views.

For the tasks in Experiment 2, where students had to draw simple objects, perspective was less relevant. However, it was interesting to see that students spontaneously used perspectives even in these tasks. Task 1 in Experiment 2 involved simple, largely symmetric static objects – solid cylinder and hollow pipe – and their assembly. About half the students (31 out of 60) depicted both the circular ends of the cylinder and pipe (see Figure 2a). These students had not been exposed to technical drawings, and perhaps they were trying to show every detail in a "realistic" way. Most students resorted to X-ray views in the bicycle task and to show the assembly of a cylinder inside a hollow PVC pipe. In the bicycle repair task, students faced difficulty in showing the pedals perpendicular to the spiked wheel. Though most drawings showed lateral views, some students attempted an aerial view to meet the challenge.

Figure 4: Depiction of motion in three contexts: (a) in a windmill model, (b) assembly of a cylinder and pipe; and (c) bicycle chain assembly.



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CONCLUSIONS

This study used activities to engage students in drawing simple and complex, static and dynamic 3-D objects set in three task contexts. The task contexts included designing a windmill model as part of a D&T unit, translating textual information to depiction, and depicting the solution to a problem stated in text. The study aimed to see if different kinds of objects and task contexts influenced the extent of exploratory sketches and the aspects of description represented by students in their drawings. Students' visualisations of objects and the meanings they attributed to textual descriptions were analysed and students' preferred orientations of objects were noted. Graphicacy skills in depictions were analysed in terms of students' use of the dimensions, conventions and strategies used for drawing static and dynamic objects.

Students' spontaneous ideas influenced their visualisation of objects and drawings in the three contexts in different ways. Design visualisations, which were generated by the students working in groups, gave rise to the largest number of exploratory sketches among all tasks. Several needs – to share one's design with other group members, memory offload and ease of manipulation of an external representation – all may have led to this increase in explorations. The sketches often evolved from doodles that suggested analogical transfer from known objects to newly conceptualised design. Descriptions of abstract objects had fewer explorations, and a problem solving context involving a familiar artefact had the least exploratory sketches.

The different task contexts stimulated different strategies for visualisation and depiction. Students tended to show a solid cylinder in a vertical orientation when drawing from description. However, the orientation of the cylinder as part of assemblies was decided by its location – either horizontal or vertical. They made use of X-ray drawings and graphical symbols (like circular lines or arrows to indicate motion or the direction of movement). Students who participated in the D&T unit trials (design) were briefly exposed to technical drawings, which led to their use of conventions in indicating dimensions and units. They also used multiple perspectives in this context.

The results of the tasks in different contexts reiterate the use of drawings as a potential medium for visualisation, comprehension and exercise of skills and techniques in depicting ideas about objects and assemblies. Technology is largely perceived as objects by middle school students (Mehrotra et al, 2003) and our understanding of the artefactual (technological) world can be aided by drawings. It is hoped that exposure to complex and dynamic assemblies can help students go beyond the technology-as-object perception to viewing technology as processes and systems as well.

The study suggests that present school curricula have not equipped students to translate textual description of artefacts to drawings. However, students have the ability to visualise complex and dynamic artefacts and make drawings as seen in the design and bicycle chain problem solving task. In order to train students in drawing from text and using the diagrams supplementing the text in textbooks, making drawings in different task contexts – design, problem solving and abstract descriptions – needs to be integrated into existing school curricula at all stages.

Acknowledgement

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What informs pupil's perceptions of technological literacy and capability? An investigation into pupil's situated knowledge

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Abstract
The work in this paper seeks to gain a better understanding of the role that technological literacy and capability play in technology learning. It does this by examining pupil's perceptions of these concepts and how these reveal themselves during their school technology experiences. The work gives details of a small scale research study which explores the nature of pupil-held values. A cohort of ten trainee teachers were used for the qualitative study; an aim being to relate the respondent's notion of technology literacy and competence with how they engaged with their school practices. The work begins by discussing the nature of technological competence within a community of practice framework. This is related to the development of 'technological capital' through the concept of 'habitus'. These can be regarded as useful concepts with which to explain the way that pupil's acquire a working, often tacit, knowledge of capability and literacy. The methodology, ethics and rational of the study are outlined and the results discussed in terms of 'habitus' and communities of practice. The work concludes by discussing how some of the outcomes may be useful in exploring technological habitus systems. This being a first step in developing tools to encourage pupils to engage reflexively with technological literacy and capability.

Introduction
Having an understanding of the depth and degree of technological literacy and capability is a welcome ontological shift from viewing technology teaching and learning in purely technological transfer terms. Technological capability, for example, can be thought of as a practice that has a personal value dimension that interweaves with the more technical aspects of competence. Therefore, objectifying teaching and learning in a purely competence based terms gives a very limited view of the outcomes of many technological education programmes.

This work for this paper is placed within this context. It gives details of a small scale research project that aims to gain an insight into the way pupils perceive the technological experience that they have had. Exploring the way in which pupils reflect on their practice is useful in designing meaningful teaching and learning programmes. In particular, it helps identify some of the values and attitudes that a pupil may hold, and how these relate to the wider aspects of their learning. Technological design is complex and pupils often have to respond to new and unfamiliar situations. These include addressing changes in design circumstances, working in an active cultural environment and engaging with some of the less tangible aspects of the design process.

In many teaching situations (for example the design and make model that is associated with the delivery of design and technology in the English and Welsh curriculum) pupils construct an understanding of technological application within a dynamic classroom culture. This may be a technology workshop, a design and technology studio or an industrial linked environment. These settings, invariably, allow pupils to work freely in a relatively unrestrictive atmosphere, share ideas with other pupils and explore a range of materials and processes through thought and action. In essence they are working within a community of practice: a concept that provides the theoretical framework for this study.

Communities of practice have been defined by Wenger and Synder (2000) as groups of people who engage in a process of learning through a shared domain of endeavour. Learning is therefore situated in a particular context and very much dependent upon the social resources and dynamics that operate within each practice (Lave, 1993). A large amount of this learning is 'hidden' (Seeley and Druid, 1996) and is often shared though situated narration and collaboration. In this way it is envisaged that pupils construct a shared understanding of technological literacy and capability when operating within technological communities of practice.

Technological *Habitus*

To help make sense of a how pupils develop and display their technological fluency the concept of *habitus* has been adapted to reflect the degree to which technological principles have been internalised. To Bourdieu (1990) *habitus* reflects the ingrained values, dispositions, habits and internalised understandings that structure a person's experience of the world around them and which they take for granted. Depending on a person's technological *habitus* their perceptions of the technical world may differ from person to person. For example, in the case of design and make activities this could depend on how deeply they have internalised the taken-for-granted thinking processes and 'ways of doing things' that are distinctive to the way that technologists work. In this way they start to acquire 'technological capital'. They are, thus, learning to engage with the dispositions of technological thought and action; a process which may be socially acquired and shared within a community of practice.

Research methodology

The purpose of the methodological approach was to provide a 'topology' of pupil's perceptions of technological literacy and how they acquired some of the tacit qualities of technological capability. Such a descriptive field provides a basis for exploring their insights into their technological world. Gaining a deeper understanding of some of these issues is useful in making explicit the pedagogic processes that are at work. By adopting a phenomenological, social constructivist approach this study explores the relationship that exists between pupils and their learning excursions through the design process. The methodology has been designed to draw data from an analysis of the accounts of pupil's experiences in school.

A qualitative, case study, approach has been used where data was collected using semi-structured interviews. The sample of respondents consisted of a sample of ten pupils aged between eighteen and nineteen. These had recently completed their 'A' levels or vocationally equivalent studies. There were three boys and seven girls in the sample. Each respondent had completed a course in a technologically related subject and had worked at a range of design and technology levels: from primary through to the secondary stage. All had left school and were studying for a higher qualification. All respondents had wide experience of working through design and making activities in schools and as such it was envisaged that they would have acquired a degree of 'technological capital' through these processes.

The merits of the qualitative approach have been well documented (Bryan, 2004) (Blaxter et al, 2001) and is particularly suited to exploring pupil's perceptions of social and personal issues. This enables a first hand view of the pupil's internalised technological world by focussing on what individuals say and do. The approach provided the opportunity to probe and expand on meaning where applicable. Individual meaning may be complex and not always revealed by less flexible data gathering methods.

Each interview lasted about forty minute and was recorded and transcribed. The research design was guided by ethical considerations given by the British Educational Research Association (www.BERA.ac.uk). Each respondent gave permission for their views to be included in this paper and were able to review the transcribed material. All respondent's identities remain anonymous and alternative names have been used in the text.

The interview strategy was designed to (i) discover some features of the technological 'journey' that the respondents had made during their school experiences and (ii) to allow them to discuss their perceptions of the terms technological literacy and capability, and how these may be developed through communities of practice. It was deemed important not to cite these terms directly early on in the questioning sequence. This would allow the respondent's perceptions of literacy and capability to emerge 'naturally' from the research conversation. This policy was designed to reduce bias in the early part of the interview and lead the respondents to 'disclose' their perceptions through indirect means.

The general interview questions were:

1. Your technological 'journey' through school is useful in providing a picture about how you have developed as a 'technologist'. Please tell me about this experience and what aspects you felt were important to you.

2. Explain how and why you think that these experiences may have helped you gain an insight into the way that technologists think and act.

3. Tell me about some of the projects that you have done in your schools.

4. What were these early experiences like? Who inspired you? And what did you consider to be important?

5. How did you feel when you engaged with these technology activities?

6. What you feel were the social and cultural experiences that you acquired when working through your design and make processes?

7. Tell me about how you worked in your design and technology sessions. Was there a sense of community? Was this experience different to other lessons? How do you think this helped you learn technology?

8. What values do you, personally, think are important when you are working as a technologist?

9. Why do you think that your learning of technology might be important to you in your future life?

These questions were used as a guide and extra prompt questions were introduced during the interview process. This was deemed necessary to gain a deeper understanding of some of the points, help enrich the discussion and to encourage a continuity of dialogue.

Selected findings

This section gives an outline of some of the findings that emerged from the study. It can only give an indication of the nature of the dialogue and how this could be interpreted. In particular it relates points within the transcribed texts to (i) perceptions of literacy and capability (ii) how pupils may have acquired these perceptions and (iii) how these constructs may have been developed through situated cognition within communities of practice. In analysing the text, attention has been given to uncovering elements of the dialogue that reflects critical and 'hidden' experiences in the way that pupil's work through their design and make space. Each respondent gave a different account of their 'selves' which reflected different levels of 'technological capital'. Therefore the technological *habitus* which each pupil had constructed depended upon their unique technological experience.

> The first time I was in my design and technology lesson in secondary school it felt daunting... We were given a task to do…just to make a simple pull along toy…[I] hadn't done any thing like this before…I didn't have a clue before I started…nearly all the others in the class had done some of this type of work in their primary schools. I hadn't! They were very confident and got down to working very quickly…I just

> followed them at first and copied what the girl next to me was doing…She gave me some advice and I later on I was able to work much better… (Julie, eighteen year old student).

This type of sentiment was expressed by other respondents in the research cohort. However it can be contrasted with Nichola's experience in a dynamic and go ahead primary environment

> …I've always liked technology…I was in year four when we did our first project. We had to make a device that let a ball roll down a slope in a certain time. We use all sorts of materials to do this…It was really good…the best thing that I have done at primary school…[and] the only thing I can vividly remember doing…It really turned me on to technology…I can remember every bit of it…the project took six weeks to make. I was really enthralled. (Nichola, eighteen year old)

When asked why she thought the project was so good she commented that;

> …we had a great teacher. I think that she must have specialised in design and technology…she really got the group working…we must have been motivated…it was the best thing we had ever done in that school…

Prior experience and history seems to be important in how pupils perceive, adapt and respond to their technological learning. It is also noticeable how the respondents seemed to learn aspects of their capability through working in a practice community. Julia had been able to gain knowledge and build up her understanding of the ways in which design and technologists operate through interacting with other pupils. Nichola's situated experience seemed to be more influential. The six weeks spent working within a 'powerful' design and technology environment, a community consisting of the pupils and their teacher, has had a marked effect on her insight into the way that technological processes work.

When further asked about how this affected her interest in the subject she said that she worked better in a group.

> …it's how I work best. I need to bounce ideas of other people…I also need to make things and I find some subject areas difficult…in design and technology you a free to make your own decisions…you are not limited to what you are told…as in maths. The subjects not rigid and I seem to have a better flow of thought…I learn a lot better in a more relaxed atmosphere…Other subjects [I found] simply clogged your brain up with rubbish…design and technology allows you to learn yourself, make some mistakes and find out why you went wrong…

The design experience, then, allows pupils to build up their technological *habitus*. They will see the technological word, in which they operate, differently to others and construct a personal view of capability and literacy.

> …I think that I learn a lot about my technology in a subconscious fashion…there seemed to be no pressure in the subject to learn facts for the sake of it…We had no technology teacher for a year…I had opted to take textiles for 'A' level. The teacher wasn't really interested and we had to learn most of the things ourselves…I gained more confidence with working with others and we learned a lot together…we all mucked in and shared ideas…I became more confident in the subject and started to enjoy it...this way of working made us learn many things in technology without thinking too much about it…it was all subconscious really… (Alexandra, eighteen)

Working within a community of practice as a vehicle for learning was emphasised by most of the respondents. Even though they didn't explicitly recognise that they were working within such a community many of the respondents explained how they favoured and gained a great deal of understanding through learning in such an environment. John, a nineteen year old vocational engineering student, explained that he;

> Just liked working with [his] design and technology group…I found it more imaginative and creative…the things that we did also have stuck in my head…I can explain many projects to you. I find this hard to do with some of my other subjects…I've even forgotten much of the stuff in these subjects…we were encouraged to work in groups and share ideas…This was how our teacher taught…he also made it fun…when we did our research he always got us to think… we could share our ideas with others…this was good for me…

It was interesting to discuss with the pupils how they perceived their understanding of literacy and capability. Did they consciously learn how to be technologists? And did they think that this was an important part of their learning? In general the pupil's found these concepts difficult to articulate. Most discussed how important they were and how they related to the design process after prompting, and when deeper explanations were offered. They found it much easier to describe and discuss technological applications in terms of the concrete knowledge and understandings that they had acquired. Many of the value aspects of capability and literacy can be seen to be tacit and pupils need mechanisms to bring them to light and to make them more explicit. Responses such as;

> [technology literacy] is integrated…I don't think about this sort of thing when I'm actually doing [design and technology]…take computers for example. These are an important part of technology but I learn these without thinking…what I've learned though is very important…without this knowledge I wouldn't get far in my design work or for that matter the rest of my life… (Peter, eighteen year old student).

In a similar way Karl, a nineteen year old student who had studied resistant materials at 'A' level commented that;

> You pick up ideas about technology as you go along…it helps you learn a bit about life skills…and it helps you relate to what is happening in…[the world] of work…you can pick up creativity when doing design and technology…design and technology is around all the time…and you pick it up because it is everywhere…

Discussion

The work carried out in this study goes some way in helping to understand how some technology pupils perceive the tacit aspects of literacy and capability. As the literature suggests, pupils who work through a design and make process learn effectively by participating in communities of practice. Here cognition is situated within a contextualised technological framework.

The knowledge that pupils learn through such communities can be regarded as both 'visible' and tacit. The 'visible' elements are easier for pupils to articulate and include physical working practices that are central to designing and making. The 'hidden' aspects of technological literacy and capability are not so obvious. Pupils often acquire these subconsciously and without any active thought engagement.

However, tacit elements of learning can be seen to be important in developing fluency when pupils act out their roles as technologists. This activity will have both meaning and action. The degree to which they engage with this role can depend upon how they have constructed their technological *habitus;* a construct developed through their engagement with design and technology processes.

The notions of *habitus* and the acquisition of technological capital seem useful concepts with which to compare the degree to which pupils engage with the tacit elements of technological learning. In particular it provides a theoretical framework that can be used within the cultural settings that typify design and technology practice.

This initial study provides the basis for further and more extensive work. The next stage at Edge Hill is to explore cultural issues within a number of communities of practice. The research emphasis will be the same. It will focus on a qualitative understanding of pupil's perceptions of technological learning and how this relates to their ability to function as active technological practitioners.

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Graduate Study in Technology Education State-of-the-Art

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To keep a profession strong, members must research and understand the issues and developments that its members are facing. Professionals who prepare technology education teacher teachers, master teachers, and college and university professors need to know how others do business on their campuses. Professional development occurs when we learn what others are doing and we can reflect upon our own views. One area of interest for faculty and students is graduate education. The technology education faculty at Old Dominion University sought to determine the current state of affairs of graduate education in this teaching field.

Reasons for undertaking this study were practical in that the faculty wanted to determine if their M.S. program was up-to-date compared to other universities with the same interests. Old Dominion was also beginning a Ph.D. program with an emphasis in technology education and it sought to determine if others had any unique practices in the preparation of teacher educators at this level.

The Old Dominion University study was guided by the following research questions:

1. Did other colleges and universities have graduate programs where students could specialize in technology education?
2. What types of graduate degrees were offered where specialization could occur in technology education?
3. What type of core course and technology specific courses composed the graduate programs at other colleges and universities?
4. What modes of delivery were used to make the graduate offerings available to students?
5. What research requirements were placed upon students who sought graduate degrees in technology education?
6. Was there a projected growth for professors of technology education?

The researchers chose to use survey methodologies to gather data for this state-of-the-art analysis. There were two populations studied. First, U.S teacher preparation colleges and universities were studied. To limit this population, institutional members of the International Technology Education Association (ITEA) were surveyed. There were 46 institutional members of this professional association. The second group that was surveyed in this study was faculty at international institutions who regularly attended the PATT Conference (Pupil Attitudes toward Technology). This population was 14. The surveys were distributed by mail and using electronic means.

Of the two groups, the following return rates were achieved. Thirty-seven of the 46 ITEA institutional members were returned for an 80.4 percent return rate. Ten of 14 international institutions were returned for 71.4 percent return rate. See Table 1.

Table 1. Return rate of institutions surveyed.

Institutions	Sent	Returned	Percentage Returned
U.S.	46	37	80.4%
International	14	10	71.4%
Overall	60	47	78.3%

Findings

Question 1 of the survey asked, do you have a graduate program where students can specialize in technology education? Of the 37 U.S. universities responding, 29 or 78.3 percent offered graduate study in technology education. Of the eight responding universities that did not offer graduate studies in technology education, one was planning to begin a M.S. program in 2007 (University of Arkansas). This information was gleamed from survey Question 2. Of the 10 responding international universities, seven or 70 percent offered graduate study in technology education. An important note to offer is that all U.S. universities that offered a Ph.D. or Ed.D. degree, they also offered M.S. work. At six international universities, the M.S. or M.Ed. was offered; four offered the Ph.D., with two of these also offering the Ed.D. Also, graduate study at some international universities was not accomplished by the traditional completion of differing courses, but credits and degrees were earned through research mentorships where the student worked independently under the mentorship of a university faculty member(s). One international university, University of Glasgow, was interested in beginning an M.S. program.

Question 3 asked, what type of degrees do you offer in your graduate program where specialization can occur in technology education? Of the 36 institutions that offered graduate education in technology education, their degree levels/structures varied. These degrees and their number were reported as follows:

35 Masters (masters of science, masters of art in teaching, masters of education)
6 Educational Specialist (a degree that is 30 or more credits beyond the masters)
11 Doctor of Philosophy (Ph.D., research intensive)
8 Doctor of Education (Ed.D.)

A total of 13 institutions offered the Ph.D. or Ed.D. Some universities offered both the Ph.D. and Ed.D. When communicating with faculty at these universities, it was found that politics of the country, providence, or state dictated which colleges or universities were allowed to offer M.S., Ed.D., and Ph.D. degrees. The Ed.S. was offered by some U.S. universities who were not granted permission by their state governing agencies to offer the doctorate. It was offered for teachers to qualify for positions or salary increases. The Ph.D. was considered a more research intensive degree than the Ed.D., with the Ph.D. usually requiring 15 or more hours of research courses as compared to 12 or less for the Ed.D. Table 2 lists the universities where the doctorate degree was offered with specialty studies in technology education.

Table 2. Doctorate granting institutions offering technology education programs

University	Ph.D.	Ed.D.
Aix-Marseille (France)	X	
Edith Cowan (Australia)	X	X
Georgia (USA)	X	X
Griffith (Australia)	X	X
Indiana State (USA)	X	
Maryland-Eastern Shore (USA)		X
North Carolina State (USA)		X
Ohio State (USA)	X	
Old Dominion (USA)	X	
Purdue (USA)	X	
Rhodes (South Africa)	X	
Utah State (USA)	X	X
Virginia Tech (USA)	X	X

Question 4 sought to determine if the university/college had their courses of study available online for the researcher's to further analyze. Of the 36 institutions to offer graduate studies in technology education, 50 percent of the institutions had their degree course requirements available on the web. Others were able to provide copies through other electronic means, emailed attachment or faxed.

Participants were asked to identify non-technology education required coursework in the areas of foundations, curriculum, instruction, research, and other areas. This was Question 5 of the survey. It was hoped that a review of the required coursework would reveal whether program control was at the program/department level or at the college/university level. Foundations courses, for example, were identified to be either general (i.e., Advanced Educational Psychology) or specific to technology education (i.e., History/Philosophy of Technology Education). However, further review of catalog descriptions and/or syllabi in the areas of curriculum, instruction, and research would be needed in many situations to make that distinction.

Curriculum courses were mostly focused toward technology education (i.e., Implementing Technology Education, Curriculum Planning in Occupational Studies). However, it was not clear whether the intended audience was teachers, teacher educators, administrators, or a combination of constituents. Courses in instruction, on the other hand, varied widely. Many institutions had broad courses (i.e., Instructional Strategies & Innovations), while others focused on areas such as leadership development (i.e., Instructional Leadership).

Research at the master's level varied widely and was often not clearly defined. Many master's programs did not require a thesis but, instead require a research paper, project, or portfolio. Research coursework at the master's level was typically one or two courses (3-6 credit hours) with a two-course sequence consisting of statistics and research design/methodology. Research coursework at the doctoral level often required 12 hours for an Ed.D. and 15-18 hours for a Ph.D. Most of the doctoral institutions had course offerings on qualitative research methods. Some institutions (i.e., Georgia, Old Dominion University) required doctoral students to take qualitative methods. Additionally, Georgia offers doctoral students a certificate if they take three or more courses that focus on qualitative research. Table 3 lists the requirements in these areas by degree.

Table 3. Non-Technology Education Required Coursework.

	Masters[a] n=35	Specialist n=6	Doctorate[b] n=13
Foundations	29	4	11
Curriculum	23	3	9
Instruction	22	3	7
Research	30	4	12
Other	9	3	5

[a] Includes 1 M. T., 30 M.S. & 6 M.Ed. (two institutions offered M.S. & M.Ed.).
[b] Includes 6 Ed.D. & 11 Ph.D. (four institutions offered Ed.D. & Ph.D.).

Other required non-technology education coursework demonstrated that some programs had themes running through their programs. Common thematic areas include science, technology, engineering, and mathematics (STEM) integration, workforce development, and instructional technology. Other programs require coursework in supervision and administration or working with special populations, so candidates are prepared (e.g., licensed/endorsed) for positions in those areas as well as technology education positions.

Question 6 asked the institutions to list the specific technology education graduate courses that they offered. Required technology education courses involve both professional and technical courses. Professional courses included seminars, readings, leadership, and other innovative topics related to philosophy, technological systems, and program development. Most institutions require courses in instructional technology. Other technical coursework included technical systems and problem solving. The minimum hours of required technology education coursework was 6 hours at the master's level and 18 hours at the doctoral level. Specific course titles included: introduction to technology, history and philosophy of technology education, technological systems, program development in technology education, readings or studies in technology education, technology education – a discipline, cognition in engineering and technology education, design thinking, engineering design and analysis, methods of integrating science, technology, engineering and mathematics, technology education at the elementary level, appropriate technological development, etc. These entries seemed to be as broad as the interests of individual faculty member

Distance Learning

Faculty were also interested in determining the means that universities were using to deliver graduate level programs and courses. At many institutions, students had to come to campus for their graduate education. This prohibited some from taking advanced course work in technology education, if they were not located near a campus. Some universities began to offer classes at off-campus locations, where the professor traveled to the areas where a group of teachers were working, usually cities. If this was not an option, adjunct faculty were employed at the sites. However, this created problems for university accreditation, if the adjunct faculty member did not possess a doctorate degree. Because of these limitations, universities began offering courses via distance learning. Some universities conducted correspondence courses using mailed out assignments by the faculty (some on CD/DVD) and mailed in assignments by the student. As technology developed some campuses began to offer two-way, audio-video, televised courses. These systems relied on video technology and telephone connections between sites. There was limited capacity allowing only several sites to be connected at the same time. When the www became available, some universities began offering graduate studies using these electronic resources.

Question 7 asked how is your graduate technology education program delivered? Of the 36 institutions offering graduate programs, 32 institutions offered campus-based programs. Twenty offered courses via distance learning technologies; nine doctoral programs had distance course offerings. Nine universities reported offering classes from extended campus locations with faculty or adjunct faculty teaching off-campus, mostly at K-12 sites or university regional centers.

Question 8 asked if distance learning techniques were utilized by the faculties, what methods were used. Two universities reported using televised, one-way video and two-way audio instruction; five reported using televised, two-way video and audio instruction; seven reported using video-streaming over the internet; four used CD/DVD technologies; and 13 reported using non-video, web-based delivery.

Ndahi and Ritz (2002) completed a study to determine the use of distance learning techniques by technology education faculties. The results of this study indicated that 60.4 percent of U.S. universities that teach technology education and industrial technology were using distance learning technology to deliver their programs. The current study showed a 55.5 percent use of distance learning technologies. Several universities expressed that they had developed courses but could not sustain a student population to continue the courses using distance learning capabilities. This finding almost reversed the line of thought that many professionals have that course delivery by electronic means is increasing and will continue to expand. Note that Question 9 is reported at a later part of the discussion.

Question 10 asked those universities involved in graduate technology education who were not using distance learning technologies, if they intended to use these course delivery techniques in the near future. Four universities planned to implement distance learning in the near future, while eight universities had no short range plans to begin using distance learning techniques.

Research Requirements

The survey next inquired about the research requirements associated with technology education graduate studies programs. Question 11 focused on determining if the universities had themes or topics that graduate students would research as part of the degree requirements. The researchers were interested in this question, since many students in the science and literary fields select a university graduate program based upon the line of research that their faculties are studying.
Twenty-nine programs reported theme-based research studies were not required of their graduate students. Eight or 21.6 percent of the programs required theme-based research, including such themes as:

- Engineering education
- Effects or value of technology education program
- Action research - technology education
- Class activities to support technology education
- Technological literacy
- Cognition and student learning through technology education

Additional studies can provide evidence of the amount of graduate research being conducted (Reed & Sontos, 2006) and the focus of technology education graduate research (Sontos, 2005). Table 4 provides the number of doctoral dissertations completed in the United States from 1999-2005. This analysis shows a mean of 21 dissertations per year (excluding 2005) which demonstrates consistency since the mid-1990's (Reed, 2002).

Table 4. Recent Dissertations in the United States (Reed & Sontos, 2006).

Year	Total Studies
1999	18
2000	34
2001	19
2002	17
2003	23
2004	19
2005	8[a]

[a]This number represents studies through the summer of 2005 only.

Table 5 classifies recent doctoral dissertation topics in the United States. The majority of studies have focused on instruction. This is a change from the last major review by Zuga (1994) when curriculum was the leading research topic from 1987-1993. It is also interesting to note that almost 20% of the dissertations were classified under the heading "Foreign" which meant the researcher was looking at technology education in countries other than the United States.

Table 5. Categories of Dissertation Research in the United States, 2000-2005 (Sontos, 2005).

Categories	Number of Studies	Percentage
Attitudes	7	12%

Instruction (how)	17	29%
Curriculum (what)	5	8%
Continuing Education	2	3%
Professional Develop.	8	14%
Foreign	11	19%
Work-based Education	9	15%

Participants were also asked if graduate students were required to submit theses and dissertations to a clearinghouse (i.e.,University Microfilms International [UMI]), Question 12. Fifteen respondents, 45.9 percent, indicated that they do require students to submit their research to UMI. Due to the limited number of research studies in technology education, such a requirement can greatly increase access to student research if this requirement became mandatory (Reed, 2002).

Question 9 inquired about residency requirements of students who enrolled in graduate study. This question arose because of interests in distance delivery of courses. Thirteen institutions, 35.1 percent, had graduate residency requirements. These ranged from specific numbers of credits students had to be enrolled per terms to students having to be on campus for a set number of semesters. Some universities are avoiding the on-campus residency with meeting their institution's requirement by being enrolled full-time from a distance.

Faculty Needs

The final questions, survey Questions 14 and 15 of the survey asked participants about the need for teacher educators, faculty members, in upcoming years. Recent research in the United States shows a slight increase of needed positions in the last three years (Hicks, 2005). Table 6 shows that there were198 faculty openings for 2001-2005 in the United States. This is a daunting number considering the annual mean for technology education dissertations in the United States is 21 (Reed & Sontos, 2006).

Table 6. Recent Faculty Needs for Technology Teacher Educators in the U.S. (Hicks, 2005).

Year	Technology Education Positions	Industrial Technology Positions
2001	7	33
2002	2	40
2003	1	13
2004	8	43
2005	9	42

As is evident in Table 6, the majority of positions are for industrial technology faculty in the United States. Respondents in the present study projected needs only for technology education faculty. Nevertheless, Table 7 shows that there is a fairly significant need for faculty within 1-2 years. The projection for needed faculty members tapers after five years, however, possibly because it is often difficult to plan for needed faculty in the long-term. The inference from this data is that the majority of the increase in teacher educators will replace retiring or "leaving" faculty. Further research is needed to investigate if this is so and to see how many positions, if any, are based on program growth. It is also interesting to note that 7 (50%) of the international respondents claim they will need faculty within 1-4 years.

Table 7: Projected Faculty Needs in Technology Education

Years	Number of Faculty Needed
1-2	19
3-4	7
5-6	4
7 or more	3

Conclusions

Based upon the information collected from faculties from around the world, the following conclusions are drawn. The majority of the universities that responded to the survey, 37, or 78.3 percent, had graduate programs where students could focus their studies in technology education. Graduate degrees offered included masters, educational specialist (e.g., masters plus 30 credit hours), educational doctorate, and doctorate of philosophy. Of the universities responding, 13, or 27.6 percent offered the doctorate as their terminal degree.

Graduate study in technology education programs had differing categories of courses contained in the following schemas – foundations, curriculum and instruction, research, and technology education specialty studies. Universities who had these structures had somewhat generic offering for their core course requirements, indicating that these types of courses were required of other majors in the department or college, i.e., educational statistics, research methods in education, curriculum development in career and technical education, etc. Thirty-six universities, 81.7 percent, had specific courses directed to students studying technology education. These courses varied depending on the interests of the faculty and the faculty's acceptance of the movement toward design and technology and technological literacy.

Faculties were expanding the delivery of their degrees through distance learning techniques. The prevalent delivery was faculty members and students on campus or delivery using web-technologies, 13 or 36.1 percent.

Most universities had research requirements for graduate students specializing in technology education. Most masters programs required six hours of research, while doctoral programs required 12 or more hours.

The data also suggests that there is a need to prepare graduate students in the professorial role to replace those faculty that are nearing retirement or for those who are interested in teaching technology for undergraduate majors who plan to seek employment in business and industry (industrial technology).

Summary

This study developed a picture-in-time of graduate study specializing in technology education. It included data from universities throughout the world where faculty had careers as university professor and lecturers of technology education. The response rate to the survey was 78.3 percent, which showed that faculty members were interested in what was occurring in graduate study in technology education.

Opportunities to offer graduate study specializing in technology education were controlled by university and government politics and the interests of faculty members. Some faculties would like to have graduate programs, particularly at the doctoral level, but because of university missions and administrative and government decisions, could not offer such degrees.

One of the intensions of this research study was to determine which universities were offering specialized graduate study in technology education and a second intention was to determine specific courses offered by these universities. Answers to these questions were addressed at this stage in the development of technology teacher education. Further research is recommended to determine the strength of the programs that offer this gradate degree study. This would include a self-assessment by the faculty involved and to determine the occupational need for future technology teacher educators.

Another recommendation for the profession is to determine what design and technology or education for technological literacy should be both designed for teachers and for the students who study under these teachers. What should a graduate student know and be able to do. Discussion with faculty from around the world indicated that education for technological literacy is on a continuum from generalized study about technology and its impacts to the other rend of the spectrum of vocational career preparation. What needs to occur to have design and technology, i.e., technological literacy, to be taught in our K-12 schools? What should be the goals of K-12 technology education?

Agendas of needed research must be agreed upon and shared among colleagues, so that students in graduate study can focus on these topics and collect the data to aid in the future growth of technology education. As we defend the need to educate K-12 students to become technological literate, research needs to be at hand so informed data-based decisions can be made.

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The role of reflection in a technological activity

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Introduction
Brandt (1998) points towards some of the conditions under which people learn well, such as: What they learn is personally meaningful to them; what they learn is challenging and they accept the challenge; what they learn is appropriate for their developmental level; they can learn in their own way, have choices, and feel in control; they use what they already know as they construct new knowledge; they have opportunities for social interaction; and they receive helpful feedback. Similarly, Johnson (1997) stresses the following four principles essential for significant learning and developing pupils' intellectual skills: contextual learning, learning by doing, peer-based learning and learning through reflective practice. One can see that learning technology in general, and projects in robotics in particular, are a natural environment for putting the learning concepts identified above into practice. Indeed, an increasing number of studies (Barak & Doppelt, 2000; Vernado, 2005; Bers & Portsmore, 2005) have reported positive contributions of project-based learning in robotics on pupils' motivation to learn and achievements in technology education. However, the mere engaging of young children in robotics-type activities does not promise good learning in class, and much depends on the way the program is built and the type of activities the pupils are occupied with. This paper presents a two-year study in which a robotics course for middle-school pupils was assessed, re-designed and followed-up very closely in its revised approach. The main question that guided this study was what elements of robotic activities influence pupils' interest the most in the course and foster learning processes in the class.

Study participants and context
The study took place within a robotics course offered to middle-school pupils (7th and 8th graders) who came once a week for half a school year (15 weeks) to the robotics lab at the Holon Academic Institute (HIT), an engineering-oriented academic college located next to their school. The instructors were the co-author of this paper and another teacher, both having at least five years of experience in teaching robotics. In the first year (2005/2006), 76 pupils (29 of them girls) from two schools participated in the course; in the second year (2006/2007) all of the first-year pupils continued in the program and participated in an advanced course, and another 116 pupils (67 of them girls) took the beginner's course. The robotics program was considered an extension of science and technology studies in the school, and a teacher from each school followed the pupils' participation in the course. The course format, however, was significantly changed in the second year, as discussed later in this paper.

Data collection
The follow-up of the courses was aimed at collecting as much information as possible of pupils' activities in the class, their work patterns individually and in teams, the processes they underwent in completing the tasks they tackled, and the content of the presentations they prepared and presented to the class. These data were gathered using diverse methods, including: writing a detailed journal of each class meeting; documenting spontaneous conversations with the pupils and anecdotic events in the class; keeping records of pupils' computer files, such as programs and electronic presentations; photographing the systems the pupils constructed; videotaping selected lessons; and carrying out discussions with parents, school teachers and principals regarding their points of view of the course. This paper addresses part of the findings of this research, with focus on the pupils' motivation to study the course.

Findings
The first version of the course: Content-oriented

In the first year, the beginners' course was designed primarily to teach pupils a range of robotics principles and the design of electro-mechanical systems. The pupils dealt with questions such as what determines the strength of a bridge or the power of a car; they constructed mechanical systems using Lego blocks, and devised scientific-type experiments to explore the properties of these systems. A typical lesson consisted of a short presentation made by the teacher, hands-on work done in groups, and a concluding discussion. Conversations with the pupils and observations in the class revealed that the pupils regarded the robotics course just like any other school subject. Not all of them exhibited great motivation or made special efforts to complete the tasks presented to them, and they seldom prepared the homework assignments given by the teacher. The rate of pupils' attendance in the class was about 85%, very similar to the situation in school.

A distinctive motivation among pupils that participated in a robotics contest

Different from the picture described above, very high motivation was found among 10 pupils from the same group who, in addition to attending the regular course, prepared to participate in a nation-wide annual robotics competition for middle-school pupils . The following are several examples of what was observed in this class:

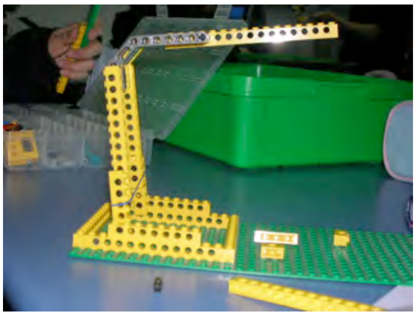
- The pupils worked independently, while the teachers' intervention was minimal. For example, at the pupils' initiation, they split into three teams: the investigation team, the construction team and the programming team.
- The pupils remained in the lab until very late at evening or even over the weekends to work on their project.
- The entire group met at the house of one group member at least once a week.

The fact that these pupils invested much greater efforts in preparing for the robotics contest than in completing the assignments of the robotics course was perhaps the best indication that the concept of the course needed revision. Consequently, this course was re-designed, as described below.

The revised course: Project-based learning

In the second year, the beginners' course was modified to meet the following guidelines:

1. The program adopted a project-based learning approach, whereby the projects' complexity gradually increased. The pupils started with a number of simple projects, such as constructing the longest and strongest fishing rod possible using Lego blocks; at the end of the semester, they dealt with the more complex task of designing a computer-controlled car. Figure 1 shows two examples of pupils' projects.
2. The teaching of engineering-related concepts, such as the properties of mechanical structures or the role of a gearbox in a power transmission system was reduced, and presented mainly in the context of pupils' projects rather than as general robotics topics.
3. The pupils were encouraged to document all their work on the projects; to this end, they filmed themselves working on their system using a video camera that was available on a regular basis in the class.
4. Selected photos and videos were put on the course's Website shortly after the lesson.
5. At the end of each project, every group prepared an electronic presentation about their work and presented it to the class as a part of a peer-evaluation discussion.



Crane

Computerized car

Figure 1: Examples of pupils' products in different projects.

These changes in course approach resulted in a considerable improvement in pupils' interest in the course. Since the scope of this paper is too narrow to describe in detail the phenomena that were observed in the class, we will hereby present just a few examples or anecdotes from what was observed.

- Pupils arrived at the lab before the lessons formally started, and remained there during the breaks or after the lessons were finished to continue working on their projects.
- One pupil in the class reported that she worked with her father on his laptop computer to improve her presentation to the class. She also watched videos with her father on class discussions they retrieved from the course's Website.
- One school teacher, having no background in technology or science, sent the robotics course instructor some material on bridges she had found on the Internet; she told the instructor that she had become interested in bridges after "the pupils did not stop talking about what they had learned in the robotic course."

Pupils' viewpoints of the presentations they prepared for their projects

Unexpectedly, the pupils took the task of presenting their work to the class very seriously. It is worth mentioning that although most of the pupils had prior experience in preparing electronic presentations, many of them invested considerable efforts in presenting their robotics projects. To explore this point further, upon completing one of the projects, the pupils in one group (18 in total) were asked to write down their opinions of the course presentations on small cards. The pupils filled in 15 cards, on which they wrote 30 comments. In analyzing these data, three categories were identified from what the pupils had written. The first category was, naturally, about 'presenting your work to others.' The following are examples of pupils' remarks in this regard:

"The presentation is an important part of the project because in the presentation we show the audience how we constructed the product."

"Although it is more complicated [to prepare a presentation than build your system] *it helps in presenting your product and shows different sides of the explanation."*

A second aspect identified in the pupils' remarks was that the mere preparation of the presentation helped them better understand their own work, as the following quotes illustrate:

"In my opinion, including the preparation of a presentation in the project is very important because it helps you better understand what you are doing."

"It is very important [to prepare a presentation] *to know how we built our bridges and cranes, and also to know what our problems were so that we don't repeat them."*

The third interesting point in the pupils' comments was that the presentation raised their self-confidence, as exemplified in the following comment made by one pupil:
"*The presentation helped me because it presented my idea and backed me up while I presented the project verbally to the class."*

A parent of one pupil also raised another point, which is described below.

Parents' viewpoints

The parents of eight pupils were interviewed extensively during a parent-teacher evening held in one of the schools. The robotics instructor sat next the class teacher and asked each parent individually questions such as: Do you know what your daughter or son learned in the robotics course? What are the course objectives in your opinion? The pupil sitting next to his/her parent sometimes joined in the conversation. The following extracts from these interviews illustrate typical parents' answers:

One mother said:
"I can report that my son is very satisfied with the course… on Monday mornings [the day course is held] *he is excited to go to school…Monday is a special day for him… he anxiously waits it…"*

"He told me about the bridge they had to build… he went into great detail… how they tested their bridge with weights… he enjoys this very much, it stimulates his senses."

"I have other children at home… usually children of this age do not tell much… if he is enthusiastic and tells me about it, this is a sign that it is very interesting to him."

One father said:
"I don't know what he learns each week, but in general I strongly support the program… it is important that he learns about advanced technologies."

"We watched the course site together … I saw their work on the fishing rod… if needed, I was there to help out."

"I saw how he presented his work to the class in the video… it was very important for us to see it… we also watched other children… my son is a little shy… it helps his self-confidence… it is also good that other children see his work on the Internet."
A third mother said:
"I downloaded photos of my daughter's group project from the Website, printed them out and hung them on the refrigerator in my kitchen."

These data from discussions with the parents indicate that many of them were not only aware of what their children were learning in the robotic course, but they were also actively involved in what was happened in the class. Certainly, this was a very different attitude in comparison to the situation common in many families. The photographing and videotaping of the pupils' work, their presentations to the class, and putting these materials on the course's Website served as an important tool for fostering reflection in the class and encouraging parents' interest in their children's learning.

Conclusions

The advantages of a robotics learning environment have long been recognized in the educational literature. Questions still exist, however, as to how to design a course that meets pupils' expectations in building sophisticated robotic-like machines, developing their knowledge of the design and construction of technological systems, and promoting their learning skills.

The present study highlighted two important aspects in this discussion. The first had to do with the advantages of a 'developmental' project-based learning course in which the pupils gradually progress from simple assignments and mini-projects to more complex and open-ended tasks. The second aspect concerned the importance of encouraging the pupils to present their ideas to their peers, observe the ideas of others, and discuss problems and solutions in completing the tasks they tackled. By presenting their work in class, the pupils came to better understand what they have done or the process they underwent. If one conclusion must be drawn from this study, it is that presenting, discussing and reflection on design and problem-solving should be considered as an integral part of the concept of 'doing' in technology education.

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Instructional Methods of Information Ethics / Morals and their Effects on Pupils' Attitude to Information and Communication Technology

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Abstract
Typical Information Morals education performed in Japanese primary and secondary schools focuses on teaching rules and avoiding trouble when pupils use cellular phones, E-mail, the Internet, etc. There are various problems with this method; for example, too much time is needed to deal with specific examples, and there is no mechanism for pupils to apply the lessons to new situations. Thus, Tamada et al. (2003) proposed a new instructional method for Information Morals that teaches pupils to apply judgment using three types of knowledge; "ethical code knowledge", "knowledge of information and communication technology (ICT)", and "knowledge of rational judgment". They also verified that the results of their new method were superior to those of the conventional method.

However, because both methods emphasize the concerns of ICT, they may provoke negative attitudes in pupils, such as "ICT is unavoidable and is only used reluctantly", rather than positive attitudes, such as "ICT is useful and should be used willingly". Therefore, we focused on pupil attitudes toward ICT as an important aspect to measure the effects of Information Morals education. Thus, we first proposed new instructional methods based on Tamada et al.'s method, and we then developed a questionnaire to measure pupil attitudes toward ICT. Finally, we conducted an experiment to compare pupil attitudes with the new instructional method to those with the old method.

1. Introduction

Education about information and communication technology (ICT) is known under many names in different countries, including Informatics Education (UNESCO 1994), ICT Education (UK), and Computer Literacy Education (USA). In Japan, in order to distinguish between cases in which teachers use ICT as a means of instruction and cases in which they teach ICT as a topic of study, the former is called Information-oriented Education, Educational Computing, etc., and the latter is called Informatics Education. The objectives for Informatics Education in Japan were defined by the word "JO-HO KATSUYOU NOURYOKU: Information Literacy" in the mid-1980s. Although the meaning of the word has been revised according to advances in ICT, the present definition was stated in the 1997 report of a task force held in the Ministry of Education, Culture, Sports, Science and Technology, as follows:

(1). The practical ability to make use of information in problem solving and communication, with the knowledge to decide whether or not to use information technology, without being misled by its seeming usefulness (Abilities to Utilize ICT for Problem Solving).

(2). Understanding the appropriateness of methods for making adequate use of information and information technology, based on their properties (Scientific Understanding of ICT).

(3). Developing attitudes sympathetic to taking part in the creation of a desirable information society with an understanding of the roles of information and information technology and their influences on society (Attitude as a Member of the Information Age).

The 1997 report stated that these three sub-objectives are mutually related and are not to be taught independently. However, many researchers of Informatics Education and teachers in schools tend to teach them independently and break them down further for ease of instruction. This is based on the notion that thinking and problem-solving are cultivated by teaching knowledge. However, this causes the unexpected situation in which only lessons inclined toward specific sub-objectives are performed. In such Informatics Education, lessons focusing on the second sub-objective, which introduces how to utilize ICT according to its advantages, and lessons focusing on the third sub-objective, which explains the issues and demerits of ICT, are performed independently. In addition, lessons focusing on the first sub-objective tend to become an occasion to train pupils in computer operation.

Moreover, due to recent incidents regarding children's abuse of ICT being reported in the media, people in Japan have tended to focus on the negative aspects of ICT and the idea of "considering creation of a better information society", the aim of the third sub-objective, tends to be overlooked. School teachers have come to consider what they should do to avoid responsibility when their pupils are involved in such a problem. As a result, they select various examples that pupils may encounter when using ICT, and teach them many rules in the form of "Take care not to..." or "Don’t...". Negative ideas are instilled into pupils by such instruction. However, they are unable to learn how to utilize ICT effectively while avoiding problems that might occur with the use of ICT.

Recently, the relation between technology and ethics has mainly been discussed within the context of engineering ethics. The use of technology has always included both merit and risk. Therefore, we cannot discuss whether a new technology should be introduced or not without having trust in the engineers. However, when discussing the use of ICT, the distinction between suppliers and consumers is meaningless, as the action of any person may cause an unexpected scale of influence within a short time. Of course, abuse of ICT can occur at anytime due to somebody’s ill will; or conversely, it could occur when he/she is trapped and unconsciously participates in it. In addition, if we make a judgment based on only traditional morals when using ICT, we may fall into an abusive trap.

As the first objective shows, the ability to judge whether ICT should be utilized or not is a necessity for problem solving. There are two ways to consider the negative influence of ICT. One is to list cases where ICT is considered inadequate, as stated above, and treat them as the constraints of the problem. From this perspective, teaching ethical codes is important. The other method of consideration is to treat both positive and negative influences as target functions. In this case, the establishment of moral standards in individuals is a crucial point of education. As decision-making for this method is far more complicated, sense and accountability to weigh each target function appropriately in a given situation is required On the other hand, in the former method, it is necessary to learn all constraints and follow their changes constantly. Moreover, as decisions regarding right and wrong produce an atmosphere where any exception is not allowed at all, less confident users may avoid using ICT altogether. This factor could induce digital divide

2. Purpose

In this article, we propose a method of instruction for promoting the ability to solve problems by creating ideas to utilize ICT with respect to its merits and demerits, and to avoid the trouble resulting from use of ICT. The context of problem-solving discussed here focuses on cases where ICT is used for searching for information, communicating with others, etc., and the demerits represent cases such as causing trouble to others, being deceived by falsification, or suffering harm from one's own carelessness. In order to achieve our purpose, we revised the instructional methods for Information Morals by Tamada et al. (2003). The reason we used the methods of Tamada et al. is that they focus on teaching how to think in order to solve problems regarding ICT, rather than simply instilling rules. This method takes the second approach outlined above, which emphasizes the establishment of moral standards in individuals to help cope with negative effects. However, the method of Tamada et al. suggests that it might be better to consider an alternative to ICT if any trouble is anticipated. This might reinforce negativity toward ICT in learners. Therefore, the method of instruction proposed in this article intends to cultivate a positive attitude toward using ICT for problem solving, and overcoming the problems of ICT. For that reason, in order to evaluate its effects, we developed a questionnaire to assess "attitudes about utilizing ICT for problem solving", and compared the effects of the new method with those of the method of Tamada et al.

3. Proposal of the New Instructional Method of Information Morals
In many countries, people cultivate their morals and ethics through religion. However, in Japan, religion does not contribute to moral education. Elementary and Junior High Schools allocate a "time of morality" for 1 hour a week. The National Course of Studies states four objectives for the "time of morality" as follows: 1) to be aware of the roles and responsibilities attached to members of society, to improve the collective welfare of society, to respect law and order, to be fair and just, etc. (concerning collective values and society), 2) to be polite, to care for others, to respect the personality and perspective of others, etc. (concerning others), 3) to acquire a desirable lifestyle, to have enough sense to tell right from wrong, to improve oneself, etc. (concerning oneself), and 4) to cherish and protect nature, to be moved by something beautiful, to respect the life of both oneself and others, etc. (concerning nature and piety). The informational moral education that emphasizes rules such as "Don't use ICT when ..." tends to be independent of general moral education. On the other hand, the method of Tamada et al. intends to perform it on the basis of general moral education in the "time of morality" in Japanese schools.

3.1 Instructional Method of Tamada el al. (2003)
The method of Tamada et al. aims to teach judgment based on a combination of three types of knowledge; "knowledge of principles (ethical code knowledge)", "knowledge of situations (knowledge about ICT)", and "knowledge of rational judgment". This method is based on Murai's (1987) instructional method of moral judgment. Matsuda (1999) said that many problems regarded as Information Morals are essentially problems of general morality. Therefore, by guiding the information moral judgment based on the three types of knowledge, Information Morals education may be minimized and the pliability to respond to technical changes is ensured. When teachers use this method, the "knowledge of rational judgment" (Figure 1) is first shown, and the pupils are given problems and asked to examine how to behave in each situation based on viewpoints such as "breach of law", "trouble to others", and "personal damage", according to the flow of the figure. In fact, these viewpoints correspond to the first three objectives from the "time of morality", stated above. At this point, pupils are suggested to brainstorm similar cases that can be solved in everyday life with "ethical code knowledge" from each viewpoint. They are recommended to adopt a solution that does not involve ICT use, if possible. Otherwise, pupils are asked to examine whether an alternative solution has no problem specific to ICT use. Again they are asked to generate alternatives until they find one that would not cause worrisome points.

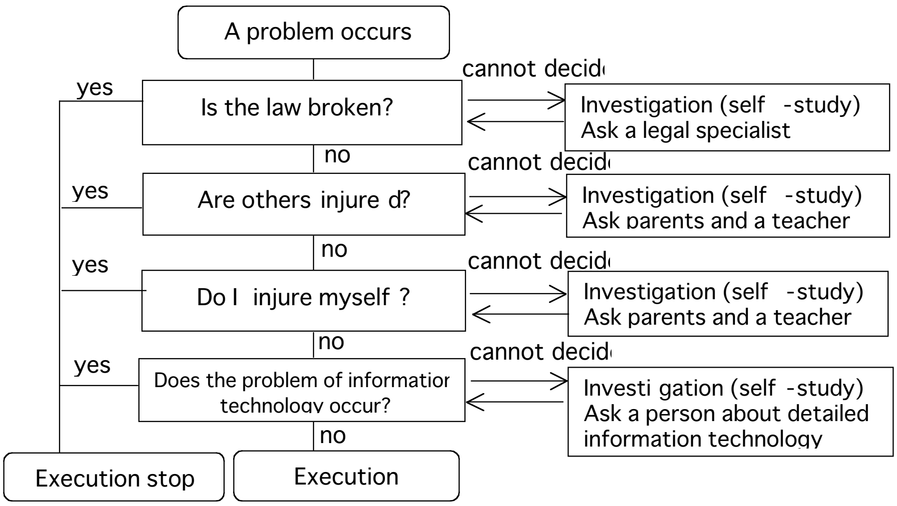

Figure 1: knowledge of rational judgment on Information Morals

Tamada et al. developed game-based e-learning instructional materials on the Instructional Activities Game (Matsuda 2004), in order to perform a lesson in upper secondary schools for about 50 minutes based on this method. The flow of the lesson plan using this instructional material is described as follows.

First, the game presents "a mail asking for blood donation" and asks pupils whether they would forward the mail. Next, the game asks ten questions regarding sending or receiving such a mail; for example, “Is there a legal problem?”, “Is it helpful for someone?”, “Did you feel troubled when you received it?” By referring to their replies to these questions, the game analyzes the problem based on the procedure in Figure 1. This problem fundamentally belongs among those related to ICT use. However, if a pupil answers "I would get angry if I receive such a mail", the game tells him/her "It is morally wrong to do what you feel is troublesome to others", and recommends considering alternatives at an earlier stage. After making pupils understand the thinking process of Figure 1, the game then asks two questions regarding moral judgment in daily life, such as "What do you think about a friend who purchases a cheap book that someone shoplifted?", and "What do you think about a friend who tries an ATM card that was found on the street?" Finally, the game provides the pupil with Information Morals problems, such as “Are there any problems with downloading commercial software from personal web sites at low cost?” and “Is it all right to try to login on a computer using someone else’s ID?” If he/she makes morally wrong decisions, the game explains why his/her judgment is unsuitable by referring to both Figure 1 and his/her answers to the previous questions.

3.2 New Instructional Method

In the revised version of the instructional method to Information Morals, the teacher firstly asks pupils “Do you download commercial software from personal web sites at low cost?” and "Do you forward e-mails asking for blood donations?", as described in the previous section. The teacher then shows Figure 1, and explains the thinking process using Figure 1 to convince pupils that this framework is useful for solving Information Moral dilemmas. In the second step, the teacher proposes a new problem, for example, “Suppose that one of your family needs to undergo an urgent operation at a hospital, and it is necessary to find many people to donate blood at the hospital. How do you find people to cooperate with your request?” Pupils are asked to make decisions using a newly developed e-learning instructional game to find a solution, and are only permitted to use either the telephone call function or e-mail function of a cellular phone. They are requested to consider the merits and the demerits of each function, and to consider issues based on the viewpoints from Figure 1. When trouble is expected, in order to deal with it, they are requested to find ways to avoid it; for example, choosing suitable contents for the e-mail, sending messages directly to avoid it becoming a chain mail, asking someone to mediate in order to avoid tying up the sender’s telephone line, and so on. For promoting such activities, the game system displays a list of contents which might be included in a message to send or to tell, such as “Don’t call the hospital”, or “Don’t forward this e-mail.” After a pupil selects the content items, the game system asks him/her to select reasons why he/she chose each item. The reasons are prepared using the perspectives from Figure 1, such as “Because I may be accused of obstruction-of-business if too many telephone calls are made to the hospital”, “Because personal information could be circulated and may be abused”, etc. Then, the game system provides feedback corresponding to his/her choice. Finally, the teacher explains that it is better to utilize two or more functions (generally two or more ICT tools) to take advantage of each characteristic rather than using only one function, and asks the pupils to examine a solution on a worksheet in which the telephone call function and the E-mail function are combined.

4. Questionnaire for Measuring Pupils' Attitude toward ICT

Both of the methods shown in 3.1 and 3.2 teach thought processes to minimize trouble. Although the former emphasizes moderate use of ICT and adopting alternatives if trouble is expected, the latter encourages utilizing ICT by taking advantage of its merits, and compensating for its demerits by combining two or more tools or functions, choosing adequate contents and expressions, and/or considering procedures for problem solving. It is expected that these differences affect whether pupils form positive images toward ICT. Moreover, they might influence the pupil’s opinions of societal progress through computerization. This may affect whether pupil attitudes are positive, such as "Our consciousness and how we behave dictates whether future society will become better or worse", or negative, such as “The introduction and direction of ICT in our society is controlled by people and companies pursuing their profits, and many people have to follow them.”

Therefore, in the next section, we conduct an experiment to investigate how the two methods of instruction affect pupil attitudes toward ICT or an information society. For this purpose, we need to use a psychological scale to measure "attitude/awareness of ICT use" with sufficient reliability and validity. Specifically, the scale should indicate whether a pupil avoids using ICT, or uses ICT positively, recognizing the various characteristics of ICT. Concerning ICT use, the "Computer Anxiety Scale: CAS" (Ogawa, 1990), "Readiness for Informationized Society" (Kobayashi et al., 2000), and "Skills of Practical Use of Information" (Takahira et al., 2001) are available. However, CAS is focused on situations when using a computer, and the test by Kobayashi et al., as well as the items by Takahira et al., measures the acquisition of fundamental knowledge and skills for using ICT in daily life. Since these scales were not sufficient for our needs, we developed a new scale according to the general procedure for the creation of psychological scales, as follows:

(1) Based on eight people, including a fourth-year undergraduate, a second-year doctoral student, and a professor belonging to Matsuda laboratory of the Tokyo Institute of Technology, typical opinions representing positive or negative attitudes toward ICT were identified through brainstorming, and eighty opinions were obtained.

(2) Using the KJ method, similar items were classified into categories, and twelve positive items and eighteen negative items were selected from the eighty opinions to constitute the questionnaire.

(3) Six in-service "Information Study" training course students answered the questionnaire developed in step (2) using a four-grade evaluation format, from “agree” to “disagree”, before and after attending a microteaching lesson performed using Tamada et al.’s method, as described in 3.1. Because a clear change was not seen in the sums of the positive and negative items, the items were reexamined.

(4) In order to investigate how the questionnaire should be improved, we collected data from 52 junior college students who took a computer literacy class in the same manner as in (3). Suitable factors to be interpreted were not extracted, other than being divided into positive and negative items. Moreover, the alpha coefficient was low, as items with negative correlations in the same factor were identified.

(5) Based on the above results, we found that some students tended to reply inconsistently, and would reply "agree" or "disagree" to both positive and negative items with similar content. We also devised the following hypotheses; “The new instructional method proposed in 3.2 will increase the number of pupils able to reply consistently to positive and negative items, while increasing the pupils' positive responses.”

(6) In order to verify the hypothesis, the contents and expressions were changed so that the items in the questionnaire comprising positive and negative items had more similar contents. Finally, the 30-item questionnaire was completed.(Main items referred in section 5 is shown in Appendix 1)

5. Experiment

In order to compare the effects of two methods of instruction described in 3.1 and 3.2, we conducted experimental lessons to collect data.

Lessons were held in the Tokyo Tech High School of Science and Technology, and three of the five classes of tenth grade pupils (aged sixteen to seventeen years) participated in the experiment. In that school, five classes of pupils, including participants in this experiment, take lessons on six different themes, carried out every four weeks, by rotation. “Information Morals” is one of these themes. The three classes that participated in the experiment were those taking the lessons in October 2006 (control group), November 2006 (experimental group 1), and January 2007 (experimental group 2). The first lesson of the four was the experimental lesson. The lesson regarding Information Morals was not performed in other subject. The control group was studied using the method of Tamada et al. (as described in 3.1), and replied to the questionnaire after their lesson. Experimental groups 1 and 2 replied to eighteen items selected from the questionnaires prior to the lesson, and replied to all 30 items after studying by the new method proposed in 3.2. Since we revised the instructional materials and some items used in the questionnaires between November 2006 and January 2007 based on the results of experimental group 1, the result of each experiment are to be shown separately.

5.1 Experiment 1

Firstly, we analyzed the data of experimental group 1, 36 pupils' responses to all items of the pre- and the post- questionnaires, and the following results were obtained:

a) 15 pupils replied to the paired items more consistently in the post-test than in the pre-test, and 13 pupils did the opposite. The difference in the number of each pupils' consistent answers between the pre-test and the post-test was not statistically significant, as tested via chi-square analysis.

a) Focusing on the consistent answers, the number of pupils who had fewer negative opinions than positive opinions was 17 in the pre-test, and 16 in the post-test. On the other hand, the number of pupils with fewer positive opinions than negative opinions was 14 in the pre-test, and 16 in the post-test. In addition, as shown in Table 1, the total number of positive opinions was 70 in the pre-test, and 73 in the post-test, and the total number of negative opinions was 80 in the pre-test, and 79 in the post-test.

b)

Thus, the hypothesis mentioned in (5) of Chapter 4 was rejected. To clarify the reason for the results, we analyzed the data in detail, and found the following:

c) Focusing on the responses of the post questionnaire, with regards to items 1 and 7, more pupils answered negatively than positively; as shown in **Table 1**. In contrast, regarding items 3 and 8, more pupils answered positively than negatively.

d) Concerning items 3, 5, and 8, there was a large difference between the answers in the pre-test and the post-test, as follows.

- Item 3: 9 pupils changed their opinion from negative to positive in P3 and/or N3, whereas 5 pupils changed them from positive to negative.
- Item 8: 2 pupils changed their opinion from negative to positive in P8 and/or N8, whereas 9 pupils changed them from positive to negative.
- Item 5: When the item is positively expressed [P5], 10 pupils changed their opinion from negative to positive while 1 pupil changed it from positive to negative; in contrast, when it is negatively expressed[N5], 10 pupils changed their opinion from positive to negative, while 2 pupils changed them from negative to positive.
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Considering these results, the contents of items in Appendix 1, and the lesson described in 3.2, we concluded that: 1) responses to items 1 and 7 demonstrate anxiety toward the advancement of ICT; suggesting that the necessity to create a positive attitude with regards to ICT is relevant, and 2) since the items in which we found characteristic changes in pupils' responses are related to the problems presented in the lesson, the change in consciousness must be attributable to the lesson.

However, it is necessary to examine whether the unexpected changes in items 5 and 8 were caused by the instruction or the questionnaire. In our opinion, the reason that negative opinions increased in item N5 is that pupils categorized "cases where telephone call functions are used" as "a solution without using ICT", although ICT is used in those cases. Moreover, the reason we found an increase in pupils who changed their opinion from positive to negative in item 8 is that they might feel that, for inexperienced users, it is important not to take the risk of utilizing ICT in some situations. The change in the responses to item N8', in which positive opinions increased, supports our hypothesis.

To compare experimental group 1 with the control group, we conducted the analysis of a) to d) above using only the post data of the control group, and found the following.

a) The frequency distribution of consistent replies was almost the same as that of the experimental group.

b) 15 pupils replied more positively than negatively, and 17 pupils replied more negatively than positively. This tendency was similar to that of the experimental group. The ratio of negative opinions was slightly larger than that of the experimental group, as shown in **Table 1**.

c) The ratio of negative opinions versus positive opinions in items 1, 3, 7, and 8 is shown in **Table 1**. The ratios of negative opinions for item 3 and 7 were higher than that of the experimental group.

These results showed a tendency for the control group to have a more negative attitude than the experimental group, though the difference was not statistically significant

Table 1: The Number of Consistently Positive or Negative Opinions to Either of Paired Item

	Item 1 (P1 & N1)		Item 3 (P3 & N3)		Item 4 (P4 & N4)		Item 5 (P5 & N5)		Item 7 (P7 & N7)		Item 8 (P8 & N8)		Item 8' (P8 & N8')		Item 9 (P9 & N9)		Total	
	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.	Posi.	Neg.
Experimental Gr.1 Pre-Test	2	24	14	10	3	6	6	7	3	17	22	2	9	3	11	11	70	80
Experimental Gr.1 Post-Test	2	22	12	4	2	8	12	13	6	15	17	5	11	5	10	11	73	79
Control Group (Post-test)	3	26	13	8	8	5	9	13	0	13	15	4	8	4	11	14	67	87

* A "Positive" opinion means that a pupil answered "agree" to a positive item, and "disagree" to a negative item.

* This table does not include the number of inconsistent opinions such as "agree" or "disagree" to either of paired items.

5.2 Experiment 2

Based on the results from 5.1, we conducted an additional experiment using another class (38 persons) from the same school in January 2007. We made the following improvements to the questionnaire, method of instruction, and teaching materials prior to the experiment:

- Since there were few consistent answers for the paired item 7, a Japanese expression was changed in order to make the sentences more similar.
- It was emphasized in the instructions on the worksheet that "cases where telephone call functions are used" are categorized as "cases where ICT is used".
- Although in the 1st step of 3.2 we explained that "It is common sense that e-mail is not used to ask for a blood donation", this is not consistent with the aims of the exercise problem. Therefore, we revised our instructions, so as to explain a problem more focused on ICT, such as "A communication line has capacity restrictions, and sending lies or useless information wastes capacity."

As only about 40% of pupils in the experiment group 1 used only one function of the cellular phone in the worksheet task, a direction to emphasize "both telephone call function and e-mail function must be used" was added to the worksheet, and was included in oral instruction.

The data of experimental group 2, 32 pupils' responses to all items of the pre- and the post-questionnaires, was analyzed and the following results were found:

a) 15 pupils replied to the paired items more consistently in the post-test than in the pre-test, and 6 pupils did the opposite. The ratio of the former versus the latter is higher than that of experimental group 1 and the control group.

b) Focusing on consistent answers, the number of pupils with fewer negative opinions than positive opinions was 13 in the pre-test, and 16 in the post-test. On the other hand, the number of pupils with fewer positive opinions than negative opinion was 13 in the pre-test, and 12 in the post-test. In addition, the total positive opinions was 74 in the pre-test and 83 in the post-test, and the total negative opinions was 71 in the pre-test and 81 in the post-test.

c) Focusing on the post- questionnaire, regarding items 1 and 7, more pupils answered negatively than positively; similar to the other groups. Additionally, regarding items 3 and 8, more pupils answered positively than negatively; again similar to the other groups.

Furthermore, the relation between the result of the worksheet task and the change in awareness was examined for experimental groups 1 and 2. Firstly, while there were 14 pupils in experimental group 1 whose solution for the worksheet exercise only used a single function, there were only three such pupils in experimental group 2. Table 2 shows the ratio of pupils whose consistent replies increased versus decreased in each of the pupils who used single / multiple functions of the cellular phone. Chi-square analyses revealed that this consistency was significantly higher ($p<0.095$), which indicates the effectiveness of the improved method of instruction.

Table 2: The Numbers of pupils whose consistent answers increased or decreased

	Increased	Decreased
Pupils who used only single function	6	8
Pupils who used both telephone call function and e-mail function	25	19

Next, we examined whether there were inconsistencies between each task and the reasons given for the choice, and the relation between the consistency of work and the changes in attitude was investigated. We found 23 pupils in experimental group 1 and 18 pupils in experimental group 2 whose work was inconsistent. We selected the paired items in which typical changes in the frequency of positive / negative attitudes were observed. In every item, it was observed that, while negative responses tended to decrease in the consistent group between pre-test and post-test, they tended not to decrease or increase in the inconsistent group.

6. Discussions and Future Perspectives
This study shows that most pupils are aware that, due to the progress of ICT, the risk of ICT-related crimes or accidents is likely to increase, and the need to study the use of ICT prior to using it is important. This implies that a method of instruction developed to foster a positive attitude toward ICT is necessary. In fact, 90 % of High School pupils have their own cellular phone (M.H.L.W. 2006), and hence use ICT daily. This clarifies the need to study more about the appropriate use of ICT.
As described in section 1, informatics education in Japan tends to teach three objectives independently, and focuses on training in skills for operation and technical knowledge. On the other hand, our instructional method emphasizes that pupils solve problems while weighing the merits and demerits of ICT, and judge that weighting according to a specific situation. To begin with, we considered it important to break down the contents into messages and procedures into tasks, and then complete each task for communicating messages by combining two or more devices or functions in order to avoid the troubles, which are anticipated, using Tamada's objectives. Although there might be some concern that this complicated method may evoke a negative reception from the pupils, the experiment in section 5.2 demonstrates that the fluctuation in the attitude regarding ICT was reduced more in the pupils who adequately judged the situation, which suggested that they were more conscious of how to use ICT. The effectiveness of this type of teaching method is in common with that of Mita's method of technology education (Mita and Matsuda 2003), which integrates a lesson and an experiment into "Monodukuri" activities. Moreover, its effect should be related to the concept of "gestalt communication", which Duke (1989) referred to in advocating the effectiveness of using gaming simulations as a method of communication. The underlying idea in these methods is that learning is not always accomplished only by systematically teaching all of the elements of the target objective, but in some cases a holistic approach is effective. This idea does not contradict the instructional design theory. For example, Gagné et al. (2005) states that the instruction of "problem solving" includes the following conditions; 1) presenting a problem, 2) making the learner apply problem-solving strategies, 3) providing feedback to improve the learner's strategies, and 4) encouraging the learner to reflect and verbalize his/her strategies to strengthen retention, following repetition of steps 2) and 3). In the experiment outlined in Section 5.2, no feedback was given to individuals following the worksheet task. The results suggest that providing feedback should be important, in order for the learner to make adequate judgments.

Therefore, we must develop e-learning teaching material using the IAG system, including personalized feedback regarding the decisions made in the task, and conduct an experiment to assess its effect. In addition, based on the instructional design theory, whether or not a pupil has acquired the appropriate cognitive skills affects the learning of problem solving. Now, we furnished the function to draw a concept map for the IAG system as a communication interface and tries to utilize the concept maps in various contents of problem-solving tasks, such as "engineer's moral education", "Monodukuri education", and “information morals education” to help understand complex relations among the elements by and promote analogical thinking by making a learner externalize his/her image using figures and find common patterns in maps.

Continuous lessons are more effective at uplifting consciousness and fostering a healthy attitude than intensive lessons, although there is no need to spend many hours studying only information morals education. Instead, it is desirable for pupils to repeatedly have the opportunity to consider information morals, in the context of various problem-solving activities, in the subject of "Information Study" in the Japanese High School curriculum (Matsuda 2006), We insist that our method, which emphasizes the need to utilize ICT positively, while considering its demerits and avoiding its negative effects, should be applied to the instructional design of those activities. This kind of activity should be performed on several separate occasions, in order to evaluate the long-term effect of information morals education. Finally, a comparison between our method and Tamada's method is necessary with regards to the educational effect not only on the attitude to ICT use but on the abuse of ICT,.

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Appendix 1: Items for Measuring Pupils' Attitude toward ICT (Portion)

P1. I believe the risk of crime or accidents will decrease with the advancement in ICT.

N1. I fear that the progress of ICT will raise the ICT skills of persons who would try to abuse it, therefore the risk of crime will heighten.

P3. I think we can offer reliable information through the Internet or other ICT tools if we make a little effort or pay extra attention, as there is also much unreliable information supplied by such tools.

N3. I think the web, e-mail, etc. are not good tools for providing important information, as I am afraid the reliability of information I send might be damaged, due to the fact that there are some people who send fake information or try to trap others.

P4. When we exchange information with someone through ICT, I think it is important to confirm the reliability of the information from several perspectives, rather than only depending on the reliability of the sender.

N4. When we exchange information through ICT, I think the most important thing is to make sure that it is sent from a trustworthy person, for it's difficult to verify the reliability of each message.

P5. Since ICT is basically secure and convenient, I think it's better to consider solutions utilizing ICT first, and I only have to find another solution when there is danger that I might become involved in some trouble if I use ICT.

N5. I think we have to find solutions without using ICT first, since ICT always causes trouble.

P7. I think the progress of ICT increases eases the use of its tools, which decreases the necessity of studying before use.

N7. I think the progress of ICT increases the required knowledge for adequate usage; so harder study will be needed.

P8. I think it is important to use ICT tools not only by customarily following specific rules, but also by flexibly selecting adequate ones, or combining some of them by considering their merits, depending on the purpose and situation.

N8. I think it is better to use ICT tools only by following the way we have already learned, because it is hard to use them by considering their respective merits and demerits.

N8'. I think it is most comfortable for me to use ICT tools by simply following the rules outlining how to use them, without the need for diligent consideration in each individual case.

P9. I'm not so worried about the abuse of my personal information, as I am careful about how I send or offer them over the Internet, although there might be someone who will try to abuse my information if I'm not careful.

N9. I don't wish to put my information on the Internet, because I don't know if my information is going to be abused or utilized by someone I don't know.

'Student Success': A moribund curriculum and the pressure for student success in Ontario

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Abstract:
Since 2003, the 'student success initiative' has been a significant priority on the Ontario government's political agenda. Under the guise of 'student success', the government has formulated program pathways that theoretically have equal merit and enable all students to achieve 'success'. However, this initiative is ill-conceived. The government is not addressing the central problem of the educational system: the school curriculum is predominantly an academic, university preparation curriculum that is insufficiently comprehensive for today's learners.

Introduction

In 2003, the Ontario government implemented phase one of the Student Success Initiative (SSI) with the aim to graduate 85 rather than 68 per cent of its students. By reducing the number of students who drop out, and increasing the number of students who pursue further education, the government presumes economic and social wellness for all. 'Student success' has become a significant priority on the government's political agenda as they "deliver help to students who are struggling with the curriculum" (Ministry of Education, 11/25/2004). This help has come in the form of a 1.3 billion dollar strategy to increase educational flexibility, by expanding co-operative education and technological education, increasing social supports, and providing community outreach programs. The government "recognizes that a one-size-fits-all approach does not work. Instead, success, according to the Ontario government, is now perceived as extending beyond college and university to include apprenticeships and skilled job placements.

The government is making it clear that they are committed to meeting the diverse needs of students and are injecting millions of dollars on programming to illustrate this fact. It would seem that the government, with this initiative, is taking an important step for education in Ontario. Closer analysis, however, suggests that the initiative may be ill conceived. Changes needed in the schools for student success to truly occur have not been considered. They didn't look to the source of the drop out problem, i.e., the singular university preparation purpose of the secondary schools. Recognizing and addressing the central problem of the school system was apparently disregarded. As a secondary school teacher and a graduate student I have seen, felt, and analyzed the need for reform. The central challenge of the educational system is twofold: First, the school curriculum is insufficiently comprehensive for today's learners. Second, the public school, i.e. the government, is not interested in a grass roots change that would see academic and practical curriculum interests balanced.

The fact that the curriculum is insufficiently comprehensive for today's learners is not a new revelation. The curriculum, to a large extent, is and always has been, an academic, university preparation curriculum[1]. Schools traditionally have operated in what Durkheim calls the "conservation of the past" (Bourdieu, 1977, p. 488). The curriculum has typically been a "high culture curriculum for a small minority who are academically minded (drawn, presumably, from the upper and

[1] It is argued that schooling contributes to a priority of legitimacy of literacy, and that this denies the legitimacy of experience which is necessary for learning. (Sheridan 2000)

middle classes, whose tradition is high culture)" (Lawton, 1975, p.13). In modern society the prevailing view of knowledge is a bourgeois one: art, literature, music, morality, history and philosophy (Lawton, 1975). Schools reproduce this tradition and maintain the bourgeoisie view of knowledge. Yet different social classes have different ways of perceiving reality, and more importantly, have a need for different forms of knowledge. Different groups perceive the world differently because they are socialized differently, and have acquired different sets of skills and different kinds of knowledge (Mannheim, 1955).

While all types of knowledge and skills are needed in our diverse society, the educational system has not historically given equal weight to all subjects. Academic knowledge has continually been favoured and as a result only those students who have inherited the bourgeoisie 'habitus'[2] are served and succeed in school. The middle class children are poised to gain an academic education that will open doors to professional and management occupations and working class children will be mislead, diminished, and disorientated. Nothing could be further from the truth! Today's technical work, e.g. auto mechanics, requires knowledge, competence, and capacity. Still, schools, under the guise of multiple pathways of success, perpetuate the social inequalities that have historically been embedded in the educational system. Change will only occur when the educational system and society give merit to multiple forms of intelligence. This merit must be economically supported by equality of both "the mind and the hand" (Donaldson, 1978). Yet, this solution seems incredibly hard to grasp. Tracing the history of schooling in Ontario helps the reader understand how the academic curriculum and the sorting function of schools, evolved

Education in Historical Context

Compulsory attendance began at the turn of the 20th Century. It brought the challenge of how to change the curriculum to meet the needs of widening segments of society because it was "obvious that many children were neither able nor willing to follow the traditional academic program offered at the secondary school level" (Royal Commission of Learning, 1995). For more than a hundred years there has been debate about the formal education of adolescents and how to create a curriculum that is relevant to students with very different needs, and to what extent the schools and programs should be tailored to academic and vocational purposes. While academic courses have dominated within the secondary school curriculum, a variety of programs and courses to meet the needs of an increasing number of students, have been created. Manual training, domestic science, technical and vocational schools were established.

The 1950s and 1960s, were a period of significant focus on diverse student needs. The dramatic rise in participation rate in secondary education, due to the 'baby boomers', was met with a comprehensive and varied curriculum, one that more closely related to students' experiences. A decrease in rote learning combined with the expansion of the community college sector created an increased momentum for vocational education (Royal Commission of Learning, 1995). By the 1970s the percentage of high school graduates going on to college fell and public support for education began to decrease as college graduates were driving cabs and others were collecting unemployment cheques. The school system was unable to support the "myth of equal opportunity and full personal development" (Bowles & Gintis, 1976, p. 4). The dropout rate phenomenon emerged.

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[2] Habitus represents the way in which culture becomes embedded in the individual, formulating the character of a person's thoughts and actions. It includes the cultural, academic, and linguistic capital. Cultural capital involves a person's ideologies and beliefs, including religious, political, familial, and their participation in cultural activities. Academic capital refers to the value that a community places on education. Linguistic capital refers specifically to the use of the first or dominant language within our society. A person's use of language specifically denotes his/her level of education as well as his/her place in our society. (Bernstein 1971)

The increased high school student drop-out rate continued into the 1980s. By the middle of the decade, Premier David Peterson was gravely concerned about the lack of student success in school. He commissioned George Radwanski, then an editor of *The Toronto Star*, to review the problem. Radwanski's report, the *Ontario Study of the Relevance of Education, and the Issue of Dropouts*, published in 1987, concluded that the education system had become irrelevant in an economy where the emphasis was shifting from manufacturing to services; moreover, many students were uninterested in what they were being taught at school. They lacked appropriate skills and knowledge. (Royal Commission of Learning, 1995) Quite simply, the students who left school before graduation did not find success in school because they found the curriculum irrelevant to their lives, moribund according to Schwab (1971).

The ‘drop out’ problem continued into the 1990s, but it was not until 2003 when governmental action was firmly stated. In 2003, the Student Success Initiative was publicly announced with its ambitious goal to graduate 85 per cent of Ontario’s students by 2010. Since then multiple phases of this initiative have occurred to increase student success. Again, an emphasis on technical education has been deemed a priority, but the same problem still exists. There has not been a significant alteration to the academic curriculum.

Curriculum theory and practice has been historically determined by the university and has been, as Bernstein (1971) claims, characterized by “uncommonsense knowledge”. School curriculum has largely been taught in total isolation from the practical world. The curriculum traditionally has been concerned with ‘knowing that’ rather than ‘knowing how’ (Ryle, cited in Pring, 1977), thereby preventing a large percentage of students from finding success in school. This fact has been acknowledged for the past hundred years by the Ontario government. The present government, like the ones of the past, has acknowledged this problem and has created educational programs to combat the problem. There is a recognition that “there are tools of the mind as well as tools of the hand” (Donaldson, 1978, p. 85). Still, despite the emphasis on the equality of multiple educational pathways, literacy and experiential learning were, and still are, valued and legitimized differently (Sheridan, 2000). In sum, schools, under the guise of multiple pathways of success, perpetuate the social inequalities that have historically been embedded in the educational system.

The Educational System and Social Inequalities

Schooling and the premises underlying it rarely receive a unfettered analysis (McLaren 1994). The writings of Paulo Freire, Henry Giroux, Jane Gaskell, Michael Apple, Joel Spring, Paul Willis and others, have set a tradition of critical pedagogy. These educators and theorists call attention to the fact that schools are designed and operated in the interests of the state, whose social function is primarily to sustain and legitimate the status quo (McLaren, 1994). The school system has operated from a dominant, colonialist, and misleading position (Friere, 1987). Domination has transpired with the expectation that students unquestioningly accept the information taught within the classroom. With unquestioned authority, the school system misleads (often unknowingly) the students by perpetuating myths about reality (Friere, 1987). The greatest and most debilitating myth is meritocracy: success and progress in society is based on ability and talent rather than on class privilege or wealth. The reality, it seems, is that social inequalities are significant factors in a student’s success or lack of success in school and consequently in life.

Of the multiple social inequalities that exist in society, social class is the greatest factor that limits student success. Students who do not often succeed in school are the students who are poor, are the least likely to have educated parents and therefore, the least likely to bring to school notions of how to do well there (Oakes 2005). These students do not have the cultural capital[3] that allows them to succeed in the school system that is based on middle class norms. Bourdieu (1977) believed that cultural capital is directly connected to educational achievement. Unequal distribution of capital between the classes is linked to unequal performance in school. This occurs as schools utilize particular linguistic structures, curricula, and authority patterns that are closely connected to middle class norms and values. Children from higher socio-economic backgrounds enter schools already familiar with these types of social arrangements and succeed in schools because of their ability to cash in their cultural capital (Larsen, 1999).

Bowles and Gintis in their book *Schooling in Capitalist America* (1976) explored how the sorting and selection among students occurs throughout the educational system. They found that schools socialize students in order to prepare them for their future. Socializing children differently reinforces the values and characteristics of their family's social class, which prepares students to meet the demands of the occupations they are expected to assume within the existing class structure. Since not all people can be leaders or achieve economic success in society, schools become what Joel Spring (1976) calls "sorting agents". Schools and the educative process select certain individuals for occupational roles at particular levels of the social hierarchy. Schools create and reinforce patterns of social class, which allow them to relate properly to their eventual standing in the hierarchy of authority and status in the production process. The school system simply serves the interests of the dominant class and those who are not in the dominant class will struggle in school.

Streaming has been and still remains a common practice in Canadian secondary schools. It is based on the assumption that students learn better when they are grouped with other students with similar academic ability: the bright students continue to learn and are not held back by slower students who need more attention and remediation. Streaming is also based on the assumption that grouping students based on intellectual ability enables them to have positive attitudes about school. While streaming and the assumptions that it is based on may seem logical, it perpetuates social inequality. Students are socialized differently in the different streams and teacher expectations perpetuate these inequalities (Oakes, 2004).

Academic classes are more likely to emphasize behaviours such as critical thinking, independent work, active participation, self-direction and creativity. In contrast, applied, or low-stream course content involves predominately simple memory tasks, comprehension and basic literacy skills. Teachers of applied level classes are more likely to emphasize student conformity: students getting along with one another, working quietly, improving study habits, being punctual and conforming to classroom rules and expectations (Oakes, 2004, p. 76). Thus streaming creates a difference between learners. High academic stream students tend to have a more positive school experience with high teacher and personal expectations. Low academic stream students, conversely, tend to have a negative school experience with lowered teacher and self expectation. This lowers aspirations for the future and fewer educational plans are made. The lack of success in school is internalized and low-stream students often become disassociated with school. This disassociation and discontent with the educational system alters the student's attitude and it is these students who have a greater likelihood of school and classroom misconduct and delinquent behaviour outside of school. This delinquent behaviour also plays into the cycle of social and educational inequality that keeps certain students in the lower economic stream.

Paul Willis discovered, in his ethnographic account of working-class boys (1977), found that students are not passive recipients of socialization, but the lower class often resists their lot in society. Due to the lack of success in schools, students openly reject both the knowledge and behaviours the

[3] Cultural capital involves a person's ideologies and beliefs, including religious, political, familial, and their participation in cultural activities.

school system values. Willis found that the working class boys found ways to leave the classroom, to smoke, to divert or subvert teachers' agendas, to disrupt routine and break rules in order to assert some measure of control over the school and classroom environment. This study illustrated that when schools do not meet the needs of certain students, and focus on the dominant culture and cultural styles, dissatisfaction grows. The lower-stream students continue to find a lack of success in school and these students are increasingly alienated. The more alienated they become the worse they will be able to handle it. Then, to use Friere's (1985) phrase, a "culture of silence" deepens with the widening of oppression. Students often shut off their minds and hearts to the educational system and cease to try to find success in a school system that they do not understand nor find support in.

Conclusions

As the Ontario government tries to increase student success, it is apparent that greater changes need to occur in the educational system for students to feel supported and school to seem relevant. While the government has recognized that there is a large percentage of students who do not find success in school the solutions they pose are limited. With academic knowledge still central in the curriculum and perceived as more notable and prestigious, schools will only continue to reinforce social inequalities within society. Merit must be given to courses and occupations of both the mind and the hand. Yet, the government of Ontario, and in reality many of the governments of the Western world, seem largely disinterested in facing the root of the problem. In order to break down the stereotypical perceptions of knowledge in schools, the curriculum needs to equally reflect all types of occupational pathways, and to respect diverse skills. If it does not, the inequity between academic and technical knowledge and skill will persist.

Still, I believe change can occur. If the government gives equality to both academic and practical knowledge in the school curricula, then this value will be mirrored within society. The government has incredible power to make a change. Although the 'student success' initiative is only three years old its effectiveness is suspect. I believe, however idealistically, that there is hope for equality between academic and technical education. "How poor is the revolution that doesn't dream…anticipate tomorrow by dreaming today" (Friere, 1987, p. 187).

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Structuring technology education for pre-service teachers

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Abstract
It is evident that there are numerous conceptions of what constitutes technology in the primary classroom, and yet a shared understanding of the subject area is crucial for the productive development of the discipline. In this study, pre-service teachers reflected on a new method of teaching technology that provides for a shared conceptualisation of the Key Learning Area. It is apparent that such a structure may allow for meaningful and shared insights into technological practice and provide a possible basis for structuring technology education courses, particularly for those students unfamiliar with the subject. This research is significant in that it examines a pedagogical method that has, until now, not been utilised in such pre-service courses, and addresses some of the major concerns being voiced in the subject area.

Introduction
It is evident that the term ‘technology’, and hence ‘technology education’, are terms that are open to a large degree of interpretation, and that clarification of what the field entails is still required. Research from around the world demonstrates that the understanding of technology as an educational endeavour is still being tackled, as shown by the work of, for example, Rogers and Wallace (2000) in Australia and the UK, Plucker (2002) and Crismond (2001) in the USA, Moreland and Jones (2000) and France and Davies (2001) in New Zealand, Hill and Anning (2001) in Canada and the UK, Doornekamp (2001) in The Netherlands, and Tairab (2001) in Brunei Darussalam. This is indicative of a multiplicity of viewpoints held by those tasked with its introduction into schools, a situation which is still not completely resolved. Hill and Anning (2001, p. 112), for example, commenting on their research in Canada and the UK, contend that there is a:

> … lack of evidence that examines, together, the triad of how teachers in the elementary/primary schools are translating curriculum requirements for teaching design, within technology frameworks in their classrooms, how their students proceed with design, and how ‘school situated design’ relates to ‘workplace design.’ (punctuation as in original)

There is also debate as to the scope of technology. Pavlova (2005), for instance, discusses how wider conceptions of the nature of technological knowledge are required, a view that is reinforced by the writings of De Vries (2005) where he discussed the importance of students being made aware of the ethical and other value aspects of technology. It is also clear that notions of technology must go beyond purely technical concerns. Models of technology activity, such as those devised by Davis (2005), acknowledge this through the inclusion of aspects such as process and personnel as central considerations when interpreting classroom technology. Authors such as Coles and Norman (2005) have also argued that the influence of values in decision making must be better understood in technology education.

In the classroom context it is also evident that further research is required. Wilson and Harris (2004), in their review of Design and Technology (D & T) in the UK, identify a number of gaps in research evidence, including the identification of effective teaching and learning. This is a theme that recurs in the literature. Hansen and Lovedahl (2004), for instance, conclude that there are serious problems with technology education models that are based on technical competencies, while Lewis (2005) argues that pre-service teacher education must include creativity, and not just the technical aspects of technology.

Models of technology have tried to capture some of the elements discussed above, from the Queensland School Curriculum Council's (1999) model that highlights what may be considered as cyclic, iterative or recursive nature of design, to the Assessment of Performance Unit's (1994) model that considers design as a continual interaction between the mental and materials aspects of the problem at hand. Other authors (Kimbell, 1997; Ritchie & Hampson, 1996) have proposed models that include various interactive loops in design processes.

To do other than to accept the above more flexible interpretations, according to Pendergast (1999), does not do justice to the contribution technology can make to the curriculum, and may lead to a situation where a single process is blindly followed without understanding, a situation termed "design fixation" by Mayo (1993, p. 49). It is also evident that the assessment of products does not constitute an assessment of the process (Jones, 1994) and that the role of design in the curriculum is diminished if such an approach is taken. Jones (1994) also identifies, for example, what may be called an artefact focus that is the result of emphasis on end products that inhibits problem solving.

It is evident, therefore, that there needs to be a conception of technology in the classroom that enables teachers to access the design processes that students are undertaking. This cannot be achieved through artefacts alone, nor can it be achieved though observations of students in action. One means to conceptualise technology is that of the narrative, as described by Davis, McRobbie, and Ginns (2004), whereby any artefacts created must be considered as being part of a narrative, and that it is the accompanying story that highlights the decision making processes that students have undertaken, the values that they have applied to the problem, the learning that they have encountered, the technical competencies that they had to acquire, the personnel that they had to consult, as well as the manner in which their artefact came into being.

This research reports the initial results of using the concept of a narrative approach to technology with pre-service teacher (PST) students. The principal aims of the research were;

1. to investigate how PSTs reflected on the technological exercises they undertook in terms of their creation of a narrative, and
2. to determine the usefulness of a narrative approach as a teaching methodology.

Methods and techniques.

An interpretive methodology (Erickson, 1998) was utilised as this approach is able to provide "the meanings and purposes attached by human actors to their activities" (Guba & Lincoln, 1989, p.106). In this instance the researcher was seeking evidence in the discourse, actions and writings of the participants of their views of technology, and how they might frame the understanding they developed in a narrative framework. Researcher field notes were also used to provide evidence relating to the effectiveness of teaching methodologies.

Participants

The participants in this research were volunteer students undertaking a graduate teacher pre-service course. The students undertook the activities as part of a semester unit of work relating to science and technology education. The activities occurred during weekly scheduled four hour classes, three of which were devoted entirely to technology education. These classes focused on theoretical issues associated with technology education, as well as the practicalities of undertaking classroom technology. In all of the technology classes students were required to design and make a variety of artefacts. Students recorded their experiences in journals, as well as through a focused reflective piece of writing that formed part of their formal assessment. Certain students also took photographs and video recordings of the activities they undertook. All names are pseudonyms.

Data analysis

The documents produced by the PSTs were examined to determine how they recounted the narrative of the artefact they had created. The decision making processes, as well as interpersonal issues, contextual factors and problem solving strategies were categorized with a view to identifying common themes, issues and difficulties.

Findings
The findings are presented in terms of some key phases of a simple narrative structure. The identification of orientation, characters and events, as well as values that underpin actions are highlighted by examples from the data.

Orientation
PSTs undertaking this narrative reflection often structured their responses in a two tiered manner. They first of all listed key aspects of the activity in manner more akin to a high school science report, followed by a narrative description. Edward, for example included the following headings in his report; Participants in activity, Aim, Materials, Tools, and Process. The actual narrative of the activity was commenced in the process section. Others, such as John, just listed the group members, and then commences his narrative, while Ian (and others) dispensed with any subheadings and commenced their narrative immediately.

Once the PSTs had commenced their narrative, they all discussed the initial decisions that they had to make, and located the problem within a context. Benita, for example, in her first paragraph discusses the initial decision of the group as to what to make, the process they undertook in selecting materials and how to use them, the roles of the group members, as well as how they envisaged the design would progress. The activity is elaborated beyond the design brief to the specifics of the group and the context in which they are working. This, in itself, is an important means to develop understanding of technology problems (see, for example, Lewis and Gagel (1992) in relation to the context specific nature of technological solutions to problems).

Not all PSTs were so forthcoming. Hannah, for example, simply listed the order in which things were done in point form:

- We chose to make a dress
- We looked at the available materials.
- We felt that a pillowcase already looked like a top and the easiest thing to use for a skirt would be the sheet.
- Sherry was the smallest so we decided that she would be the model. (Reflective writing)

Even terse description such as this reveals much of the orientation of the students, and the manner in which the materials influence decision making processes, in this case not so much by what to make but, rather, how to make it. When looking at the final product made by the PSTs, these initial decisions can be informative with regard to interpreting the artefact they have made, and how its final form came into being.

Characters
The PSTs made particular comment on the attributes of the group members, such that the final artefact was not so much a product of equal individuals contributing in similar ways, but was the result of different individuals making different contributions. Liam, for example, discussed his group members in the early phase of their project:

> Many ideas were presented on how the design of the car should take place. One member of the group took a hands-on approach to designing the car by playing with the materials, while another member of the group began drawing plans on

> paper. The final member of the group studies the materials and thought intently on how they could be interlaced together to create the toy car. (Reflective writing)

Understanding such dynamics within a group is essential to developing a cohesive view of how artefacts are created and the manner in which they are developed. Just looking at the final design is to ignore important intellectual effort of the group. Narratives also revealed the past experiences that group members bring to technology problems. Andy, for example commented on his group's decisions to use the person with the most sewing experience exclusively on the sewing machine, while others supported this role. His terminology for the others in these roles ('gophers') indicates the hierarchical structure that he felt was necessary for the team's success.

Events

The events that shaped the activities of the students were mostly presented in a chronological order, identifying key incidents that progressed the design:

> We were going to have a belt, but when we tried it, it didn't look any good so we changed it and it didn't have one. (Fiona, reflective writing)

The PSTs also made reflective commentary on decisions that provided insights into how they developed any artefacts. Ian, when discussing the catapult that his group made stated that:

> …any changes that occurred during the construction process were practical (i.e. necessitated by the materials or tools available and determined through trial and error) or cosmetic. (Reflective writing, parentheses in original)

The most innovative approach to reflection was attempted by Edward, who produced a narrative recount in the genre of a police report, complete with B-grade movie dialogue.

> It happened like this, Rob, this strange looking bloke, came to us and says, "I need some research done into the safety of Bungee jumping, stuff on how much they can hold and the like"……. (Reflective writing)

He concluded

> What we leaned from this was the ability to do our maths skill, you know, mathematics, to make the data mean something, from this we could demonstrate how the relationship between stretch and weight can change. (Reflective writing)

While informal in approach, Edward's narrative contains dialogue that informs the reader about the process that was undertaken, and allows an insight into the motivations and decision making of participants. It is also readable and amusing, encouraging the reader to continue with their exploration of the activity.

PSTs also reflected on problems and how they were resolved. Meredith, for example, while discussing the development of a costume commented that:

> With the skirt we wanted it pleated at the top, but at the bottom we wanted a balloon hem, but there wasn't enough material to do this, so we just cut off the length to fit the model. (Reflective writing)

Such problems and resolutions form important aspects of any narrative, and it is probably instructive to further explore exactly what are regarded as problems by participants from a participants point-of-view, rather than from an outside observer's. In this regard a narrative approach may form a means to access this particular viewpoint.

Values

The majority of PSTs who completed a narrative reflection of their activities included aspects that might be considered as value statements. They included commentary on the aesthetics of what they had created, as well as discussions on the feelings that they had either during, or after the completion of the project. Typical responses included:

> We felt fulfilled as a result of our product because it was effective and met our outcomes and objectives. (Charlie, Reflective writing)
>
> The feeling during the experiment was one of satisfaction, knowing that we can be given a few objects and we need to find out optimal levels of height and weight. (Denice, Reflective writing)
>
> It was particularly gratifying during the testing phase to observe the different aspects of the model interacting with each other quite successfully (Ian, Reflective writing)
>
> Collectively, each of these steps (that we undertook) revealed an increasingly more aesthetic toy. (Liam, Reflective writing)

The PSTs, through the process of narrative development, had identified values and feeling that might not be articulated during more traditional approaches to technology education. The narrative form employed in this research allowed for PSTs to highlight such aspects that are important considerations in the development of technological artefacts.

Discussion

The PSTs in this research were able to construct meaningful narratives that expressed the processes that they undertook to create artefacts. It appears that the use of this technique may address some of the major concerns in technology education at the present.

The need for a common framework for technology may be tackled through the use of the concept of narrative. It might be considered that all technology should be considered as part of a narrative, thus providing a reflective tool for the student and teacher, as well as a means to develop assessment protocols based around the narrative of technology activities. The PSTs in this research found the use of narrative to be a natural means to explore their understanding of what they had produced, and the responses they provided allowed for some quite detailed insights into their learning.

Of particular note is that they were able to not only explore the material manifestations of the activity, but also the personal journey, complete with feelings, that they experienced. The values, therefore, and not just the practicalities of the exercise were allowed to become an important factor in what they learned.

From the point-of-view of the teacher, the narrative approaches used in this research allow for students to more fully explore what the artefact they have created actually means, through locating it as part of a meaningful personal journey. It also allows them to be not only creative in their technical explorations, but also in their reflections of the events. This is not to say that all guidance is removed. All narrative to be meaningful has structure, and it would certainly be of use for students in schools to be explicitly taught how narrative is constructed as well as the different types of narrative genres that may be appropriate for technology activities.

Conclusions

Clough (2002, p.8), while talking about the use of narrative in educational research, describes the functions of narrative that are of relevance to narrative in technology education.

> So, in setting out to write a story, the primary work is the interaction of ideas; in the act of thinking, tuning in, decision making and focusing on the primary intent of the work. And of course, writing a story – like constructing a building – is not carried out outside of a need, a community, a context. These are actually the primary ingredients.

The PSTs in this research formulated their own narratives to demonstrate these interactions of ideas. From discussions of orientation and context, to decision making about the division of labour, to time constraints and how to manage them, all of the PSTs formulated their own story that reflected the experience, both personal and social, that they had undertaken. In this regard they have taken their understanding of technology beyond the purely technical and have incorporated values, context and community.

The focus of technology in this regard moves beyond the artefact; the artefact becomes one aspect of a continuous narrative that brings in experiences from before, during, and after. In this regard, Clandinin and Connelly (2000) frame narrative inquiry through the notion of inquiry space, and the dimensions by which narrative can be interpreted, including temporal notions of past, present and future. This is termed the dimension of *backward* and *forward* (p. 49). There is evidence in the writing of the PSTs to indicate that their experiences are not bounded by the exercise they undertook, and that to appreciate their story one must take into account what happens beyond the classroom itself. Clandinin and Connelly (2000, p. 49) also discuss the dimension of *inward* and *outward*; inward being internal conditions of narrator, including feelings, hopes and aesthetic reaction, outward being environmental conditions. There is evidence, once again, that PSTs are including such notions in their narratives.

While this research is at a preliminary stage, there is sufficient evidence to conclude that the use of narrative may provide a way forward for technology educators to interpret the experiences of their students. It is also evident that this may provide a framework for the development of appropriate pedagogies in the technology classroom. Further research needs to be conducted in school contexts, particularly the manner in which children utilise narrative and the preferred narrative structures that they employ.

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